The InterNational Electrical Testing Association Journal

WINTER 2025

NETA WORLD™

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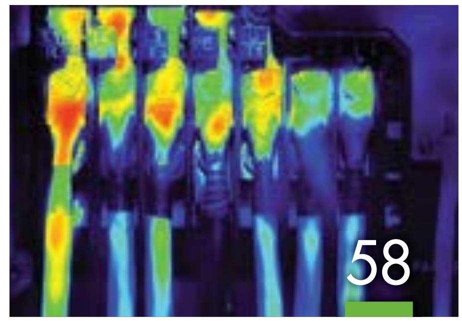

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WORKING TOGETHER FOR POWER SYSTEM LIFE EXTENSION AND MODERNIZATION

As we close out the year and look ahead to 2026, I'm filled with optimism for the continued growth and influence of NETA in the electrical power testing industry. Our association remains a trusted leader in advancing standards, training, and professional excellence, and the opportunities before us have never been greater.

Across every sector, the demand for skilled testing and maintenance professionals continues to rise. As facilities face aging infrastructure and the challenges of modernization, the expertise of NETA members is critical to ensuring system reliability, safety, and performance. Our work directly supports the backbone of power systems that keep industries, institutions, and communities operating, and that's something to be proud of.

NETA is expanding its impact through stronger collaboration with manufacturers, utilities, regulators, and educators. We are not only maintaining the highest technical standards but also preparing the next generation of technicians and engineers through certification and continuing education. These efforts ensure that NETA's name remains synonymous with quality, integrity, and technical excellence.

This Winter edition of *NETA World* highlights a central theme across our industry: **life extension and modernization**. In "From Bolted Pressure Switches to Modern Breaker Technology: The Evolution of 480-V Distribution Systems," authors Matthew Wallace and David Muir from Group CBS explore the transition from legacy bolted pressure switches to today's safer, more capable breaker technologies. Likewise, in *"Modernization – A Strategic Necessity,"* Seth Kravetz of QUALUS Corporation examines how evaluating and upgrading aging systems enhances reliability, safety, and long-term value.

Together, these pieces reflect the spirit of innovation and stewardship that defines NETA's mission. As we move into the new year, let's continue to lead our industry forward safely, smartly, and together.

Dan Hook, President
InterNational Electrical Testing Association

KEN PETERSON:

35 YEARS OF BUILDING RELIABILITY AND LEAVING FOOTPRINTS

KEN PETERSON

This issue of *NETA World's* "Insight and Inspiration" series features Ken Peterson, Vice President Testing and Commissioning, at Power Engineering Services, where he combines deep technical expertise with strategic business leadership to ensure the successful delivery and activation of critical infrastructure projects. He leads the full lifecycle of testing and commissioning and oversees marketing and sales efforts, bridging the gap between operational excellence and business growth.

Peterson's responsibilities include ensuring that every system brought online meets the highest standards of safety, quality, and performance. He leads cross-functional teams, develops robust testing protocols, and implements proactive solutions to keep projects on track and aligned with client expectations. He also plays a key role in driving regional commercial strategies by identifying new market opportunities, building strong client relationships, and helping shape go-to-market plans that support long-term growth. With a passion for delivering reliable infrastructure and creating value for clients, his mission is to be a driving force behind the company's success across all company regions.

Peterson currently serves on the TechCon North America Technical Conference Planning Committee, the NETA New Membership Application Review Committee, the NETA Training Committee, the NETA Technical Resource Committee, and the NETA Promotions and Marketing Committee. He earned a BS in sociology and an MBA with a concentration in management and leadership at the University of La Verne in La Verne, California.

NW: **What attracted you to the electrical testing field?**

Peterson: I consider myself fortunate to have had the opportunity to start my career in underground construction. After returning to college at the age of 21, I was offered a position at a small electrical testing company. As I

advanced in the electrical testing field, I realized that I had better career prospects in this industry compared to the social science field.

NW: **Please share your 35-year career path in the electrical and power industry.**

Peterson: After graduating from high school, I began working for a contractor in the telecommunications and underground construction industry. Realizing that I did not want to master the shovel, I returned to college and had the opportunity to start working for an infrared testing company. As time progressed, I transitioned from power quality and infrared scanning to maintenance and startup testing as a field supervisor. A few years later, I was offered a regional manager position that allowed me to focus on long-term preventative maintenance outages.

During my early years as a regional manager, I had the opportunity to support the company as it looked at becoming an accredited NETA company and was exposed to NETA PowerTest conferences. Being introduced to NETA standards opened my eyes to the vast opportunities in the market, sparking my quest to be part of a NETA-accredited company.

My first accredited company in the NETA industry was in 2006, when I became a field supervisor and project manager over a regional office. As we developed our region, we began working with local utilities, exposing me to the high-voltage market. This experience opened my eyes to even bigger opportunities within the sector.

After turning 40, I transitioned to focusing on renewable and utility markets, starting a new division for my employer. After a few years of growing the business, I was promoted to the director level, where I continued to mentor and grow other managers. It was at this point in my career that I discovered the importance of delegation, mentorship, and developing others. After being appointed to my first vice president position, I pursued a graduate degree in leadership. As I continue to grow in my leadership role and responsibilities, I value raising others up and keeping them motivated with what they can achieve within our industry.

NW: **What about this work keeps you committed to the profession?**

Peterson: I have experienced the peaks and the valleys of overcoming challenges in the industry. One of my favorite aspects is what I like to call "triage," which involves customer recovery on a large scale, whether at a substation or a power generation facility, including renewable energy or gas turbine plants. The process of recovering and assisting customers in this industry is never dull. Just when we settle into a routine, a curveball comes our way, and the reward of seeing the customer back online is immensely satisfying.

Reflecting on those peaks and valleys, I began my career in the late 90s, so I witnessed the construction of data centers. Today, with the advancement of AI, we are experiencing another data center boom. I was also part of the early renewable energy race in the early 2000s, working on large-scale testing and commissioning opportunities for renewable projects that were initially just bid opportunities before government funding. Now, we see these projects integrated into the high-voltage grid, creating a mature market maintained by our testing industry. It is a full circle, driven by power demand and consumption in North America.

I believe it is a great time to be in the power industry. In recent years, my wife Carol and I have become empty-nesters, which has added a new dimension to my career. Having her as a companion on many of my work-related travels has made it easier to be away from home, as I have my best friend by my side.

NW: **What has been the proudest moment of your career?**

Peterson: My proudest moment in the industry is watching two of my sons begin their careers alongside me. Recently, my middle son, Travis, began his journey as a journeyman electrician and is currently enrolled in the electrical power engineering program at Arizona State University. Last year, my youngest son, Matthew, began his journey as a pre-apprentice lineman at the age of 19. During his journey, he decided that building substations like his father was the path he wanted to pursue. We all have our own career paths, and leaving a legacy for the next generation is something I am absolutely proud of.

NW: **What do you see as your mission?**

Peterson: With 35 years in the power engineering industry, my mission has always been to ensure that every project I lead delivers the highest standards of safety, reliability, and performance. I am passionate about bridging deep technical expertise with strategic leadership — guiding teams, strengthening client partnerships, and driving growth, while keeping infrastructure dependable and communities powered. What fuels me most is the opportunity to combine engineering precision with a vision for long-term success, creating solutions that stand the test of time and add lasting value for clients and stakeholders.

REBUILDING PUERTO RICO'S ELECTRICAL GRID

Peterson recently spent 23 months on-site in Puerto Rico as Director of Substations — Large Projects at Luma Energy, rebuilding and managing the electrical grid and assisting with project planning and execution to modernize it. He worked in close collaboration with FEMA and local federal agencies to provide funding for the large substation projects.

NW: **For those who missed PowerTest, please give us a 30,000-foot overview of your work with the Luma Energy project to rebuild and manage the electrical grid in Puerto Rico.**

Peterson: In 2022, I had the opportunity to observe what Quanta was doing on the island of Puerto Rico. I learned they were seeking industry experts to support the rebuilding of the entire utility grid on the island. The task was to go to Puerto Rico and assist in building an internal utility-scale construction and commissioning team. Early in the journey, it was crucial to ensure we had the right capabilities and resources to bring to the island and support the influx of high-voltage breakers and transformers needed to stabilize the current grid. I was also tasked with evaluating contractors who would be awarded contracts for building utility-scale substations for long-term projects. As we developed the teams, we had the opportunity to support a few of the tropical storms that came through, which tested our ability to work under pressure while maintaining a safety culture. Overall, in my two years on the island, we successfully replaced the majority of the older oil circuit breakers and several transformers that were out of service due to past hurricane events. The overall goal was to rebuild a total of 48 substations that would support the grid stabilization and modernization plans.

NW: **Puerto Rico is using the latest technology in building a new power distribution infrastructure. What does that technology look like, and how is it different than the technology we find across the United States today?**

Peterson: That's a great question. In many ways, the technology used in Puerto Rico looks similar to what we see in the U.S. today. The difference is in how it's being applied and the impact it has on reliability.

One of the first big improvements was the rollout of smart meters. These meters give the utility real-time information about outages and voltage issues across more than 1.5 million customers. Instead of waiting for customers to report problems or sending crews out to investigate, the utility can now see issues as they happen and respond more quickly.

Another major step has been the automation of the distribution lines. In the past, a single fault could take down an entire line, leaving as many as 2,000 customers without power. With automation, the system can now isolate the problem and limit the impact to a much smaller group of customers — sometimes just 250. The system can also attempt to restore power automatically when faults are temporary, which often happens during storms.

Looking ahead, Puerto Rico's modernization efforts are focused on building resilience. New projects include microgrids and energy storage systems that will help communities keep power during larger outages and recover faster when the main grid is affected. At the same time, the utility is replacing older infrastructure with hurricane-resistant poles and stronger transmission structures, making the grid better able to withstand severe weather.

Taken together, these upgrades — smart meters, automated lines, microgrids, storage, and stronger equipment — are creating a more reliable and storm-ready grid for Puerto Rico. For customers, that means fewer outages, quicker recovery, and a stronger foundation for clean energy growth in the years ahead.

NW: **What is the utilities' perspective on the current power maintenance requirements from NERC? Are utilities concerned about NFPA 70B?**

Peterson: In my experience working with bulk electrical systems as a contractor, I have seen firsthand how asset management departments at utilities are heavily focused on compliance with North American Electric Reliability (NERC) standards. These requirements, particularly those related to protection and control (PRC), are taken very seriously because the penalties for non-compliance can be severe. For example, I supported a smaller municipal utility that faced more than $10 million in fines and was forced to update its entire maintenance program after deficiencies were identified. Situations like this underscore why utilities devote so much attention and resources to meeting NERC standards.

NFPA 70B provides recommended practices for the maintenance of electrical equipment. While these standards are sometimes referenced in the course of utility work, I have not seen the same level of concern from asset management teams

in the transmission, distribution, and substation areas where I've primarily worked. The focus there tends to remain squarely on NERC compliance. However, NFPA standards may have greater relevance in corporate facilities and property management, where building safety, fire prevention, and equipment reliability are directly tied to NFPA guidelines, but that has not been my focus within the utility space.

NW: **Have you seen common ground between utilities and NETA?**

Peterson: From my experience, the relationship between utilities and NETA centers on the recognition of standards and technician certifications. Many utilities rely on contractors to support capital projects, and part of the vetting process is confirming the qualifications of the people doing the work. Over the years, I've seen NETA certification consistently recognized as a credible benchmark of technical competence and field experience during this qualification process.

More recently, I've also seen utilities go a step further by referencing ANSI/NETA testing standards directly in their project specifications for third-party work. In fact, I've used these standards myself when developing test plans for large-scale utility projects, and I've noticed that their acceptance has grown steadily over the past 15 years. Today, NETA is viewed as an authoritative reference in utility projects across the industry.

The common ground between utilities and NETA is clear: reliability, safety, and standards. Just as utility standards are designed to ensure that power systems are installed, tested, and ready to operate as intended, our ANSI/NETA standards provide the framework to confirm that equipment performs reliably before being energized. On the safety side, utilities require every contractor to maintain a robust safety program as part of the qualification process. NETA certification also validates that accredited companies meet high safety standards, which creates a direct alignment between the two.

In short, utilities and NETA share the same goals: ensuring that power systems are safe, reliable, and held to consistent standards. My experience has shown that NETA's role as a recognized authority in testing and certification makes it a valuable partner to utilities as they continue to build and maintain critical infrastructure. NW

KNOWING ELECTRICAL ACRONYMS MATTERS, PLUS AN NFPA 70E–2027 UPDATE

BY RON WIDUP, *Shermco Industries*

If you work around electricity, your career…and maybe your life…depends on what's hidden in a bowl of alphabet soup. I'm talking about electrical acronyms: NFPA, OSHA, 70E, 70B, NETA, NEC, Z462, EASA, and so on. At first, they may sound like code meant to confuse you. But once you crack that code, everything about your job makes more sense…and becomes a lot safer.

UPDATE: 2027 EDITION OF NFPA 70E

First, here is the status of the current revision cycle for the 2027 edition of NFPA 70E.

The 70E Technical Committee met for the second draft (SD) meeting in August 2025 in Indianapolis. At that meeting, we acted and voted on 213 public comments and processed 93 revisions required by the NFPA Manual of Style. The second draft report will be published soon, which will allow the public to review the actions and committee comments from the meeting.

As a reminder and recap, here is the basic process for the 70E standards-making process after receiving public comments.

First Draft Report: The process starts when the technical committee working on the standard publishes its first draft report, based on public inputs (July 2024 in Memphis).

Second Draft Report: After the public comment period, the committee publishes a second draft report, outlining its final recommendations. (August 2025 in Indianapolis). The SD report will be issued on or before March 2026.

NITMAM Period: A deadline is published for submitting a Notice of Intent to Make a Motion (NITMAM). Anyone who disagrees with the committee's recommendations in the SD can file a NITMAM by March 31, 2026.

NITMAM

The NFPA's Notice of Intent to Make a Motion (NITMAM) is a formal step in the standards development process that allows anyone to propose an amending motion to a standard, such as NFPA 70E, for consideration and debate at the NFPA Technical Meeting.

The process is in place to ensure that the standards development remains a public, consensus-based procedure, providing a final opportunity for interested parties to address and amend the work of the Technical Committees

Motions Committee Review: All submitted NITMAMs are reviewed by NFPA's Motions Committee to ensure they are proper and valid (May 12, 2026).

Technical Meeting: Any certified NITMAMs are brought up for debate and a vote at the NFPA Technical Meeting, which is attended by NFPA members (June 25-26, 2026).

Standards Issuance: If no NITMAMs are filed, or if all are defeated, the document is considered a Consent Standard and goes directly to the Standards Council for final issuance.

We expect the 70E–2027 standard issuance, assuming all goes forward, in the fall of 2026.

THE ALPHABET SOUP OF STANDARDS AND ELECTRICAL SAFETY

The world of codes and standards has an inherent need — or maybe it's a yearning — to abbreviate and shorten certain words and phrases that ultimately become commonplace and part of the communication channel for the industry.

Every trade has its shorthand. Doctors talk in Latin. Pilots speak in abbreviations. Electrical workers? We use acronyms. They save time… but they also pack a lot of meaning.

When someone says, "Is this task compliant with NFPA 70E?" that's not small talk. That's a life-or-death check. Knowing what 70E is (and what it means) separates a qualified worker from a risky one.

Understanding key terms and abbreviations can help you, the worker in the field, be more knowledgeable, and it will arguably make you safer as you execute your daily tasks on the job because you have a clearer understanding of key terms and abbreviations.

Here's a list of some of the more important acronyms for electrical safety and standards. And if you aren't familiar with them already, get to know them…or maybe skim the article for now, and keep it handy to use on the job later!

Standards-Making Organizations and Regulatory Agencies

Knowing and understanding the relevant electrical safety standards-making organizations is important to the electrical worker in the field. Not only will you see and hear many references to certain numbers, acronyms, and sections, but it will also be important to understand their content and intent so you can perform your work safely.

Don't be confused by the various numbers and acronyms — embrace them! Each one writes part of the rulebook for how we install, test, maintain, and repair electrical systems. Miss one, and you're missing part of the safety net.

ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
CIGRE	Council on Large Electric Systems (English Translation)
CSA	Canadian Standards Association
EASA	Electrical Apparatus Service Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
NFPA	National Fire Protection Association
NESC	National Electrical Safety Code (IEEE C2)
NEC	National Electrical Code (NFPA 70)
OSHA	Occupational Safety & Health Administration
UL	Underwriters Laboratories

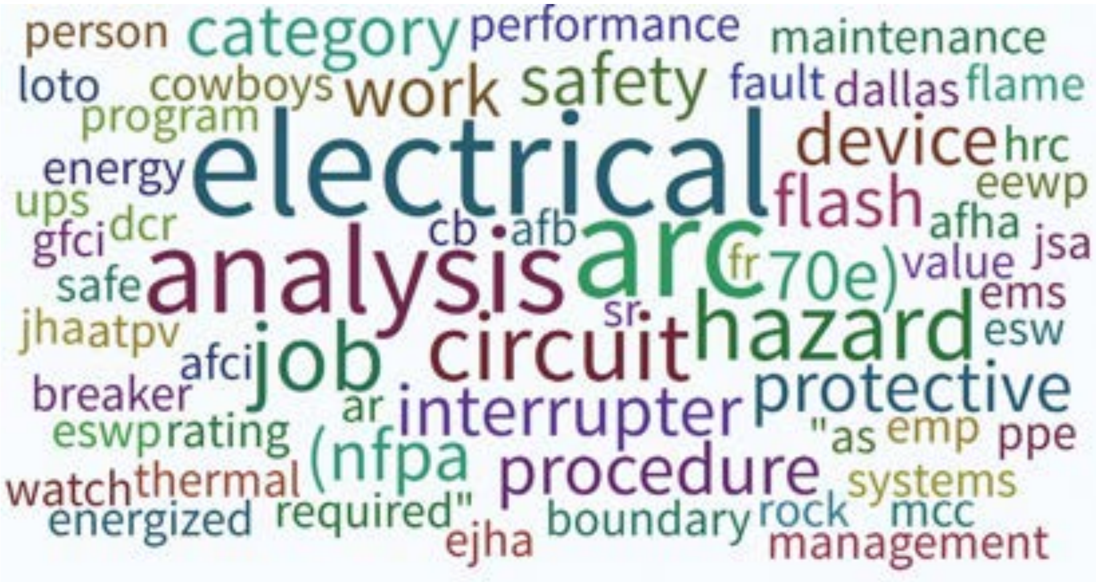
Common Electrical Terms and Acronyms

Why should you study and understand something as exciting as a list of acronyms and standard numbers? Besides curing insomnia, it helps you be a better technician/engineer/boss.

- Building your electrical safety program? Use NFPA 70E or CSA Z462 and include OSHA 1910; train to 1910.331–335, and implement LOTO with 1910.147.
- Trying to figure out what electrical maintenance and testing you should do? Whip out NFPA 70B, CSA Z463, and the ANSI/NETA ATS and ANSI/MTS standards.
- Concerned about arc flash-related topics? Better grab IEEE 1584 for incident energy calculations; label it per NEC 110.16; reduce energy via NEC's articles 240.67 and 240.87.
- What about PPE needs? Refer to ASTM, IEC, NFPA, and OSHA.

Read and understand these – it's important!

AFCI	Arc Fault Circuit Interrupter
AR	Arc Rating or As Required (NFPA 70E)
ATPV	Arc Thermal Performance Value
AFHA	Arc Flash Hazard Analysis
AFB	Arc Flash Boundary
CB	Circuit Breaker
DCR	Dallas Cowboys Rock!
EJHA	Electrical Job Hazard Analysis
EMP	Electrical Maintenance Program
EMS	Energy Management Systems
EEWP	Energized Electrical Work Permit
ESWP	Electrical Safe Work Procedure
ESW	Electrical Safety Watch/Standby Person
FR	Flame Resistant (material)



GFCI	Ground-Fault Circuit Interrupter
HRC	Hazard/Risk Category or Arc-flash PPE Category
JHA	Job Hazard Analysis
JSA	Job Safety Analysis
LOTO	Lockout/Tagout
MCC	Motor Control Center
OCPD	Overcurrent Protective Device
SOP	Standard Operating Procedure
SPD	Surge Protective Device (replaces TVSS)
SR	Selection Required (NFPA 70E)
UPS	Uninterruptible Power Supply

OSHA REGULATIONS

It's important to spend a little more time understanding key aspects of the OSHA regulations that relate to electrical topics. OSHA is a federal agency within the U.S. Department of Labor (DOL) that works to ensure safe and healthy working conditions for employees. On the electrical side, here are important sections you should be familiar with.

1910 Subpart S – Electrical

This is OSHA's standard for electrical safety in the workplace, covering the design, installation, and maintenance of electrical systems to protect employees from electrical hazards. It includes regulations for the safe installation of electrical equipment, protective work practices, and maintenance requirements.

- **1910.331 Scope and Applicability.** Applies to qualified and unqualified persons who work on, near, or with certain electrical installations
- **1910.332 Training.** Outlines training requirements
- **1910.333 Selection and Use of Work Practices.** Requires deenergizing live parts before work, when possible
- **1910.334 Use of Equipment.** Provides rules for the use of electrical tools and devices
- **1910.335 Safeguards for Personnel Protection.** Rules for using and maintaining PPE and other protective equipment and tools
- **OSHA 1910.147 General Environmental Controls.** Applies to lockout/tagout (LOTO) rules and requirements
- **OSHA 1910.269. Electric Power Generation, Transmission, and Distribution.** Applies to electric power generation facilities and the employees who work on them

SUMMARY: ACRONYMS = AWARENESS = SAFETY

Electrical work is unforgiving. You don't get second chances with an arc flash or backfeed. When you see NFPA 70E Article 130, you should instantly know it's about safe work practices and is not something to look up later.

When you can talk fluently and confidently about 70E boundaries, OSHA lockout rules, or NETA testing requirements, you're not just another worker — you're the one people turn to for answers as the subject matter expert or trusted advisor. That's how promotions, certifications, and leadership roles happen.

So keep a cheat sheet, print it out, and post it where you work. Use it daily when writing reports and summaries, and reference the standard or section number.

Electrical acronyms aren't just letters — they are the DNA of our trade. The more fluent you become, the better your decisions, your reputation, and your odds of going home in one piece.

Because in this business, the alphabet really can save your life.

Besides the very important DCR, remember this: **Always**…Test Before Touch! (IYKYK).

Arcing Bus

BONUS SIDEBAR!

Technical Grammar: It's a real thing! Here are a couple of examples.

Electrical Bus
An electrical conductor, or bus, is spelled "bus", not "buss." "Buss" is the name of a fuse by Bussmann (now Eaton). The plural of bus is "buses." The electrons on the bus go round and round….

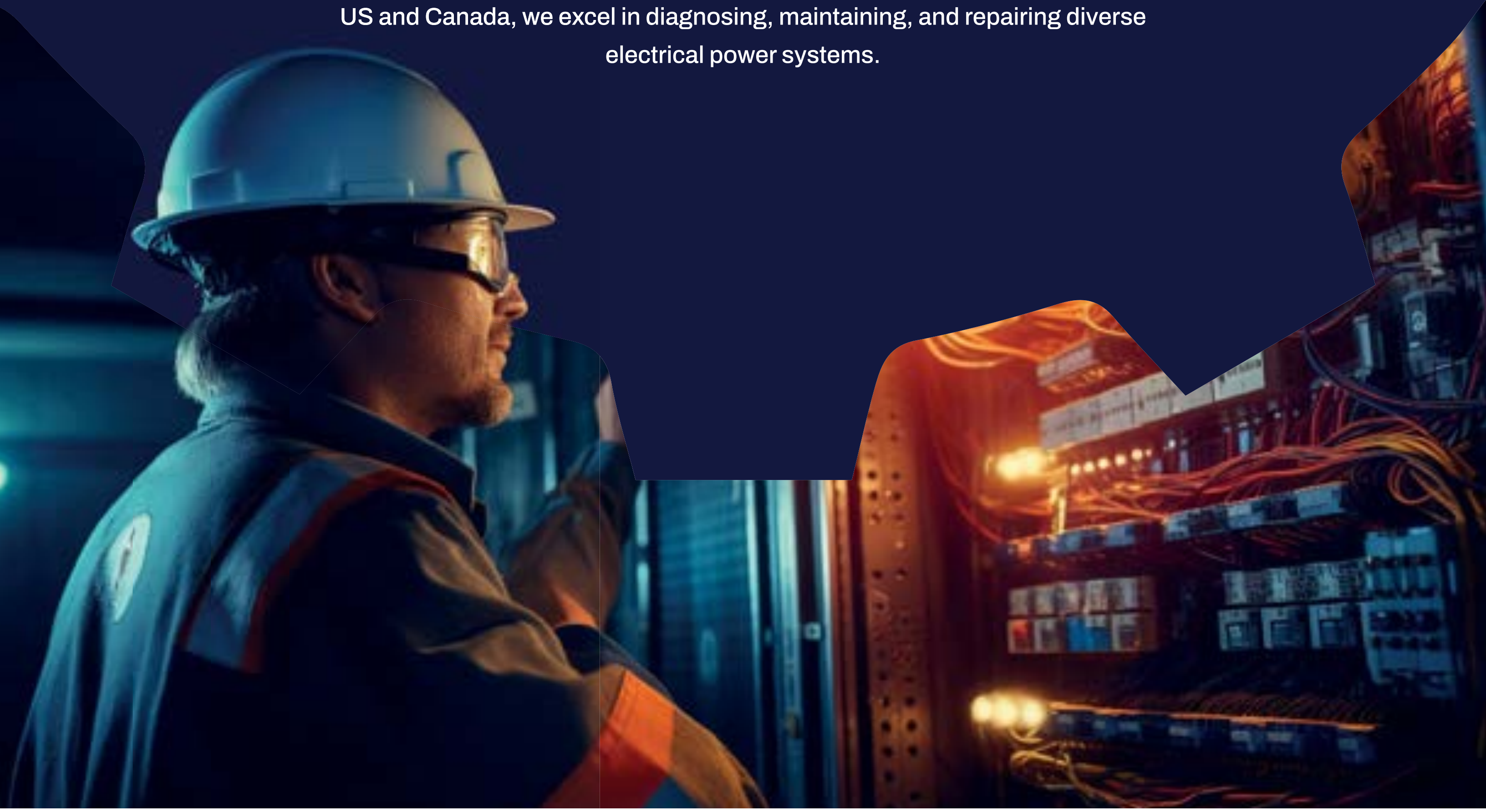
Shock vs. Electrocution
Shock = nonfatal contact with electricity. (Like Frankenstein: He's alive!!)

Electrocution = fatal contact with electricity (combines "electric" and "execution").

Ron Widup *is the Vice Chairman, Board of Directors, and Senior Advisor, Technical Services for Shermco Industries and has been with Shermco since 1983. He is a member of the NETA Board of Directors and Standards Review Council; a Principal member of the Technical Committee on* Standard for Electrical Safety in the Workplace *(NFPA 70E); Principal member of the* National Electrical Code *(NFPA 70) Code Panel 11; Principal member and Chairman of the Technical Committee on* Standard for Competency of Third-Party Evaluation Bodies *(NFPA 790); Principal member and Chairman of the Technical Committee on* Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation *(NFPA 791); a Principal member of the Technical Committee* Standard for Electrical Equipment Maintenance *(NFPA 70B); and Chair of IEEE Std. P902 (Yellow Book)* Recommended Practice for Maintenance and Operational Safety of Electrical Power Distribution Systems in Industrial and Commercial Facilities. *He is Chairman of the Texas State Technical College System (TSTC) Board of Regents, a NETA Certified Level 4 Senior Test Technician, State of Texas Journeyman Electrician, a Senior Member of the IEEE Standards Association, and an NFPA Certified Electrical Safety Compliance Professional (CESCP).*

Empowering People That Power
THE WORLD

As the largest electrical testing company in North America, SHERMCO offers unparalleled expertise in power system testing and maintenance. With 435+ NETA-certified technicians and 180+ engineers, and 40+ offices across the US and Canada, we excel in diagnosing, maintaining, and repairing diverse electrical power systems.



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With a vast North American network, SHERMCO has been the leader in electrical systems engineering and services for over 50 years. Caring for one another is at the heart of what we do, which is why we prioritize safety by honoring our commitment to protect and support one another. We don't just talk about having a best-in-class approach to safety—we embody it in everything we do.

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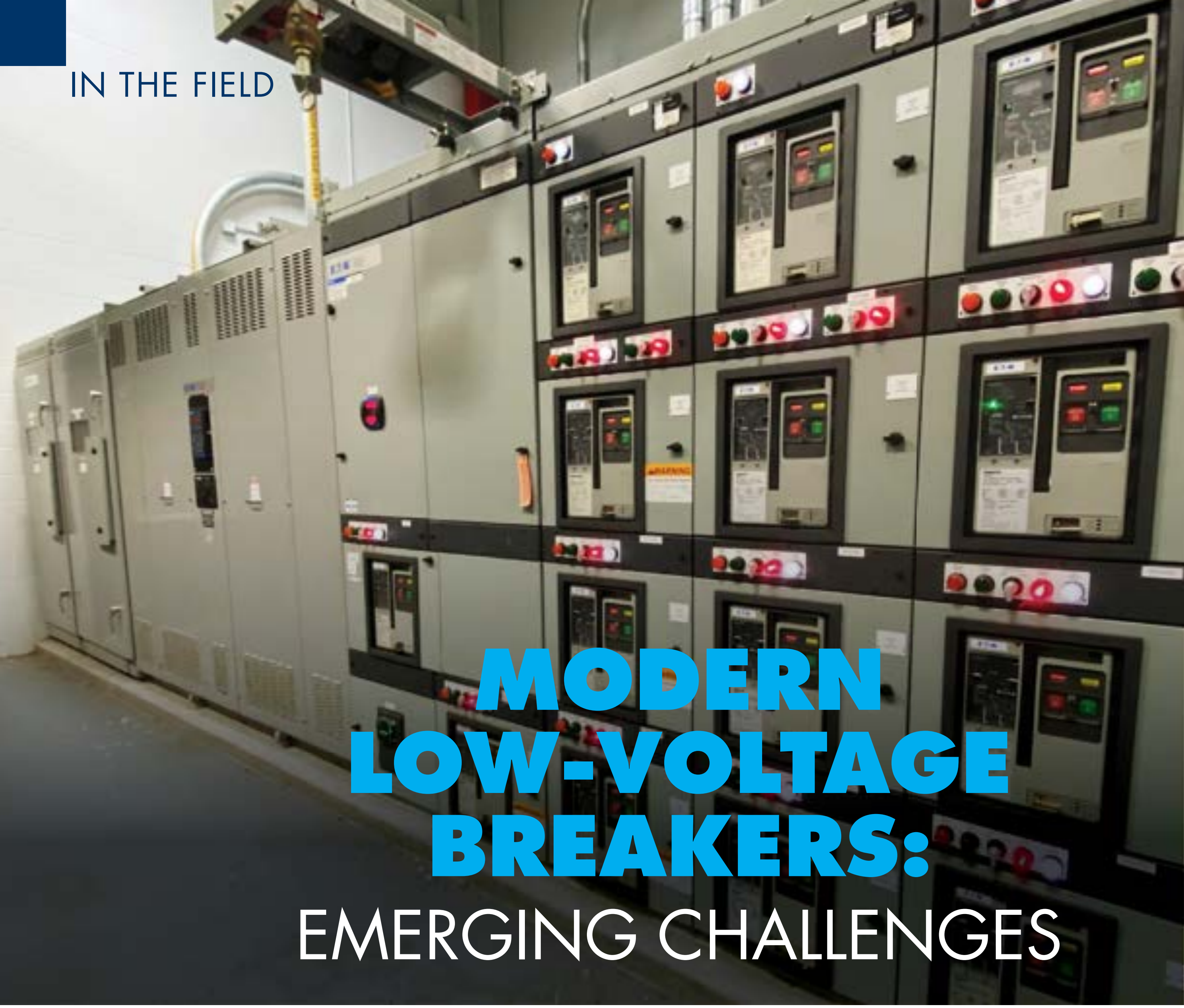

MODERN LOW-VOLTAGE BREAKERS: EMERGING CHALLENGES

BY MOSE RAMIEH, *CBS Field Services*

The days of low-voltage breakers being simple devices with basic overcurrent protection are long gone. Back then, the biggest challenge was to figure out how to defeat a ground fault or remember which jumper disabled thermal memory. Today, manufacturers are leveraging digital technology to add layers of protection and functionality. These advancements can quickly derail a routine day of testing if you're not prepared. The key is to study the manuals, share lessons learned, and stay familiar with new features.

COMPLEX LOW-VOLTAGE BREAKERS

This article highlights common challenges and lessons from the field so the next technician doesn't have to learn them the hard way.

Complex Controls

What used to be straightforward control circuits have become increasingly complex. The control drawing in Figure 1 may look like it came from a medium-voltage lineup, but it's actually for a 208-V feeder breaker.

These drawings document the entire control system. From auxiliary contacts for status lights to zone selective interlocking (ZSI), and everything in between, these drawings are essential for proper acceptance testing and troubleshooting. For reliable operation, these circuits must be functionally tested — not just assumed correct.

The catch is that this level of control complexity is seldom recognized during bidding or early project planning. Estimators, project managers, and technicians must budget time for these verifications. Competitors who skip this scope may undercut pricing but deliver incomplete testing. Make it your role to educate clients on the risks and the value of thorough functional checks.

Pro Tip: Review control drawings before mobilizing. For example, the ERMS excerpts in Figure 2 and Figure 3 show connection points and power requirements. Having this knowledge upfront allows you to develop effective methods of procedure (MOPs) and avoid surprises on-site.

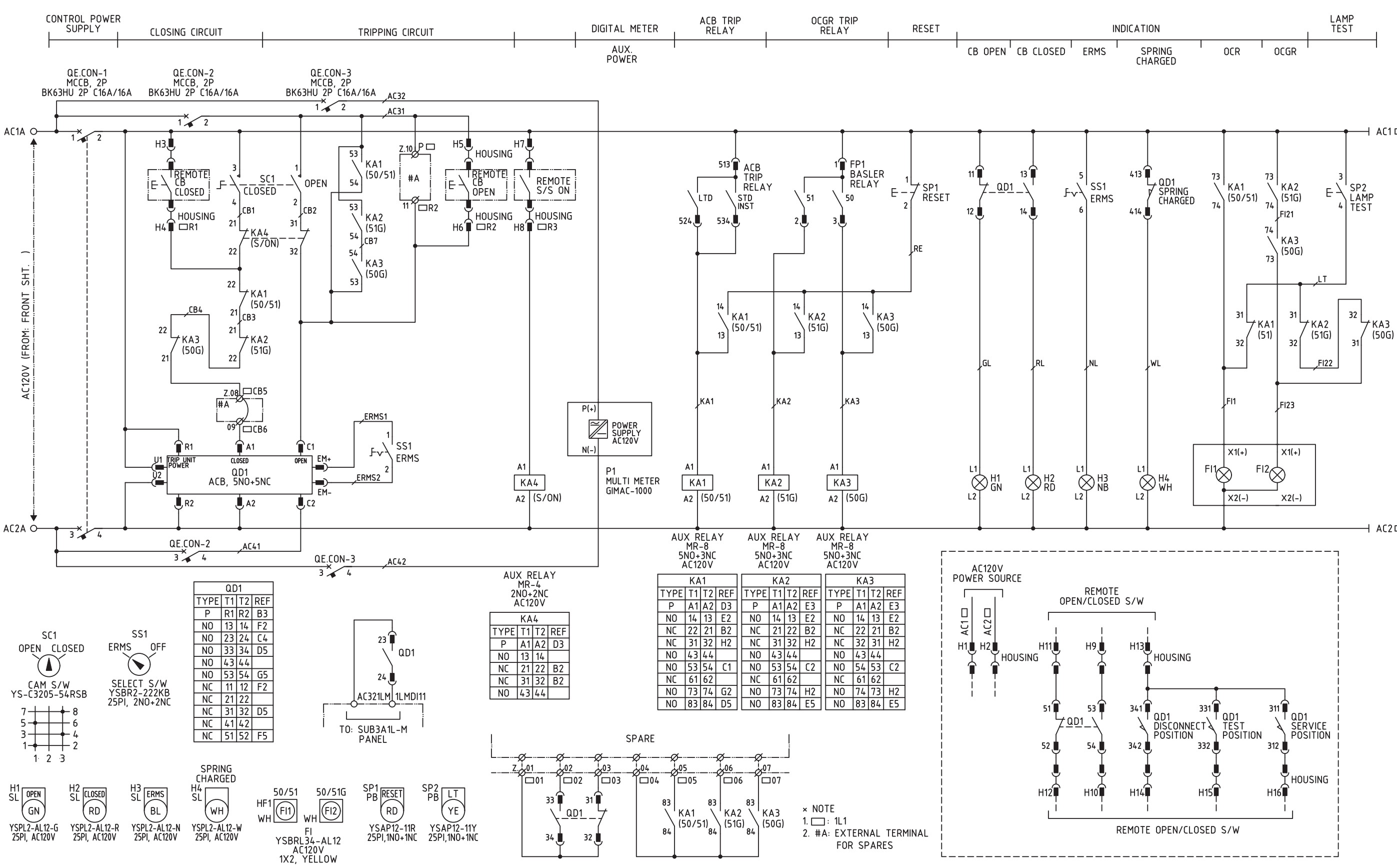

Figure 1: *Complex 280-V Feeder Breaker*

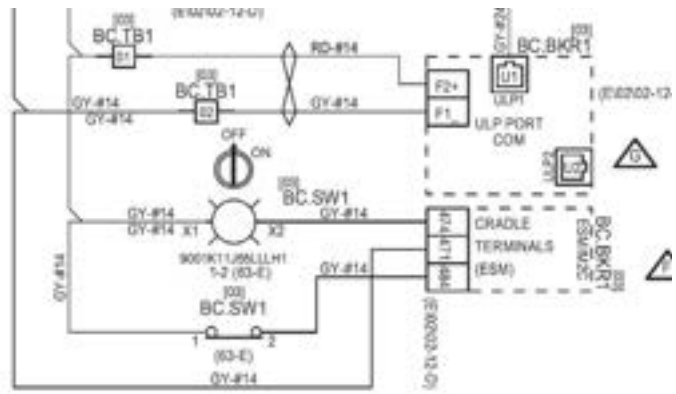

Figure 2: *ERMS Drawing Schneider Electric*
Note: ERMS is off with the switch closed.

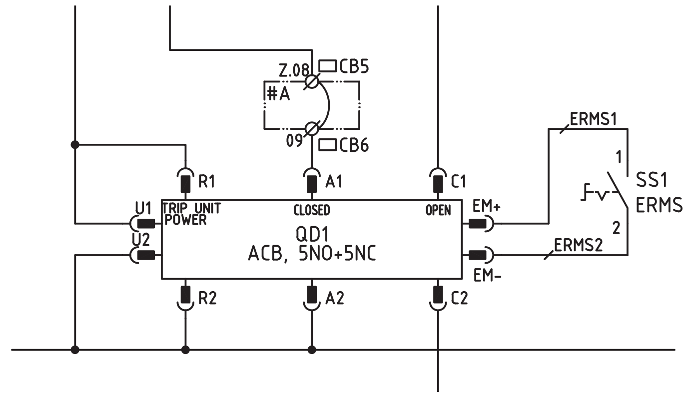

Figure 3: *ERMS Drawing LS Electric*
Note: ERMS is off with the switch open.

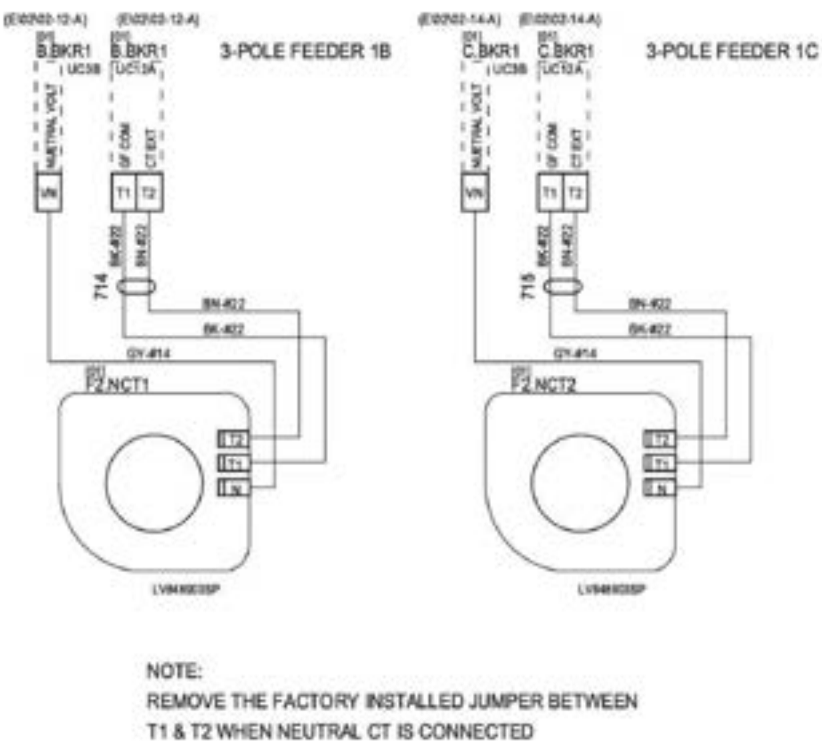

Figure 4: *Neutral CT Diagram*

Ground Fault Defeat

Ground-fault protection has been standard for decades, but it still causes headaches. For legacy trip units, many of us have relied on cheat sheets to remember the right method, whether it's installing a jumper, moving a neutral lead, or using the proper secondary test set.

With today's modern trip units, it is more critical to ensure that you have the correct software to allow for ground fault defeat. Those who have found themselves in the field downloading software tell a story of frustration. Reviewing drawings ahead of time also ensures you're ready for the required primary current tests — trip and no-trip of the ground fault system — which confirms proper CT orientation and wiring. Figure 4 illustrates the neutral CT connections and provides a note about removing a factory-installed jumper. The devil is in the details.

Zone Selective Interlocking

ZSI has been around for years. It allows downstream devices to clear faults while signaling upstream breakers to delay tripping. If the upstream breaker doesn't receive that signal, it trips faster to clear the fault.

During testing, technicians must simulate this input to verify proper time-delay operation per the manufacturer's trip curves. This is often as simple as installing a jumper between the ZSI input. In Figure 5, note the jumper needed between Z3 and Z4.

Pro Tip: Always confirm that ZSI asserts when a feeder fault occurs. Review drawings carefully, as shipping splits (circled in red in Figure 5) often reveal incomplete wiring. Some ZSI systems can be verified with manufacturer software, while others (like GE Entelliguard) require a dedicated test set.

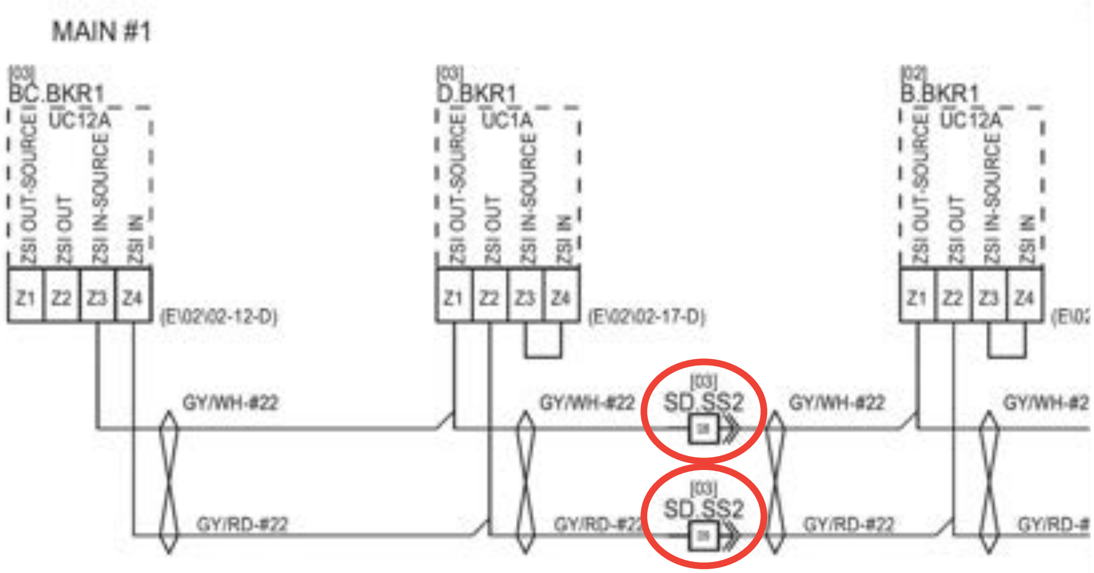

Figure 5: *ZSI Drawing Schneider Electric; Interconnect Wiring Points Circled in Red*

SPECIFIC BREAKER CHALLENGES

Siemens WL Breakers with ETU Trip Units

Siemens WL breakers with ETU trip units require ZSI to be deactivated before removing the breaker from its cell. If not, trip times default to instantaneous rather than the expected long-time delay. See Figure 6 for a picture of the device and plan accordingly to defeat ZSI.

We recently encountered phase-loss sensitivity on the ETU776 (Figure 7). It's hidden under protective parameters, but it can be disabled if you know where to look.

There is a catch, and it is in Siemens' own literature and took some digging to find.

Figure 6: *Siemens ZSI Module*

Figure 7: *PowerSen Setting*

PHOTO COURTESY JOE GOSS

Phase Loss Sensitivity

When single-phase testing, make sure that the short-time delay is not set to the 20-ms setting. In this position, the phase-loss sensitivity function is enabled. This function is designed to protect motors from heavy imbalances and loss of one or more phases. When active, and the trip unit detects that the least heavily loaded phase is 50% lower than the most heavily loaded phase, the long-time pickup setting (IR) is reduced to 80% of the setting indicated on the display or dial. When this unbalance condition no longer exists, the setting is returned to normal. Single-phase testing will be recognized as a phase unbalance, and long-time trip timing will be faster than indicated in the trip curves. For an ETU776, phase-loss sensitivity is controlled by the PhaseSen menu item under the protective parameters. When a short-time delay is set to 20 ms, phase-loss sensitivity cannot be turned off.

Figure 8: *MTZ Breaker Power Supply Connections for ERMS Defeat*

PHOTO COURTESY JESSE MASSMAN

Pro Tip: Ensure that Set A and Set B short-time delay parameters are above 20 ms to avoid phase-loss creating testing problems.

Schneider Masterpact MTZ with 6.0X Trip Units

On MTZ breakers with 6.0X trip units, ERMS can be disabled before removing the breaker as long as 24-VDC control power is applied and EcoStruxure software is available. If the breaker is pulled first, you'll need a 24-VDC power supply and secondary plugs to power the trip unit outside the cell and then deactivate ERMS through software. See Figure 8 for a basic layout of the connections required.

Pro Tip: Build a dedicated kit for these various breaker types: Use a 24-VDC supply (most common, although some use 120 VAC), appropriate secondary plugs (don't use a paper clip as seen in Figure 9), a cradle interlock defeat tool, and other tricks of the trade.

Pro-Tip: Use primary current connection plates of the correct thickness, which varies by manufacturer. To avoid breaker primary finger damage, ensure you are using the correct thickness. For example, for the MasterPact and LS Electric breakers, 3/8 inch is too thin; ½ inch is too thick.

Figure 9: *Paper Clip Used as a Jumper*

Table 1: *Examples of MTX Breaker Error Codes*

0x1442	Contact wear > 100%. Replace CB	The contact wear indicator reached the threshold of 100%.	Replace the circuit breaker. Consult contact wear interpretation on EcoStruxure Power Device app in order to estimate the circuit breaker ability to isolate withstand rated duty, operate, trip.
0x1444	CB has reached the max number of operations	The circuit breaker reached the maximum number of operations.	Replace the circuit breaker.
0x1446	Micrologic control unit has reached the max service life	Micrologic control unit reached 15 years of service life.	Replace the Micrologic X control unit.

Note on 6.0X replacement: Unlike earlier Micrologic versions that unplugged easily, the 6.0X appears hardwired to CTs deep within the breaker frame. Replacement is no simple task.

Service Life of MTZ Breakers

At PowerTest25, panelists raised a question about MTZ breaker life expectancy. My follow-up research confirmed that MTZ breakers and their 6.0X trip units have a documented 15-year service life, though conditions play a big role. Many units in service today may already be a third of the way, or more, through their life span. End of life can be checked using EcoStruxure error codes (Table 1).

LS Electric Breakers

Our first encounter with LS Electric breakers came during a maintenance outage. The customer had secondary test sets for powering up the trip units and defeating ground faults. However, upon testing the first breaker, the trip unit displayed odd readings — about 30 amps (Figure 10) on all three phases during a 1000-amp single-phase test. After repeated failures, we contacted the manufacturer.

Figure 10: *30-Amp Current on All Three Phases*

Figure 11: *Proper Current Display*

The issue: Not all LS Electric trip units are self-powered. Secondary test sets alone don't provide proper control power. External control voltage must be applied to these units in the same way as a switchboard. Once we supplied 120-Vac control power, the breakers tested as expected (Figure 11).

Supportive information from LS Electric when power control is lost:

- The trip unit shuts down (will not power on).
- Protective functions may not operate, and the breaker may fail to trip.
- Long-term operation without control power may degrade the microcontroller.

LS Electric suggests three mitigations:

- UPS installation for critical loads
- UVT coil to force a trip on loss of control power. Not recommended for system reliability; imagine an entire substation going down for a blown control fuse.
- Alarm integration to alert operators to control power loss.

LS Electric does offer self-powered trip units. Users should confirm which model they're ordering and how that impacts the system operation.

Insulation Resistance Testing

Many modern trip units include voltage sensing. Some older versions required pulling fuses or removing rating plugs. Eaton's Power Defense line (PXR) now uses internal 6-MΩ resistors for metering. During insulation resistance tests, these low values will be noted. Having the manufacturer's literature will save you time second-guessing yourself.

Pro Tip: If you see low readings that don't meet the minimums in ANSI/NETA ATS and ANSI/NETA MTS, double-check yourself, document the results, and call the manufacturer's rep before wasting time chasing a bad test.

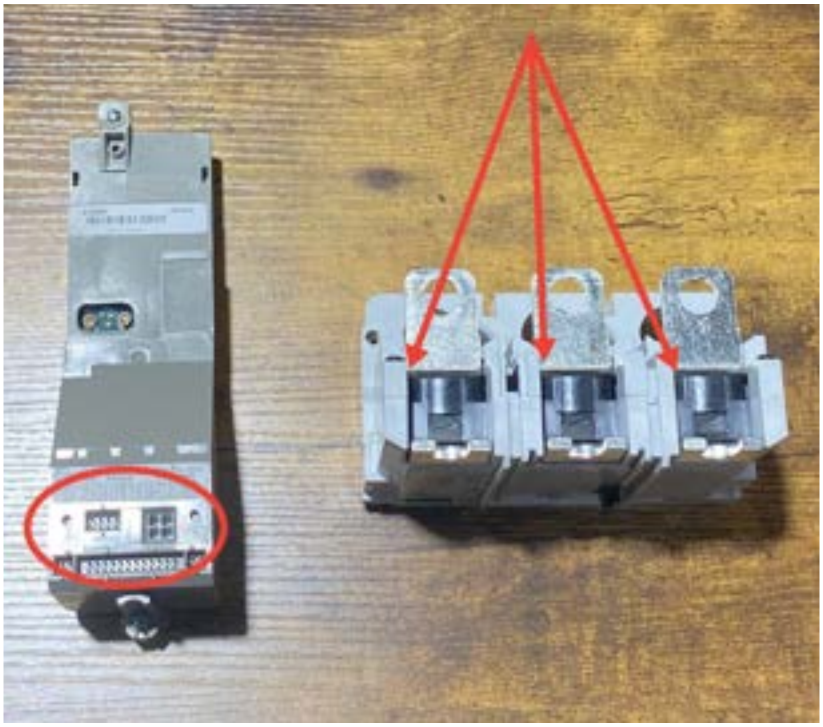

Figure 12: *CTs Integral to the Breaker (left) vs. Integral on a Trip Unit (right)*

FAILURES IN THE FIELD

Are failures more common now? Maybe, maybe not. But during recent acceptance testing of 800-A bolt-in breakers, three out of four failed to trip on A-phase during primary injection testing. Secondary injection showed that the trip units functioned properly and confirmed that the CTs were good.

At the manufacturer's direction, the trip unit was installed in a new breaker. A-Phase still failed. The lesson learned, once the trip unit was removed: In this breaker/trip unit design, the CTs are integral to the trip unit. The other lesson is that secondary injection does not identify all trip unit issues. The red arrows in Figure 12 point to the CTs on the trip unit.

In contrast, a Micrologic 6.0 trip unit relies on CTs that are integral to the breaker and provide input to its processor via a plug connection(s) circled in red (Figure 12). This is an important distinction to understand when troubleshooting trip unit failures and corrective recommendations.

FINAL THOUGHTS

As technicians, we're responsible for the safe and reliable operation of low-voltage power systems. Technology is moving fast, and our procedures must keep pace. Whether it's interpreting control drawings, learning manufacturer software, or digging deep into manuals, we must commit to continuous learning.

Sharing lessons across companies and engaging manufacturers early saves time and minimizes frustration. One technician's hard-earned experience can raise the competence of the entire NETA community. Hopefully, this article contributes to that effort.

Be safe, stay curious, and keep learning.

__Mose Ramieh__ is Vice President of Business Development at CBS Field Services. A former Navy man, Texas Longhorn, Vlogger, CrossFit enthusiast, and slow-cigar-smoking champion, Ramieh has been in the electrical testing industry for more than 25 years. He is a Level IV NETA Certified Technician with an eye for simplicity and utilizing the KISS principle in the execution of acceptance and maintenance testing. Over the years, Ramieh has held positions ranging from field service technician, operations, sales, and business development to company owner. To this day, he claims he is on call 24/7/365 to assist anyone with an electrical challenge. That includes you, so be sure to connect with him on the socials.

SIZING THE NEUTRAL GROUNDING RESISTOR FOR SUBHARMONIC VOLTAGE INJECTION

BY STEVE TURNER, *Consultant*

Stator ground faults are one of the most common disturbances for high-impedance grounded generators. A resistor is connected across the secondary of a single-phase distribution transformer connected from the machine neutral to ground to insert the high-impedance ground. The purpose of the high-impedance ground (Figure 1) is to limit the magnitude of single line-to-ground fault current flowing in the stator windings.

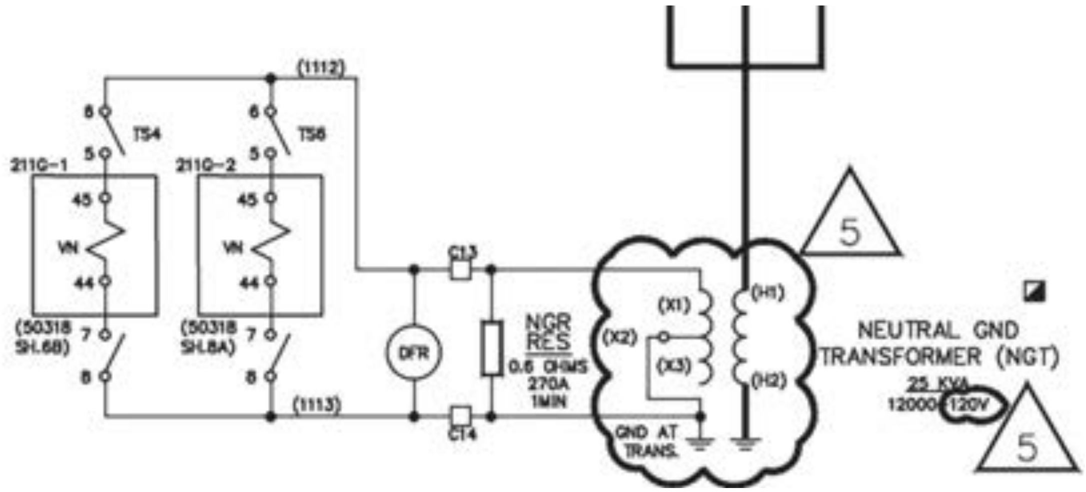

Figure 1: *High-Impedance Ground*

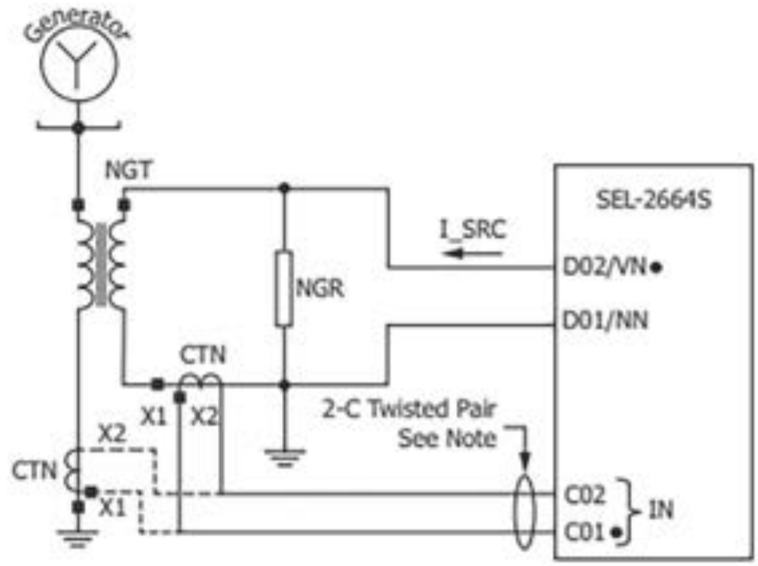

Figure 2: *Subharmonic Voltage Injection for Stator Ground Fault Protection*

Voltage-based protection, such as measuring the voltage drop across the neutral grounding resistor (R_N), is used for stator ground fault protection since the ground current magnitude in the stator is very low (e.g., 5 amps primary or less). Equation 1 calculates the distributed capacitive reactance.

$$X_C = \frac{1}{2\pi f C_g} \qquad \text{[Equation 1]}$$

Great care should be exercised when selecting the ohmic value, especially depending on the type of stator ground fault protection selected, such as subharmonic voltage injection (64S). This article illustrates such an example. Figure 2 is the single-line diagram for applying such protection.

Subharmonic voltage injection (64S) is unique because it uses a current measurement to detect stator ground faults, is very reliable, and can protect the entire winding.

Equation 2 is used to calculate the size (in Ohms) for R_N. N_t is the turns ratio of the grounding transformer. It is crucial to note that it determines the **minimum required value,** which is often not a good choice for the neutral resistor when applying 64S protection

$$R_N = \frac{X_C}{3N_t^2} \qquad \text{[Equation 2]}$$

EXAMPLE

This example shows how to calculate the minimum value for R_N. The purpose of R_N is to limit overvoltage so that it will not damage the generator insulation.

Power System Parameters

$f = 60$ Hz

$C_g = 0.49$ µF

$X_C = 1/[2\pi(60\ Hz) * (0.49\ \mu F)] = 5413.4$ Ohms

Grounding Transformer Turns Ratio

$V_{pri} = 25$ kV

$V_{sec} = 240$ V

$N_t = 25\ kV / 240\ V = 60.141$

Neutral Grounding Resistor

$R_N = (5413.4\ Ohms)/(3*(60.141)^2) = 0.499$ Ohms

The 60 Hz component neutral current flowing on the secondary side of the grounding bank (Figure 3) is calculated as follows for a ground located at the generator terminals:

$$I_N = \frac{V_{sec}}{R_N} = 481.1 \text{ A}$$

This large neutral current flows into the generator relay neutral current input (I_N) and can swamp the input circuitry. A 5.0 Ohm resistor would limit the secondary current to 48 amps.

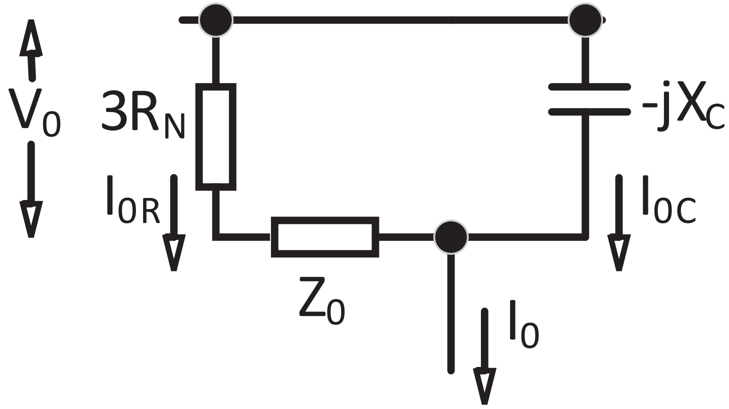

Figure 3: *Zero-Sequence Network*

CONCLUSION

This example illustrates that using the minimum required value of resistance can have a negative impact on the overall performance of 64S protection. Some European manufacturers are aware of this condition and state how to properly size R_N in their literature. NW

Steve Turner is a Consultant at Sargent & Lundy. He was previously in charge of system protection for the Fossil Generation Department at Arizona Public Service Company for five years. Turner formerly held positions at Beckwith Electric Company, GEC Alstom, SEL, and Duke Energy, where he developed the first patent for double-ended fault location on overhead high-voltage transmission lines and was in charge of maintenance standards in the transmission department for protective relaying. He has BSEE and MSEE degrees from Virginia Tech University. Turner is an IEEE Senior Member and a member of the IEEE PSRC and has presented at numerous conferences.


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WALKING AND WORKING SURFACES

BY PAUL CHAMBERLAIN, *Asplundh Engineering Services, LLC*

The most common injury in any industry is a slip, trip, or fall. Whether a fall occurs on the same level — or worse, from a higher level — any fall can cause significant injury, resulting in production downtime, reduced maintenance activity, loss or reduction of wages for the employee, loss of profit for the company, trips to doctors and specialists to get back to 100% capabilities, OSHA 300 log entries, and increases in insurance costs. The employer and the employee benefit from working together to prevent potential slips, trips, and falls.

CAUSES OF SLIPS, TRIPS, AND FALLS

Let's review some of the causes and how they can be mitigated or prevented.

Work Area

Keeping a clean work area goes a long way to preventing incidents. Ensure that trash receptacles are available and that employees use them on the job site. Employees should place them near where the work is being performed so they can dispose of things as they go. Stripped sheathing, scrap wire, wire nuts, and other detritus create a hazard.

Spills

Should a spill occur, stop what you are doing and clean it immediately. If necessary, place a barricade around the spill to prevent another employee from inadvertently walking in it.

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/HOWTOGOTO

Some chemicals require specialized materials for their removal; for instance, oleophilic (oil-attracting) materials should be used when petrochemical products are spilled.

If a petrochemical spill during disposal is a certain quantity, is absorbed into the ground, or runs into a storm drain or a body of water, you may need to contact the state environmental office. It is important to be familiar with your state's rules for spills before working with these chemicals. Clear walkways also ensure that employees have easy egress in case they need to evacuate in an emergency or if emergency rescue personnel need to enter the work zone.

Uneven Terrain

Walking outdoors presents a hazard. Uneven terrain, such as on a right-of-way or on rip rap used as a weed barrier, can contribute to slips and falls. Employees should use caution and wear appropriate footwear when working in these areas. Above-the-ankle boots with flat soles will help prevent sprained ankles. If an area sees freezing conditions, immediately clear snow and ice using shovels and an ice-melt product to prevent slips and falls. In some areas, choosing to supply traction footwear devices can mitigate potential slips.

Many commercial buildings have linoleum or vinyl flooring, which can become slippery when foot traffic brings in outside moisture due to rain. Use signage to indicate the floor may be slippery and use carpets to increase traction and capture surface moisture.

Raised and Uneven Surfaces

Walking surfaces that are 4 feet or more above a lower level — and even less over operating machinery or liquids — require top rails, mid rails, and toe boards that meet building code requirements. In a construction zone, those requirements are different, and the person erecting those temporary railings must know what materials to use and how to set them at the correct height. If railings are not used in construction zones that are 6 feet above a lower level, fall protection equipment must be used. All openings to the lower level should have a gate or be guarded. Floor holes must have a cover strong enough to support the weight of any vehicles, equipment, or personnel on that level and be marked HOLE or COVER. If a cover is not used, the hole must be barricaded with railings. Stairs should be uniform to prevent tripping, meet building code requirements, and be constructed with a handrail and/or railing on unprotected sides. Long runs may require landings and must meet building code requirements.

Ladders

Whether permanently affixed or temporary, ladders should always be clear of entanglements, and the rungs must remain clean and slip-free. They must be inspected daily before first use. Check ropes, rungs, and wear and tear; look for cracks, fading, worn feet, loose rivets, or general looseness. Never climb a ladder if any of these are found. Check boot soles before climbing any ladder.

Temporary ladders should be tied off at the top. If that is not possible, another individual must foot the ladder. An employee should never reach and should ensure their belt buckle moves to the outside of the ladder's rails.

Ascending and descending ladders should be done using three points of contact: Two feet and one hand, or two hands and one foot, must be in contact with the ladder at all times. Carry tools up using a tool pouch or belt, or use a rope and bucket to hoist them up after you finish your climb.

Ladders must extend 3 feet above the upper level to provide a grab for employees to climb off or onto the ladder. Employees must never climb above the marked rung on a stepladder (usually the third from the top) or stand on the back bracing. Never exceed the weight rating on any ladder. Permanent ladders that have a cage and several landings along the climb require a harness and rope-grab fall-protection system.

Scaffolding

Scaffolding works well to temporarily elevate a working surface. They are far more convenient for long-term use than a ladder. However, they must be constructed by a qualified person, and daily inspection must be documented. Scaffolding must have top rails, mid rails, and toe boards on unprotected sides. Climbing them can be as hazardous as using a ladder, so the same rules apply.

Buckets and Baskets

Working in a bucket or basket adds many potential hazards. Bucket trucks, crane baskets, and mobile aerial work platforms (AWPs), also known as manlifts, are generally used to work at a greater height than those requiring scaffolds or ladders. These machines can be wobbly and sway, causing employee imbalance, and insects such as bees and hornets sometimes nest in elevated equipment, contributing to a fall.

Other hazards may increase the potential for falling from a raised platform. Electric shock and blast factors, as well as environmental conditions such as wind, rain, ice, snow, and vehicular traffic, can interact with the base of the machine.

In most buckets and baskets, you must wear fall protection at all times. A retractable lanyard is preferred to limit the distance the employee could fall. For example, if an employee falls from 10 feet above the ground but wears a regular lanyard that extends up to 6.5 feet, they would be fine. But what if the base of the machine is partially below the basket? The distance the employee could fall might be less than 6.5 feet, but a retractable lanyard would prevent the employee from falling onto the base of the equipment. Retractable lanyards are also more out of the way than standard lanyards and cannot dangle down into the leg area, potentially causing further tripping hazards.

CONCLUSION

Injuries are not fun, and they are costly. Employees don't want to get hurt, and companies don't want their employees to get hurt. Both parties can identify and mitigate areas where a potential injury could occur. Identifying and correcting areas where slips and falls could occur will prevent a large number of injuries annually. NW

Paul Chamberlain *has been the Safety Manager for Asplundh Electrical Testing, LLC since 2009. He has been in the environmental health and safety field since 1998, working for various companies and in various industries. He received a BS from Massachusetts Maritime Academy.*

No. 150

POWER SYSTEM LIFE EXTENSION

BY MORGAN GIENI, *Magna IV Engineering*

All electrical equipment has a finite lifespan. Recognizing the signs of aging and understanding how to assess equipment health is essential. As NETA Certified Technicians, we play a critical role in helping to extend the operational life of electrical systems by implementing proactive maintenance strategies that enable our customers to maximize performance and reliability for as long as possible.

1. Which of the following is the U.S. standard for electrical equipment maintenance?
   a. NFPA 70E
   b. NFPA 70B
   c. NFPA 70
   d. NFPA 70C

2. What are the two main focuses for proper electrical maintenance?
   a. Efficiency and cost savings
   b. Ease of access and minimizing process interruptions
   c. Simplicity and automation
   d. Safety and reliability

3. Which of the following maintenance activities improves the condition of a circuit breaker?
   a. Measure contact resistance
   b. Lubricate moving parts
   c. Perform dielectric withstand
   d. Record contact timing

4. Which of the following is the most cost-effective way an asset owner can anticipate equipment issues?
   a. Visual inspections and walkthroughs
   b. Scheduled maintenance
   c. Research in equipment failure
   d. Online monitoring

5. Which of the following observations may indicate loose connections?
   a. Powdery white residue
   b. Discoloration
   c. Rust
   d. Bulging insulator

6. Which of the following is an inevitable outcome for electrical equipment?
   a. Electrical failure
   b. Maloperation
   c. Deterioration
   d. Adaptation

7. How can a company develop an appropriate electrical maintenance program (EMP)?

a. Itemize all equipment assets and designate criticality.

b. Develop a system to track and manage maintenance activities.

c. Ensure qualified personnel (internal or external) perform the work.

d. All of the above NW

See answers on page 116.

Morgan Gieni, CET, PSE, *is the Technical Support Lead — Technical Field Services (TFS) at Magna IV Engineering. He is a Certified Engineering Technologist through ASET — The Association of Science & Engineering Technology Professionals of Alberta and a Power System Electrician. Gieni has extensive knowledge and experience regarding the commissioning, repair, and maintenance of electrical power systems equipment. He has spent the past few years of his career building technical training programs, providing technical support, and mentoring field service employees. Gieni holds NETA Level IV Senior Technician Certification and is on NETA's Technical Resource Committee.*

FALL OF POTENTIAL TESTING GONE WRONG

BY JACOB RIOUX, *Hood Patterson & Dewar, Inc.*

As testers, where should we start? The standards! For grounding testing, the industry reference is IEEE Std. 81, *Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System*. As with most standards, familiarity and interpretation are key.

It can be a challenge to understand the intent, methods, and implementation of the prescribed testing. Fall of Potential (FOP) testing is a commonly specified test method to (attempt to) measure the impedance to earth of the ground grid under consideration. Unfortunately, we have found that many testing firms perform this test incorrectly, thus obtaining invalid results. As the test results are frequently used for ground grid commissioning, it is imperative to acquire valid data. We will present case studies and test reports that show common testing mistakes and recommend how to correct these testing pitfalls to create a successful outcome.

The concept of remote earth is integral to successful FOP testing. Per IEEE Std. 81, remote earth is defined as:

A theoretical concept that refers to a zero impedance placed at an infinite distance away from the ground under test. In practice, remote earth is approached when the mutual resistance between the ground under test and the test electrode becomes negligible. Remote earth is normally considered to be at zero potential.

Successful FOP testing requires many conditions that are frequently unmet or ignored in testing:

- **Isolated ground grid.** No connection to power, water, telecom, etc.
  - Must perform due diligence and testing to verify if the site is isolated. Many sites believe they are isolated, but they may be bonded through construction power or other forgotten connections.
- **Simple site geometry.** Invalid for large, complex, or interconnected ground grids due to long lead lengths that would be required.
  - Long leads act as an antenna. EMI and RFI noise may interfere with the test signal. The signal-to-noise ratio must be considered with conventional, low-power test meters.
- **Homogeneous soil.** Very rare

The FOP method is the most commonly specified ground-grid test method. It was developed in the 1930s, when the United States was less developed. Proper setup includes locating the current return probe at a minimum of five times the diagonal of the site under test. The larger the site, the longer the distance required — up to 10 times the diagonal. The potential (voltage) probe should be located every 10% of the current return distance, looking for a plateau in the measurements, which should theoretically be at 61.8% of the distance to the current return (Figure 1).

In homogeneous soil, remote earth has been determined to be approximately 62% of five times the diagonal distance of the ground system under test. This mathematical determination has led to the commonly employed 62% rule, where only one measurement is taken at the assumed 62% distance from the grid under test to remote earth. Problems arise from this assumption: Most sites are not homogeneous soil, and if the system under test is bonded to other structures

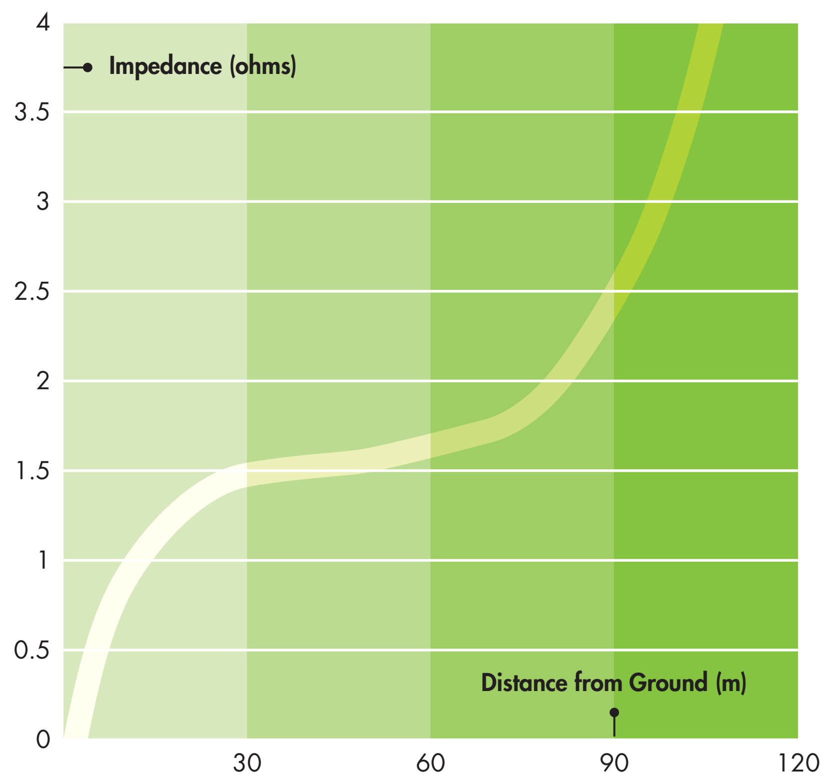

Figure 1: *The ground grid impedance value is the plateau at around 62% of the measured distance.*

or influenced by other buried objects, the resulting data can be skewed with no additional data points to confirm or refute the result.

CASE STUDIES

Testing, commissioning, and consulting firms not only test grounding but also have the opportunity to review test data from other companies. Based on our experience and the results of others, we have compiled some common mistakes and best practices for successful grounding testing using the FOP method.

Example 1 – Not Enough Data

In the real world, the expected curve with a plateau at 62% doesn't always show up (Figure 2). While this curve doesn't line up with the traditional curve shown in Figure 1, the data may still be valid. To improve the results, increase the resolution of the curve by adding additional test points. Greater resolution may show the plateau.

It is also possible that the data/curve is affected by other buried objects. Ensure you are paying attention to the test area and noting buried

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162 - Fall of Potential Test

NETA ACCREDITED COMPANY

Customer: Default Account | Job Site: Default Site | Date: | Report Number: Default Job . 162 .

Pass Test ☐ | Failed Test ☐ | See Comments ☐

Equipment Location: | Equipment Identification: | Device Identification: | Temperature: °F | Humidity: % | 0.00 Correction Factor @ 20°C

Weather Conditions: | Test Method: 3-POINT FOP

Soil Condition and Type

Gravel ☐ Clay ☑ Sand ☐ Loam ☐ Fill ☐ Chemical Enhanced ☐

Wet ☐ Damp ☑ Dry ☐

Ground System Data

Scale Multiplier: 1.00

New ☐ Existing ☐

System Voltage:

Insulation: NONE

Ground Conductors: COPPER

Conductor Size: 4/0

Rod Length (FT): 8

Conductor Bonding Type

Mechanical ☐ Cadweld ☐ Other ☐

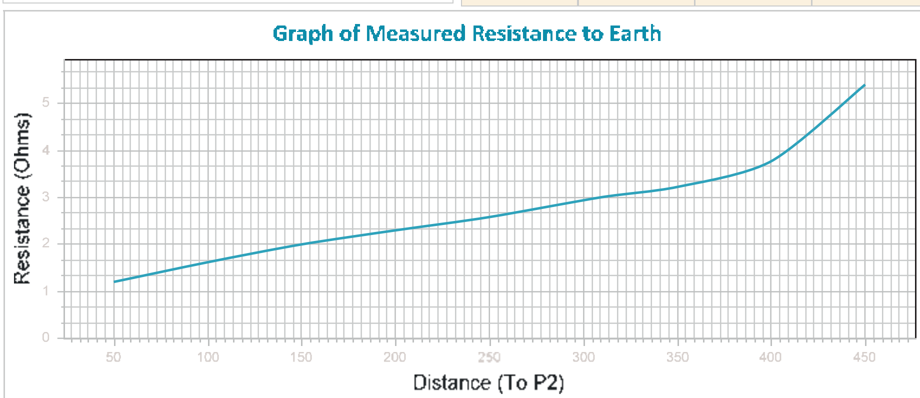
Rod Material

Steel ☐ Copper ☑ Copper Clad ☐

Description:

Test Results

Distance to C2	Distance to P2	Instrument Reading	Resistance to Earth
500	50	1.20	1.20
500	100	1.62	1.62
500	150	2.00	2.00
500	200	2.30	2.30
500	250	2.58	2.58
500	309	3.00	3.00
500	350	3.22	3.22
500	400	3.77	3.77
500	450	5.40	5.40



Resistance to Earth 3.00 Ohms

Figure 2: *The expected plateau at 62% is missing.*

pipelines, fences, etc., that could affect the results. This report is also missing information required to verify or replicate the results. The site address (or GPS coordinates), test direction, and current probe placement are not included. Since the size of the site could not be verified, it is also possible that the current return probe was not placed far enough away from the site under test — a very common testing mistake.

Example 2 – Site Not Isolated

An engineering firm was hired to perform FOP testing on the two substations with a shared ground grid (Figure 3, red squares). The larger red square is the collector yard, and the smaller one is the utility's point of interconnect (POI). The diagonal of the two substations is 500 feet, so the planned FOP current probe was placed 2,500 feet away (green line). The measured impedance was reported as 7.4 ohms while the design value was 0.89 ohms. This discrepancy in values was a red flag that something was off.

Next, a testing firm was brought in. They essentially repeated the same method, going in a different direction with their current wire (yellow line). They obtained a value of 1.48 ohms at 62%. This value was lower but still above the desired 1-ohm design value.

Next, we were hired to test this site with the specialized, computer-based smart ground multimeter (SGM) prescribed in IEEE Std. 81. After our initial test, a high error in the SGM data reported by the SGM software indicated that something was amiss. We discovered that the solar arrays were bonded to the inverters, which were then bonded to the substations through the concentric neutrals. The new diagonal of the combined sites is now 6,600 feet. For FOP testing, the current return probe should have been placed at five times 6,600 feet, which equals 33,000 feet or 6.25 miles (Figure 4).

The site had a significant amount of metallic interference, including fencing (black lines), railroad tracks (purple line), a transmission line (dashed white lines), and the arrays themselves (blue figures). Due to the size,

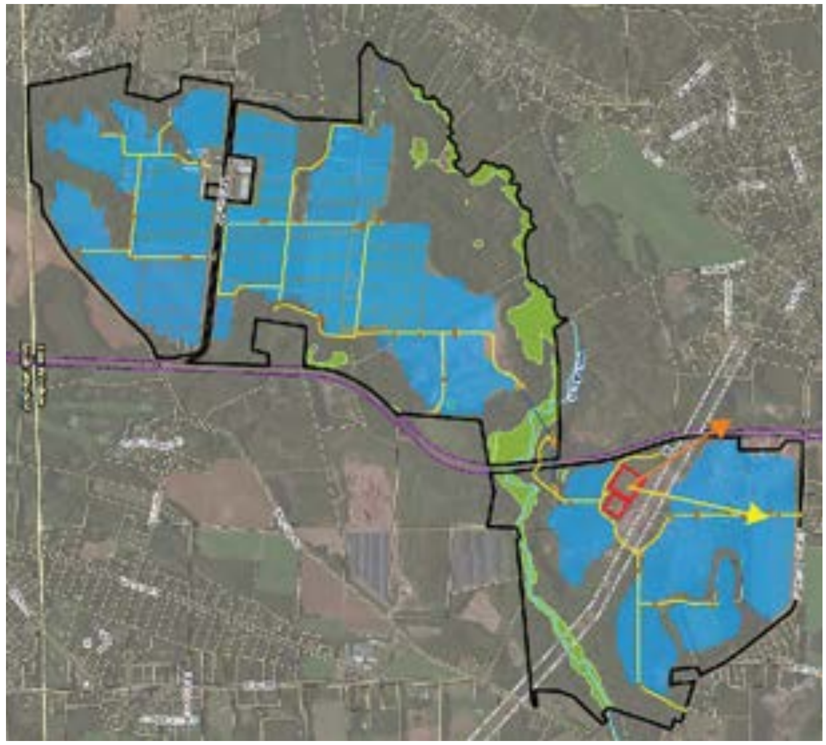


Figure 3: *Nearby sites must be investigated for potential bonding to the site under test.*

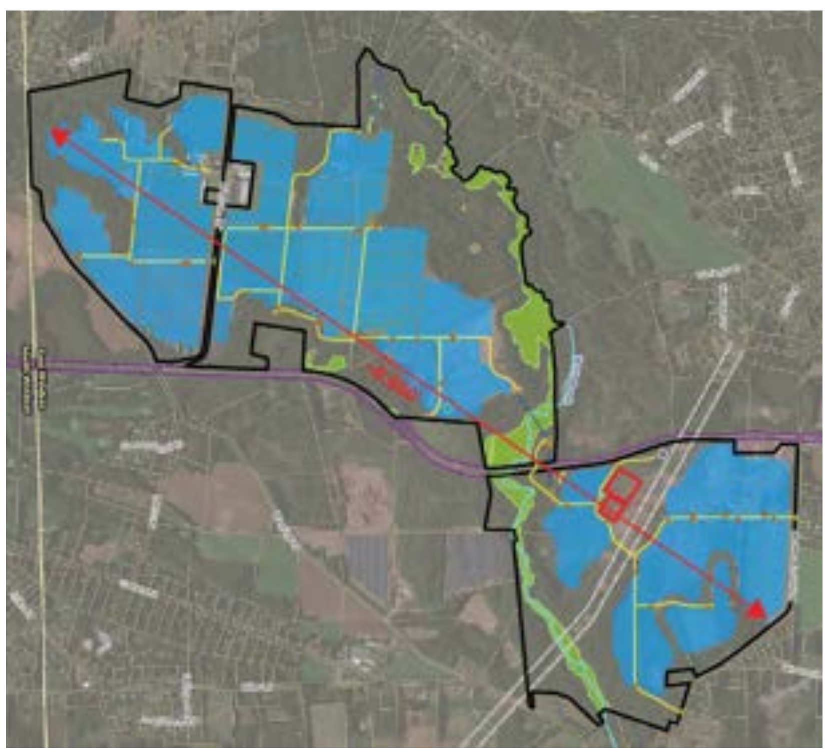


Figure 4: *The solar arrays were bonded to the substations, making the required diagonal distance for FOP to remote earth 6.25 miles.*

surrounding interferences, and the fact that the utility's substation was bonded and energized, it is impossible to test this site with the FOP method.

The SGM allows testing in these conditions if aided by a software model of the ground grid and other connected sites and grounded objects. We reduced the required remote earth distance by disconnecting the concentric neutrals from the inverters, isolating the substation grids from the solar arrays. Although we were still bonded to the utility system, the site could now be tested with the SGM. We measured 0.74 ohms versus the design value of 0.89 ohms.

PLAN FOR SUCCESS

Preplanning can go a long way towards testing success. For any large site such as a solar farm, wind farm, generation plant, urban location, campus, or other complex site, ask lots of questions!

- Get a site address and GPS coordinates and look at the site on Google Earth; drop in street view if available. Identify nearby challenges such as:
  - Possible interconnected substations/ buildings/arrays
  - Fences
  - Pipelines
  - Transmission/distribution lines
- Review the Geotech report and soil resistivity data, if available.
- Verify through testing that the site under test is isolated.
- Determine the diagonal of the site and the distance required for the current return probe; make sure you take enough current-return wire.
- Determine the test path and property access requirements.
- When on site, previously unknown challenges may require a change in the test plan.

CONCLUSION

Many project specifications will call for the FOP test. Know its limitations, be familiar with IEEE Std. 81, and follow best practices for a successful outcome. NW

REFERENCE

[1] IEEE. IEEE Std. 81–2012, *Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System*.

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MODERNIZATION – A STRATEGIC NECESSITY

BY SETH KRAVETZ, *QUALUS Corporation*

Power infrastructure failure is a common challenge across commercial, industrial, and utility sites. Failure of the underlying power system can lead to unplanned outages and equipment damage, so the benefits of prevention far outweigh the consequences of failures.

It is important to evaluate the health of a facility's power system. Following the industry-recognized maintenance practices in NFPA 70B®, *Standard for Electrical Equipment Maintenance®*, and ANSI/NETA MTS, *Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems,* can serve as an early warning system for potential upcoming failures.

This is where power equipment modernization comes into play. By actively evaluating a power system and mitigating the risks posed by aging or failing equipment, it is possible to bring a power system up to current standards, use the newest technologies in protection and control, improve personnel safety, and greatly increase the reliability and lifespan of the equipment, thereby reducing maintenance and operation costs over the life of the equipment. Since a facility's electrical system forms the backbone of critical operations, modernization is not an option; it is a necessity.

There are many approaches to modernization, and this article explores the risks associated with keeping aging or damaged equipment in service, as well as specific methods of modernization, including the benefits, use cases, and technical considerations of each method.

IDENTIFYING THE NEED FOR MODERNIZATION

The first point of discussion is the need for modernization and the risk factors that should be identified and prioritized. Equipment that has had significant exposure to a harsh environment, has been damaged, or has a negative test report indicating an item of concern should all be considered when determining whether equipment needs to be modernized.

Problem

Equipment exposed to a harsh environment, such as in a facility that processes corrosive chemicals or in high humidity areas, should be regularly evaluated for signs of corrosion and should undergo a more frequent maintenance cycle. Corrosion can have a negative impact on the structural integrity of switchgear, causing moisture buildup inside the equipment and corrosion on current-carrying components such as hardware on a busbar joint or cable connection, and leading to increased temperatures and thermal failures emdash or even arc flash. Humidity can also damage sensitive electronics, leading to device failure, which in turn can lead to mis-operation or non-operation of a circuit breaker.

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/KOSSSMOSSS

Internal damage to switchgear is a sure sign of a problem, including tracking seen on insulating components (Figure 1), burned or melted insulators, discolored conductors (Figure 2), pitting or erosion of conductors, and more. Many of these hazards hide inside switchgear and only come to light during infrequent outages, or when the equipment itself experiences dielectric failure or a thermal event.

Figure 1: *Tracking is an indication of insulation breakdown, which can lead to more significant failures.*

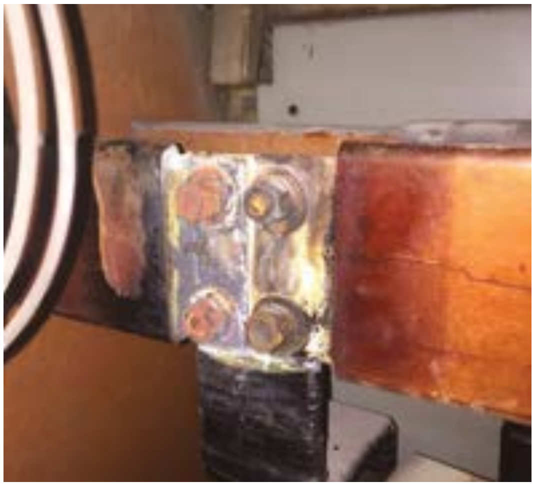

Figure 2: *Discoloration of a conductor and insulation is a sign of thermal failure. Corrosion on hardware can increase the severity of overheating.*

Regular maintenance and testing, and a thorough review of the test results, can do a good job of predicting when a piece of equipment is at risk. Common indicators include changes to breaker trip time or breaker mis-operation, poor transformer oil sample results pointing to insulation failure, or failure of a relay to produce a proper trip signal when secondary injection testing is performed. In each of these cases, it is time to evaluate options for replacing the failed equipment.

When these risks go undetected, the outcome of a failure is almost always the same: an unplanned outage and emergency recovery. Many of these failures can lead to arc flash events or cause significant property damage. Recovery from an unplanned outage can be costly and take a long time, negatively impacting production and increasing operating costs. If personnel are present during an event, there is also a significant safety risk due to the hazards of electrical shock and incident energy released during an arc flash.

Figure 3: *Results of an arc flash in a section of low voltage busway. The root cause was determined to be water ingress.*

Solutions

With the problem established, solutions can be evaluated. Full equipment replacement is almost always an option, but it can be costly and require a significant amount of time to complete. In a time of ever-extending lead times, it is not unrealistic to wait more than a year for new switchgear.

This is where modernization can truly shine. The core of modernization is this: Leave what is good and upgrade the rest. Looking at another definition, taken from IEEE Std. C37.59–2018, *IEEE Standard for Requirements for Conversion of Power Switchgear Equipment*, conversion is defined in Chapter 3 as:

the process of altering existing power switchgear equipment from any qualified design.

Modernizing power equipment follows the process laid out in this standard: Keep existing qualified equipment and alter it using modern technology. This can mean leaving the wiring in place when replacing a protective relay or leaving the bus and sheet metal in place and replacing an obsolete circuit breaker.

When considering these options, it should be noted that standards have been established for this type of work. Vendors who perform this work must understand the standards for the equipment they are modifying, as installations that do not meet the minimum design requirements or have not undergone the required rigorous testing can put an entire facility at risk. IEEE C37.59 is one such standard, along with the type-specific standards established by IEEE and other standards organizations.

MODERNIZATION CASES

Two common use cases of modernization are presented here: protective relay upgrades and circuit breaker retrofills. These are by no means the only methods to consider, but they are good solutions to common problems found in aging equipment.

Protective Relay Upgrades

Protective relays have come a long way since their initial development over 100 years ago. The relays that were installed in much of the industrial world through the 1950s and 1960s were electromechanical relays — single-function devices such as a single phase 50/51 overcurrent protection relay, although many other purpose-driven devices existed as well.

Electromechanical relays continued to be used even after digital protection relays were developed in the 1970s, and many of those relays can be found protecting equipment today.

Electromechanical relays have stood the test of time, but they present many challenges in the modern world. For example, these devices can be sensitive to physical movement, sending inadvertent trip signals sometimes triggered just by opening or closing a compartment door.

They also have limited functionality. For example, if a three-phase system required both overcurrent protection and undervoltage protection on each phase, then six separate relays were required. The space required for these devices often led to additional control cabinets installed across switchgear aisles or on top of a section of switchgear, consuming floor space that could be used for other equipment (Figure 4).

Using multiple devices also leads to additional points of failure and additional components to test and evaluate, extending the duration of maintenance outages. Aside from the physical constraints, there are also capability constraints. While technology has improved to include more complex monitoring, control, and communications systems, electromechanical relays have remained the same, and they cannot be integrated into these systems.

One solution is to modernize electromechanical relays to microprocessor-based relays. Microprocessor relays provide expanded protection and metering capabilities, and integration into existing SCADA and building automation systems. The modernization process is straightforward. First, a minimal outage is required to verify existing wiring and all connections to the existing devices. Once design and in-shop assembly and testing are completed, a new relay door can be installed during another short-duration outage (Figure 5). Some manufacturers offer kits that act as a direct replacement for obsolete relays, further reducing the required downtime for replacement.

Figure 4: *MV Switchgear before Relay Upgrade*

Figure 5: *MV Switchgear after Relay Upgrade*

The benefits of upgrading to modern protective relays are extensive. The key benefit is the extended service life that comes with updating the equipment. Once a relay has been upgraded, it should not need replacement again for more than 20 years if properly maintained. Modern relays also have added functionality that allows for improved device coordination and reduction of arc-flash risk through the addition of light detection, working in conjunction with current sensing and logic. They also provide multiple protection elements, which can reduce the overall number of relays that require maintenance.

Beyond these benefits, the ability to implement logic calculations and communications allows more complex protection and automation schemes to be implemented and integrated into building automation and SCADA systems.

Circuit Breaker Retrofills

Another modernization method is to perform circuit breaker retrofills in low- and medium-voltage switchgear. But first, there is some history to discuss.

The use of electricity introduces risks of damage to equipment and harm to those operating electrically powered equipment. With the need for protection from these risks, Thomas Edison developed early devices using fuses as the protective element, and fuses are still used for the same purpose. While there is a place for using fuses, there are also drawbacks, such as the need to replace them each time they operate.

The need for improved operation drove innovation that led to the development of what we now know as the modern circuit breaker. Early devices used the thermal-magnetic properties of bi-metals to force the circuit breaker contacts open, using air as an insulator to extinguish the arc between the contacts. As voltage and current requirements increased, these breakers had to be larger to handle the added load and interrupt current, and air alone was eventually not a sufficient insulator to extinguish the arc. This led to the introduction of insulation mediums to extinguish the arc, including oil, SF6 gas, and eventually a vacuum-encapsulated contact, which is now widely used in medium-voltage power distribution.

Technology also improved for low-voltage circuit breakers, moving far beyond the capabilities of the thermal-magnetic breaker, which had limited capability for adjustments. Oil dashpots were one early invention that allowed a delay to be introduced. Later innovations in electronics eventually led to electronic trip units that, like a protective relay, support a broad range of adjustments, improving breaker coordination and safety and reducing the risk of arc-flash.

With the rapid rise in the need for electricity and rapid improvement in technology, a significant number of circuit breakers have been installed using obsolete technology. Even with proper maintenance, devices installed in the 1960s are well beyond their expected lifecycle, putting an electrical system at risk. Continued use will lead to worn or fused contacts, tracking in insulation, oil and gas leaks, and more.

A common challenge is how to handle the replacement of these devices as a preventive measure or in response to failure. While full switchgear replacement is a consideration, the costs of this type of replacement can be extensive. It can also be challenging to move equipment into and out of a building that has been built around an electrical room, and the required downtime for a full replacement may not be reasonable. In these situations, a circuit breaker retrofill is a good option.

While the circuit breaker may experience failure or not meet modern requirements, the switchgear that contains it may not have the same issues. The copper, aluminum, and steel used in switchgear construction have not seen the same changes as the functional components of circuit breakers and can often be left in place and reused when the older circuit breaker is removed.

The process for a retrofill, like a relay replacement, begins with data collection. A site visit is performed to thoroughly inspect the switchgear and collect the required data for the design and installation of a new breaker during a planned outage. These details include nameplate data of the switchgear and breaker, detailed dimensional information for the construction, and a thorough evaluation of switchgear components. Those details are fed into the design, where the appropriate circuit breaker is specified, and components are designed to integrate the new breaker (Figure 6).

New components typically involve copper busbar conductors and sheet metal or insulating material structural members and barriers. The new components are specifically designed to meet the established standards for current-carrying capacity and short-circuit withstand capability. In some cases, these designs can be completed without type testing, but the best practice (and required practice for most IEEE standards) is to qualify a standard design by performing short-circuit and heat-rise testing. Using a qualified design ensures that the new installation can withstand the extreme forces and high currents of a short-circuit event and safely operate under normal circumstances without overheating. Once the design is complete and materials are fabricated, the installation can be scheduled. A retrofill of a single low-voltage circuit breaker can generally be completed in less than two days, compared to much longer installation time for a new section of switchgear. With the retrofill completed, a new circuit breaker with modern technology and little or no expanded footprint has been installed without tearing out a full section of switchgear.

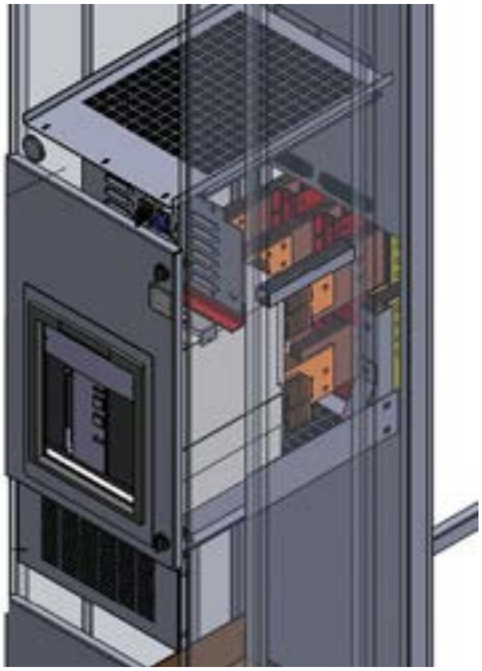

Figure 6: *3D CAD Model of an LV Circuit Breaker Retrofill*

FINAL CONSIDERATIONS

Modern technology has resulted in significant improvements in power distribution. Beyond relays and circuit breakers, other new devices, such as arc quenching devices and light-based arc flash monitors, reduce the risks associated with arc flash, and thermal sensors can actively monitor potential hot spots.

Constant innovations in this field regularly lead to new technologies to improve safety and reliability. While improving one area, additional solutions can be installed, creating an even more robust electrical system. The reasons to consider modernization can include cost, the need to improve capacity, safety, or more. In the end, modernization results in a more robust and reliable electrical system, renewing the life of the equipment it contains and reducing the risk of injury to personnel operating it.

Modernization is more than responding to aging infrastructure. It is a proactive investment in reliability, safety, and efficiency. Facilities that prioritize modernization position themselves to meet today's demands and tomorrow's challenges with confidence. NW

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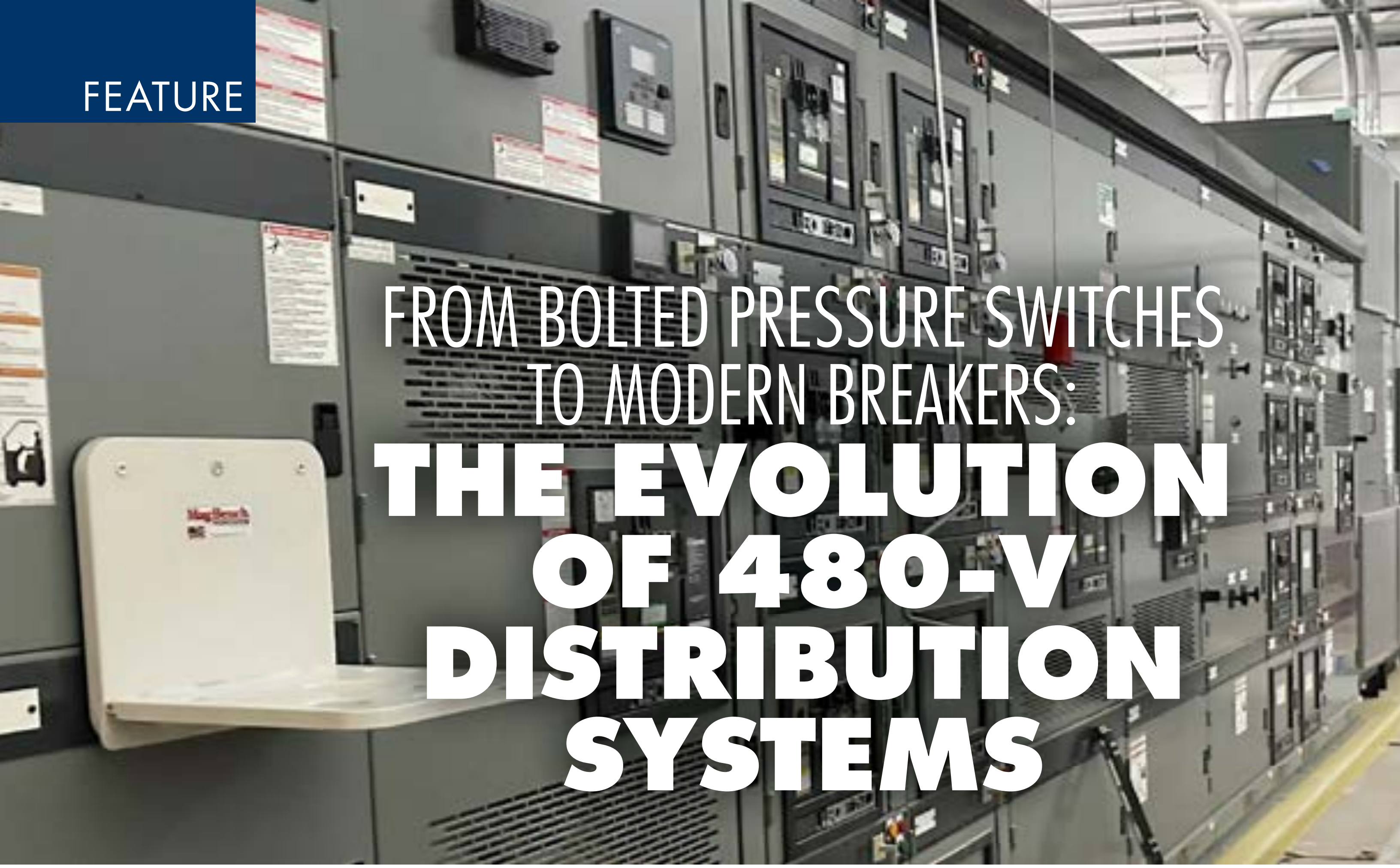

FROM BOLTED PRESSURE SWITCHES TO MODERN BREAKERS: THE EVOLUTION OF 480-V DISTRIBUTION SYSTEMS

BY MATTHEW WALLACE, *CBS Field Services,* and
DAVID MUIR, *Advanced Electrical & Motor Controls*

The bolted pressure switch (BPS) once occupied a central role in 480-V distribution systems across industrial, commercial, and institutional facilities. Known for its rugged construction and ability to withstand high fault currents, the BPS was a workhorse of mid-20th-century, low-voltage power distribution. By using spring-driven mechanical force to bolt contacts together, the BPS ensured a low-impedance path for current flow, even under heavy load conditions.

However, the BPS was designed primarily as an isolating device rather than a true switching or protective device. While it could reliably carry current, it could not safely interrupt load or fault current. As a result, operators were expected to de-energize systems prior to operation — a practice that relied heavily on human factors and was not always followed.

In the modern context of arc flash awareness, OSHA regulations, and NFPA 70E compliance, the limitations of the BPS are clear. High incident energy levels, lack of protective integration, and mechanical aging of these devices present risks to personnel and equipment. In contrast, today's breaker technologies — molded-case circuit breakers (MCCBs) and insulated-case circuit breakers (ICCBs) — provide integrated protection, fault-interrupting capability, and arc flash mitigation features that were not possible in the BPS era.

HISTORY OF THE BOLTED PRESSURE SWITCH IN 480-V SYSTEMS

The bolted pressure switch emerged in the 1950s and 1960s as an answer to the limitations of earlier knife switches and fused disconnects. At the time, the electrical industry was expanding rapidly as hospitals, universities, factories, and data centers required robust distribution systems operating at 480 Volts.

The BPS quickly gained adoption because it could:

- Withstand short-circuit currents until upstream fuses cleared
- Provide visible isolation, useful for maintenance and lockout/tagout (LOTO)
- Operate without oil or gas interrupters, simplifying maintenance

Common installations included:

- Service disconnects between utility transformers and main switchboards

Figure 1: *3,000-A Fused Eaton Pringle Switch*

- Feeder switches supplying large motor control centers
- Institutional and industrial distribution panels

Despite its prevalence, the BPS was never designed for load-break duty. Unlike breakers, it did not extinguish arcs in a controlled manner, leaving operators exposed if switching was attempted on energized systems.

TECHNICAL DRAWBACKS OF THE BOLTED PRESSURE SWITCH

No Load-Break Capability

The BPS relies on a bolted mechanical connection. Opening the device under load produces uncontrolled arcs that can persist until interrupted by upstream protection. Modeling based on IEEE Std. 1584, *IEEE Guide for Performing Arc-Flash Hazard Calculations,* shows that even a modest 480-V arc can release energy over 20 cal/cm² within a few cycles. Without arc chutes, vacuum bottles, or magnetic blowout features, the BPS is inherently unsafe for load switching.

Mechanical Wear and Degradation

- Springs lose elasticity, reducing contact force
- Lubricants dry out, increasing mechanical friction
- Contact erosion increases resistance, generating heat at the interface

Elevated contact resistance can lead to localized heating, insulation breakdown, and eventual phase-to-phase or phase-to-ground faults. Many BPS failures manifest as catastrophic bus faults during operation.

Limited Protective Functionality

The BPS provides isolation only — no overcurrent or short-circuit protection — and ground fault capabilities are through external GFR relays to a shunt trip device. Coordination must rely on external fuses or upstream breakers. This introduces three issues:

- Lack of adjustability compared to solid-state circuit breaker trip units
- Poor selectivity in complex feeder systems
- Slower clearing times at moderate fault currents

Arc-Flash Hazards

The BPS era predated the formal recognition of arc flash hazards. NFPA 70E, *Standard for Electrical Safety in the Workplace* (first issued in 1979) and IEEE 1584 (2002) formalized methods to calculate and mitigate arc energy. Many legacy 480-V BPS lineups test at incident energy levels above 30–50 cal/cm², requiring PPE Category 4 and higher, which are impractical for maintenance.

The incident energy equation per IEEE 1584:

$$E = k \cdot \frac{I_{arc}^{1.473} \cdot t}{D^{1.473}}$$

Where:

- E = incident energy (cal/cm²)
- I_{arc} = arcing current (kA)
- t = clearing time (s)
- D = working distance (mm)
- k = empirically derived constant

Since clearing time (t) is directly proportional, the slow clearing times associated with fuse/BPS systems result in disproportionately high incident energy values.

Aging Infrastructure and Parts Obsolescence

Most BPS devices in service today are more than 15 to 40 years old. Some manufacturers no longer provide replacement parts, and insulation systems have often exceeded their rated lifespans. Due to the aging equipment and the immense amount of spring pressure and force experienced during an operation, the typical BPS mechanism and internal parts suffer a higher failure rate. Continued operation represents safety, reliability, and liability issues.

TRANSITION TO MODERN BREAKER TECHNOLOGIES

By the late 20th century, MCCBs (UL 489) and ICCBs (UL 1066) replaced BPS systems in most new construction. Breakers integrate switching and protective functionality into a single device, eliminating the need for separate fuses.

Key technical advantages include:

- **Load and fault interruption.** Arc chutes and magnetic blowout paths extinguish arcs in less than 3 cycles.
- **Trip unit integration.** Long-time (L), short-time (S), instantaneous (I), and ground-fault (G) elements can be tailored to system coordination.
- **Electronic trip units.** Adjustable curves allow coordination studies per ANSI C37.13/16, *Low-Voltage AC Power Circuit Breakers Used in Enclosures*, which was superseded by IEEE Std. C37.13 IEEE, *Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.*
- **Reduced maintenance.** Self-contained operating mechanisms with limited moving parts.
- **Arc-flash mitigation.** Zone-selective interlocking (ZSI), arc flash maintenance switches, and arc-resistant enclosures significantly reduce incident energy.

These features make breakers far more suitable for compliance with NFPA 70E and OSHA 1910 Subpart S Electrical.

Figure 2: *3,000-A Square D MTZ Replacement Circuit Breaker Retrofit*

INCIDENT ENERGY AND ARC FLASH CONSIDERATIONS

One of the most important reasons to replace legacy BPS systems is the opportunity to reduce incident energy levels.

- **Legacy BPS systems.** Clearing times governed by upstream fuses result in high arc flash energies (20–50 cal/cm²).
- **Modern breaker systems.** Faster clearing times reduce incident energy to <8 cal/cm².
- **Maintenance mode.** Temporarily decreasing instantaneous pickup further reduces incident energy to <4 cal/cm², often within PPE Category 1.

REAL-WORLD EXAMPLE: FUSE/BPS TO BREAKER UPGRADE

A 480-V distribution system fed by a 2,500-kVA transformer (5% impedance, infinite bus primary) originally used a fused BPS.

Table 1: *Fuse/BPS to Breaker Upgrade*

Protection Scheme	Incident Energy (cal/cm²)	PPE Category
Fused BPS (legacy design)	23.7	Cat. 3–4 (high hazard)
Breaker (LS only)	8.16	Cat. 2
Breaker w/ Maintenance Mode	2.91	Cat. 1–2

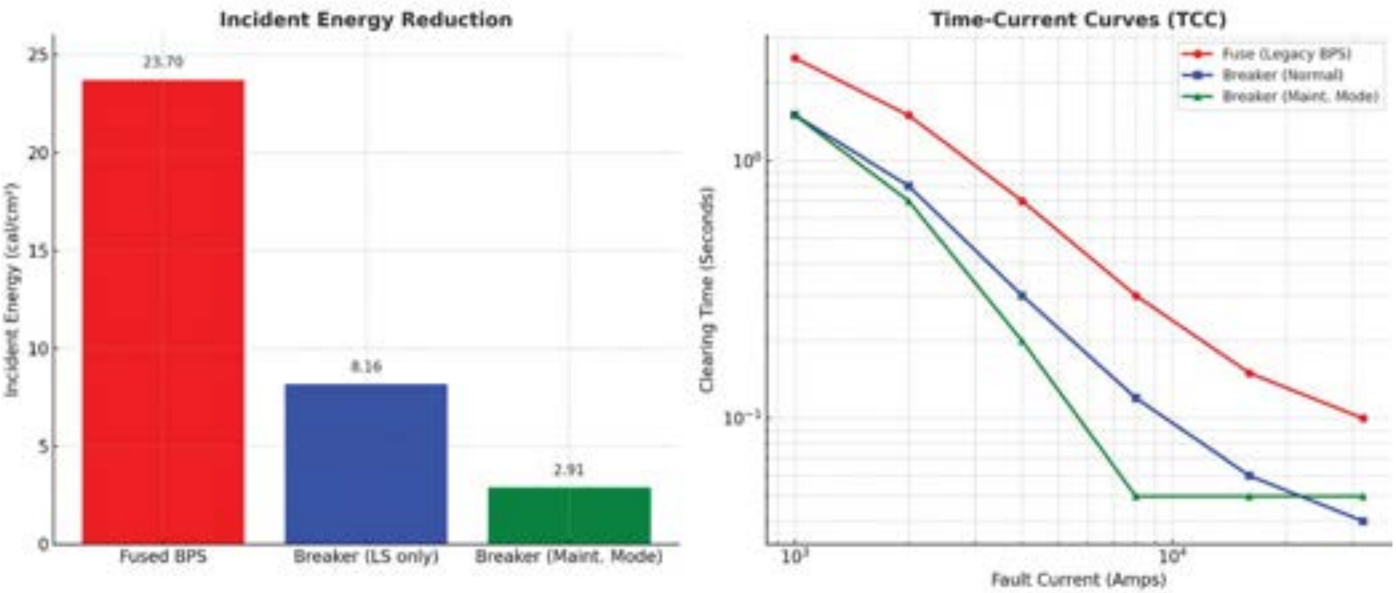

Figure 3: *Side-by-Side Incident Energy Comparison: (Left) A bar chart highlights the incident energy reduction achieved when upgrading from a fused BPS to a modern breaker (normal and maintenance modes). (Right) A simplified TCC comparison shows how breakers clear faults much faster than legacy fuses, further reducing arc flash energy.*

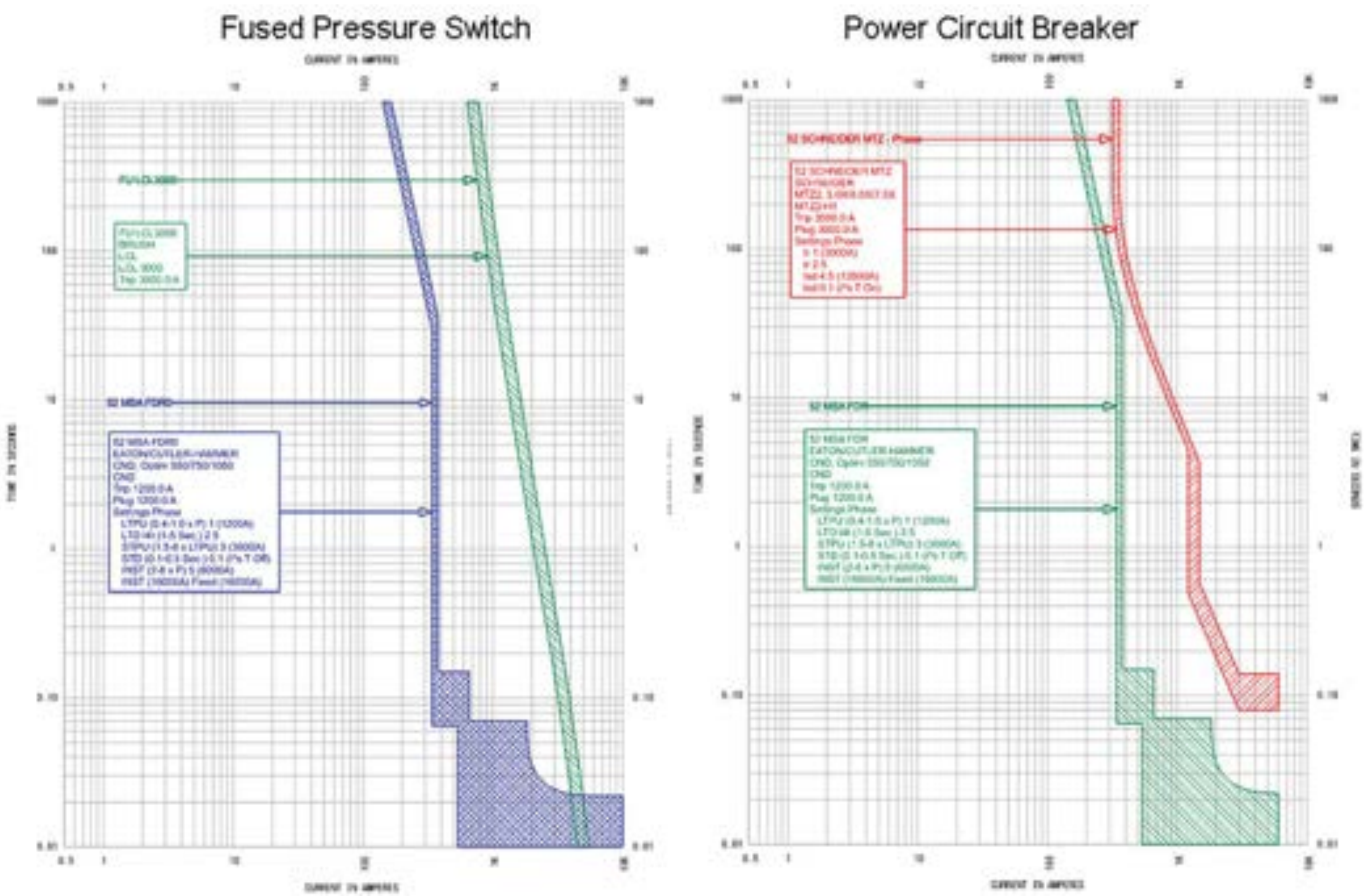

Figure 4: *TCC of a BPS vs. a Power Circuit Breaker*

The time-current curves (TCCs) reinforce this result (Figure 3):

- **Fuse curve**: slow clearing at moderate faults (hundreds of ms)
- **Breaker (normal mode)**: faster clearing with short-time trip
- **Breaker (maintenance mode)**: instantaneous clearing (<50 ms), dramatically reducing arc flash energy

The differences between the fused bolted pressure switch (left) and the power circuit breaker (right) are clear (Figure 4).

The fused BPS relies on fuse characteristics, resulting in longer clearing times at moderate fault levels — in the range of tenths to several seconds — before the fuse melts and clears. This extended duration allows more fault energy to be released, which translates directly into higher incident energy levels and greater stress on downstream equipment.

In contrast, the power circuit breaker incorporates electronic trip units that can act in the instantaneous region, clearing faults in tens of milliseconds at similar current levels. This faster clearing dramatically reduces arc flash exposure to personnel and limits damage to the distribution system, often making the difference between minor repairs and major equipment replacement.

The implication is also clear: While the BPS can carry and withstand fault current, only the breaker provides the controlled, rapid interruption needed to align with modern safety standards and minimize both personnel risk and equipment downtime.

Impact

- Personnel safety improves dramatically, moving from Category 4 PPE to Category 1–2.
- Equipment stress is reduced, leading to minor repairs rather than catastrophic failures.
- Operational uptime is preserved, avoiding costly downtime from equipment replacement.

LEGACY SYSTEMS AND MODERNIZATION OPTIONS

Facilities with BPS equipment typically face three options:

1. **Maintain**. Continue operating with inspections, lubrication, and training. Risks remain high.
2. **Retrofit**. Replace BPS switchboard cells with breaker retrofits. Preserves structure, lowers cost, and reduces incident energy.
3. **Replace**. Completely replace with breaker-based switchgear. Highest upfront cost but ensures compliance, safety, and long-term reliability.

An added benefit of modern circuit breakers is that programming for remote operation is possible, further enhancing employee safety by ensuring that personnel are not positioned directly in front of the gear when opening or closing the breaker. While bolted pressure switches can also be adapted for remote operation through third-party devices such as ArcSafe's RSA-135 remote operator (Figure 5), these solutions may not immediately be available for urgent switching requirements and often come at an additional cost.

Modernization programs are often justified by reduced PPE requirements, lowered insurance liability, and prevention of downtime losses from major equipment failures.

CONCLUSION

The bolted pressure switch represented an important stage in the evolution of low-voltage distribution systems, bridging the gap between crude mechanical disconnects and the sophisticated protective devices used today. For decades, the BPS served facilities reliably by providing a means of isolating circuits and withstanding the thermal and mechanical stresses of high short-circuit currents. In its era, the BPS was considered a rugged, dependable, and relatively low-maintenance solution.

However, its design limitations are unmistakable when viewed against modern requirements. The BPS lacks the ability to interrupt load safely,

Figure 5: *Bolted Pressure Switch Operator RSA-135 by ArcSafe*

instead relying on external fuses or upstream devices for fault clearing. This dependence not only limits coordination but also prolongs clearing times, directly leading to higher incident energy levels. Furthermore, decades of service have left many BPS installations suffering from mechanical wear, degraded insulation, and obsolescence, with spare parts increasingly unavailable. Combined with the fact that these devices were never engineered with arc flash mitigation in mind, continued operation of BPS lineups exposes personnel to hazards well above acceptable thresholds under NFPA 70E and IEEE 1584 guidance.

By comparison, modern molded-case (MCCB) and insulated-case (ICCB) circuit breakers embody the integration of switching, protection, and safety functions in a single device. These breakers provide precise trip unit coordination per ANSI C37, instantaneous clearing capabilities that drastically reduce arc flash exposure, and compatibility with advanced safety features such as zone-selective interlocking (ZSI) and maintenance mode arc flash reduction switches. Breakers also support remote operation and racking, keeping personnel outside the arc flash boundary and aligning with OSHA's emphasis on minimizing exposure through engineering controls.

The benefits extend far beyond personnel safety. Faster fault-clearing significantly reduces the energy let-through to the system, limiting damage to bus structures, cables, and connected loads. Where a fault cleared by a fuse/BPS might result in severe damage requiring weeks of repairs and production downtime, the same fault cleared by a breaker can often be followed by moderate repairs and rapid return to service. In this sense, breaker modernization is as much about operational continuity and asset preservation as it is about compliance and worker protection.

Ultimately, the transition from bolted pressure switch technology to modern breakers is not a matter of convenience or incremental upgrade. It is a safety-critical modernization strategy that directly impacts personnel well-being, equipment reliability, and facility productivity. For organizations still operating legacy BPS lineups, proactive retrofitting or replacement is no longer optional but essential. Such upgrades reduce risk exposure, ensure compliance with NFPA, IEEE, ANSI, and OSHA standards, and future-proof facilities against the increasingly stringent demands of electrical safety. By investing in breaker-based systems, facility owners protect not only their workforce but also the operational resilience of their entire electrical infrastructure. NW

REFERENCES

[1] IEEE Std. 1584, *IEEE Guide for Performing Arc-Flash Hazard Calculations.*

[2] NFPA 70E, *Standard for Electrical Safety in the Workplace*

[3] ANSI C37.13/16 ANSI C37.13/16, *Low-Voltage AC Power Circuit Breakers Used in Enclosures,* (superseded by IEEE Std. C37.13 IEEE, *Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.*

[4] OSHA 1910 Subpart S Electrical

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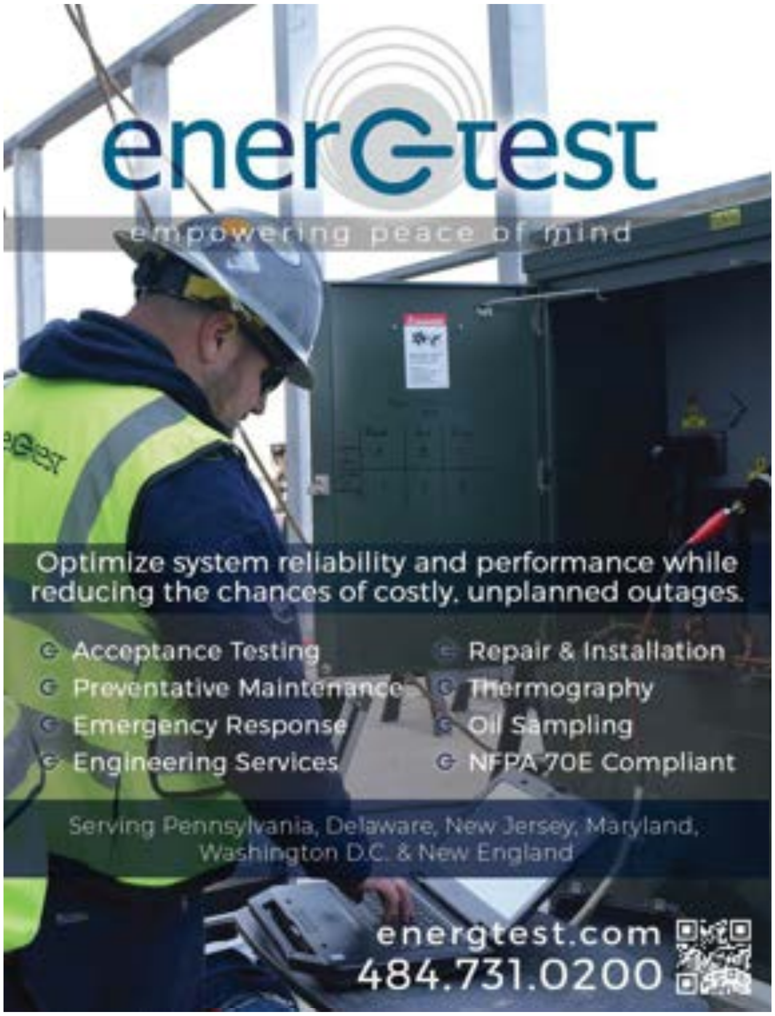


CONDITION-BASED MAINTENANCE USING REMOTE INFRARED CAMERA SYSTEMS

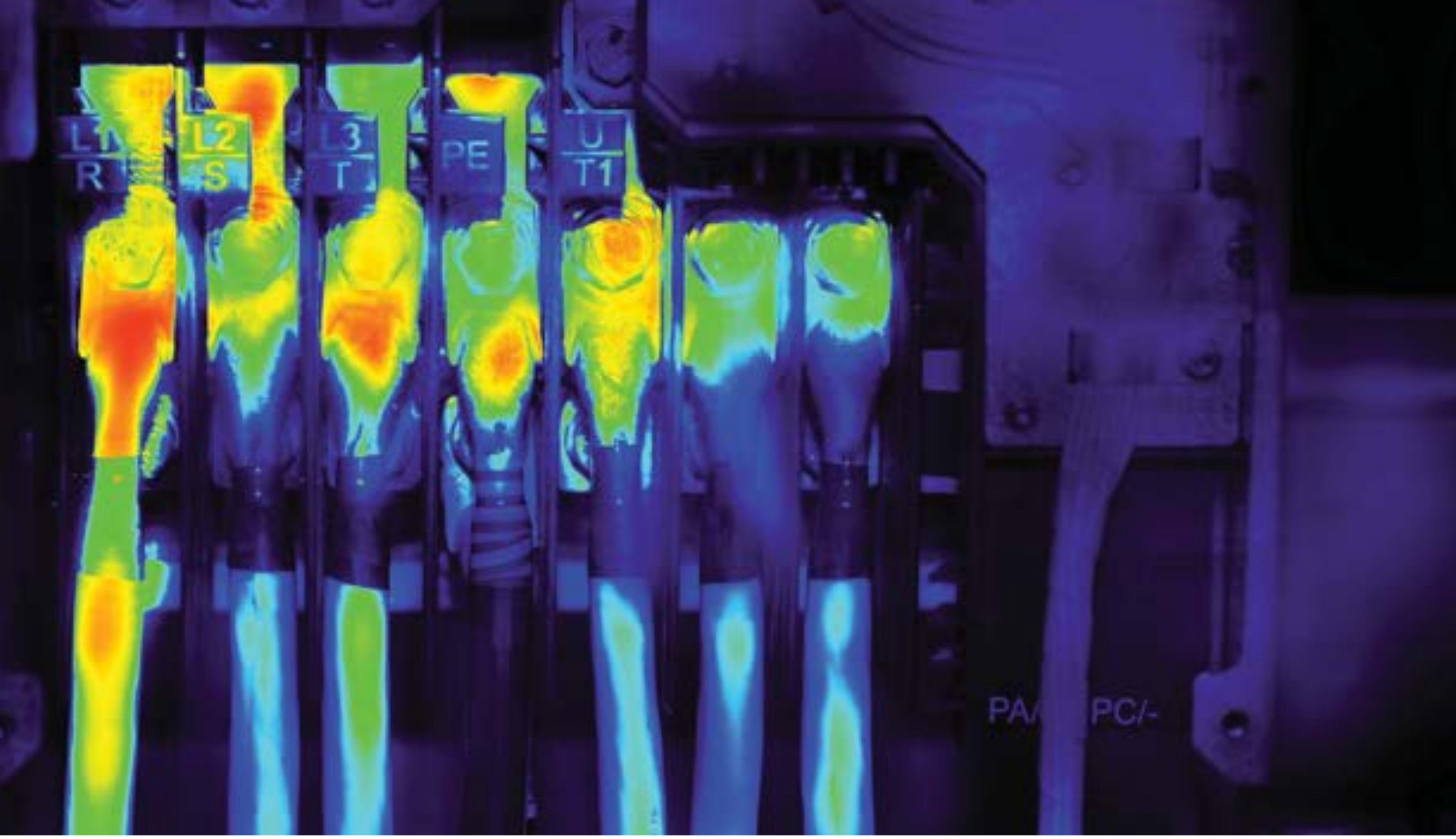
BY JOHN ANDERSON, *SYTIS*

Infrared thermography has long been a cornerstone of electrical panel maintenance, traditionally performed through periodic, time-based inspections using handheld infrared cameras. This method has been widely adopted as a best practice due to its ability to detect early signs of failure, mitigate catastrophic risks, and support the longevity of electrical infrastructure.

However, recent regulatory changes have elevated the role of infrared inspections from recommended practice to mandatory standard. Specifically, the 2023 edition of NFPA 70B®, *Standard for Electrical Equipment Maintenance®* now requires infrared thermography as an integral component of all electrical maintenance programs.

Under NFPA 70B Section 9.3.1.3, electrical equipment is categorized into three conditions based on its operational status and maintenance history. Condition 3 represents a significant deviation from normal operating parameters and is assigned when equipment has missed two consecutive maintenance cycles, undergone major repairs or replacements, or triggered alerts through continuous monitoring or predictive diagnostics such as infrared thermography. This classification underscores the urgency of intervention and the necessity of robust monitoring systems and now requires infrared inspections to be performed every six months.

The shift toward more frequent inspections reflects a growing consensus on the critical role of infrared diagnostics in maintaining electrical safety and reliability. These inspections not only extend the lifespan of aging infrastructure but also reduce the risk of injury to maintenance personnel by identifying hazardous conditions before they escalate.



INSPECTION REQUIREMENTS

NFPA 70B further refines inspection frequency by linking it to the physical condition of the equipment. Equipment is classified as:

- Condition 1 (like-new)
- Condition 2 (minor deviations)
- Condition 3 (urgent action required)

This condition-based approach replaces the traditional one-size-fits-all model, allowing for tailored inspection schedules that reflect the specific risks associated with each asset.

However, the new standard introduces a significant increase in inspection frequency. For example, while some manufacturers of new switchgear recommend thermal inspections every 60 months, NFPA 70B now mandates a maximum interval of 12 months for all electrical equipment — regardless of age or manufacturer guidelines.

This increase in inspection requirements presents logistical and financial challenges. Maintenance teams, already stretched thin due to staffing shortages and demanding schedules, may struggle to meet these new standards. Missed inspections are not only common but also now carry regulatory consequences. Under OSHA's General Duty Clause, failure to comply with NFPA 70B can result in citations and fines, further emphasizing the need for reliable and scalable inspection solutions.

INFRARED CAMERA TECHNOLOGY

Recent advancements in fixed infrared camera technology offer a compelling solution to these challenges. These systems enable continuous, condition-based monitoring, eliminating gaps in coverage and reducing reliance on manual inspections. The latest generation of compact, remote infrared cameras represents a transformative shift in how electrical panels are monitored and maintained.

These bi-spectral cameras — capable of capturing optical and infrared images — deliver high-resolution visuals with exceptional sensitivity. This allows precise identification of thermal anomalies, such as overheating components, that may indicate impending failure. For example,

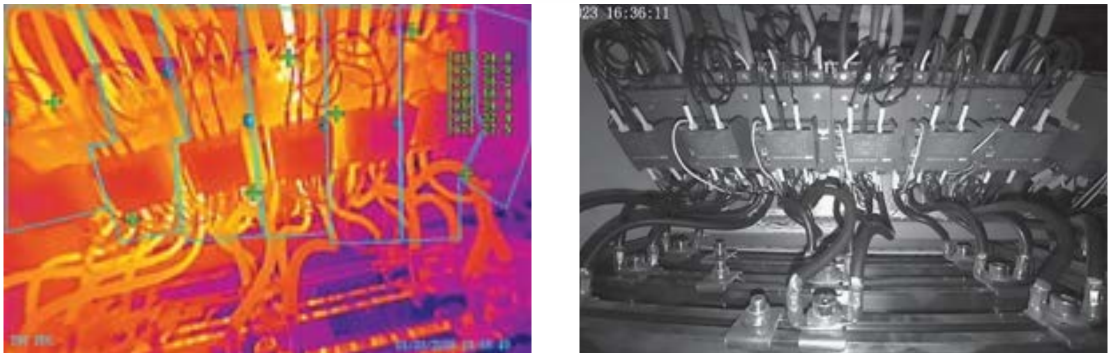


Figure 1: *Side-by-side infrared and optical images from a single bi-spectral camera inside a wind turbine electrical panel reveal an overheated wire.*

a single bi-spectral camera installed inside a wind turbine panel can simultaneously capture infrared and optical images, revealing critical issues like an overheated wire with remarkable clarity. This system is especially critical in wind turbine work, as technicians are not permitted inside the nacelle while it is energized. This means any use of handheld cameras would be totally worthless.

Accompanying software platforms enhance functionality by enabling customizable alert systems. Users can define regions of interest using polygonal overlays and set differential temperature alarms (delta-T), as well as independent high/low temperature thresholds.

Figure 2: *A compact camera is attached magnetically to a panel door, with Ethernet providing communication and power.*

Alerts can be configured to trigger email notifications or audible alarms, ensuring that anomalies are promptly addressed.

Installation

Installation of these systems is safe and efficient. Cameras can be mounted on de-energized panel doors, eliminating live electrical exposure during setup. Many models support Power over Ethernet (PoE), allowing for rapid deployment by trained personnel.

Operation

Once installed, these cameras can operate for up to two years without maintenance, requiring only a brief recalibration that can be scheduled to occur during the annual routine cleaning of the panel. With a typical drift rate of less than $1/1000^{th}$°F per year and delta-T the primary alerts of concern, the accuracy of alarms remains reliable over time.

Some units feature magnetic mounts, allowing for flexible placement on cabinet doors without compromising the structural integrity of the enclosure. Their wide-angle lenses provide comprehensive views of internal components, including wires, connectors, and fasteners, facilitating holistic monitoring without the need to open the cabinet.

This approach not only enhances safety by eliminating the need for personnel to access live panels but also removes the requirement for viewing windows, often installed to accommodate handheld inspections. By replacing manual inspections with automated, real-time monitoring, organizations can achieve compliance with NFPA 70B while improving operational efficiency and reducing risk.

DATA MANAGEMENT AND RECORD KEEPING

Beyond automating inspections, modern infrared camera systems offer robust data management and reporting capabilities. Many of these systems integrate seamlessly with enterprise-level platforms, enabling real-time visualization of system health through live feeds, charts, and historical trend analysis. Some systems offer reporting capabilities that can be generated using threat levels aligned with the Electric Power Research Institute (EPRI) hierarchy, providing actionable insights based on the severity of thermal anomalies. These features empower maintenance teams to make informed decisions and prioritize interventions based on risk, not routine. NFPA 70E requires reporting so automating these systems can help provide solutions to increased regulatory requirements.

The ability to integrate thermal monitoring systems into existing enterprise data management platforms (EDMPs) enhances operational transparency. These integrations allow stakeholders to view system health in real time, track performance metrics, and receive alerts through centralized dashboards. This level of visibility fosters confidence in the reliability of electrical systems and supports proactive maintenance strategies.

CONTINUOUS CONDITION-BASED MAINTENANCE

In aging electrical infrastructure, even brief lapses in monitoring can lead to rapid escalation of faults. Unexpected shutdowns are costly and disruptive, and often avoidable with early detection. Fixed, non-contact infrared camera systems eliminate these gaps by providing continuous, condition-based monitoring, ensuring that no inspection is missed and no anomaly goes unnoticed.

CONTACTLESS INSPECTIONS

The concept of safety by design has gained traction across industries, emphasizing the importance of engineering solutions that inherently reduce risk. In the context of electrical maintenance, remote infrared monitoring exemplifies this principle. A 2013 report published in the May 31, 2013, edition of *Industrial Safety & Hygiene News* estimates that, on average, 30,000 arc flash incidents occur every year in the United States, or about 5–10 per day. The report went on to say that those incidents resulted in annual totals of 7,000 burn injuries, 2,000 hospitalizations, and 400 fatalities. Costs incurred from arc flash damage can reach millions of dollars in employee claims, insurance costs, equipment replacement, and lost productivity.

The risk, frequency, and severity of arc flash events make it imperative that plants employ a host of mitigation processes to pave a safer path for workers who maintain electrical distribution, power control, and protection systems. Proper installation of these systems throughout an entire facility with the panels placed in lock-out/tag-out after installation, would mean technicians could do their jobs without ever opening electrical enclosures under electrical load or having physical contact with live electrical panels.

A TRANSFORMATIVE SOLUTION

Fixed infrared camera systems offer a transformative solution. By combining high-resolution thermal and optical imaging with intelligent software, these systems enable comprehensive health assessments without requiring personnel to open cabinet doors. This not only dramatically reduces the risk of arc flash during inspections but also aligns with NFPA 70E Article 105, which mandates hazard elimination as the top priority in safety-related work practices.

While infrared viewing windows have historically provided a safer alternative to opening enclosures, they are inherently limited. These windows offer only point-in-time snapshots and often suffer from misalignment with critical components. In many cases, thermographers must still open cabinets to achieve the necessary angle, defeating the purpose of the safety measure.

Moreover, internal barriers such as plexiglass shields — installed to protect personnel — can obstruct infrared readings. Because IR energy reflects off these surfaces, cameras cannot detect heat signatures behind them. To comply with inspection standards, these barriers are often removed, increasing risk. Fixed infrared cameras resolve this issue by allowing installation during de-energized conditions. Once installed, the system operates under lockout/tagout protocols, maintaining safety while delivering uninterrupted monitoring.

HIGH ENERGY HAZARDS

High-energy electrical systems pose significant hazards during manual inspections. Many thermographers avoid opening cabinets with incident energy ratings exceeding high. Some set their personal threshold rating as low as 34 cal/cm^2 due to the extreme risk of arc flash. Since fixed camera systems eliminate the need for physical access, they enable safe monitoring of even the most dangerous equipment.

Additionally, to accurately detect heat-related issues, NFPA 70B requires that inspections be conducted under normal load conditions, typically at or above 40% of rated capacity. Scheduling handheld inspections during peak load periods can be impractical or unsafe. Continuous remote monitoring ensures that data is captured during optimal load conditions, improving diagnostic accuracy and reducing risk.

THERMOGRAPHER MISINTERPRETATION

One of the most significant advantages of fixed infrared systems is their ability to deliver consistent and accurate data. Regions of interest can be predefined, and emissivity values can be calibrated during installation. With fixed camera angles and stable settings, the risk of human error is minimized. Unlike handheld inspections, which vary based on the thermographer's skill and interpretation, fixed systems provide standardized readings that can be trusted and acted upon with confidence.

ADVANTAGES OVER THERMALCOUPLES

Thermocouple-based systems have long been used for condition-based monitoring, offering valuable temperature data from specific contact points. However, their limitations are increasingly apparent. Thermocouples cannot detect anomalies in components they are not physically attached to, nor can they monitor wiring or connectors that may exhibit early signs of failure.

Thermal cameras, by contrast, provide a holistic view of the entire panel, including wires, bolts, and connectors. This broader perspective enables earlier detection of issues — often months in advance — and supports root cause analysis that thermocouples alone cannot achieve. For example, wiring may begin to overheat long before the connected component shows signs of stress. Identifying these early indicators can prevent failures and improve system reliability.

FINANCIAL BENEFITS

The financial benefits of infrared thermography are well-documented. By preventing equipment failures, reducing downtime, and improving energy efficiency, these systems contribute to significant cost savings. As the demand for qualified thermographers driven by NFPA 70B compliance increases, the cost of manual inspections is expected to rise. With an aging workforce and limited availability of trained personnel, reliance on handheld inspections may become unsustainable.

Fixed infrared systems mitigate these challenges by automating inspections and reducing dependence on human expertise. They also eliminate common sources of error, such as incorrect emissivity settings or misinterpretation of reflective surfaces. Early detection of overheating components can prevent fires, reduce insurance claims, and protect critical infrastructure.

The new NFPA 70B requirements mandating thermal inspections up to five times more frequently than previous standards have placed

2023 NFPA 70B MANDATES ARE HERE. ARE YOU COMPLIANT OR AT RISK?

NFPA 70B now requires annual infrared inspections for electrical systems.

Miss an inspection?
Noncompliance can result in OSHA **citations and fines**.

REQUIREMENTS

Under the new NFPA 70B + E mandates:

- **ANNUAL INSPECTIONS ARE MANDATORY**
- **CLASS 3 PANELS INSPECTED EVERY 6 MONTHS**
- **FORMAL ELECTRICAL MAINTENANCE PROGRAM**
- **DOCUMENTATION OF TEMPERATURE DIFFERENCE**

MOVE TO CONDITION-BASED MAINTENANCE WITH THE SYTIS TC-90™

- Continuous, remote thermal monitoring
- AI-powered, automated alerts
- Documents every inspection
- Never expose technicians to live electric panels
- Never miss an inspection
- Livestream directly into data enterprise platforms
- Lower costs and insurance premiums
- Integrates seamlessly into your NFPA 70E Electrical Maintenance Program (EMP)

The TC-90™ helped power Puget Sound Energy's award-winning safety initiative, recognized by the NSC Green Cross for Safety Innovation Award.

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unprecedented pressure on maintenance operations. Scheduling conflicts, aging infrastructure, a shrinking pool of qualified personnel, and operational disruptions caused by manual inspections all point to a clear need: Automated, condition-based maintenance is no longer a luxury. It is a necessity.

Fixed infrared camera systems offer a low-cost, high-impact solution that aligns with regulatory demands while enhancing safety, accuracy, and efficiency. These systems not only fill the gaps left by traditional inspections but also empower organizations to stay compliant, reduce risk, and optimize performance.

CONCLUSION

As aging infrastructure faces increasing strain and regulatory standards push maintenance teams to their limits, the need for smarter, safer solutions has never been greater. Infrared thermography remains one of the most effective tools for detecting early signs of electrical faults, whether caused by loose connections, dust accumulation, or component degradation.

While handheld infrared inspections have served the industry well, they are inherently limited by their point-in-time nature and the risks they pose to technicians. These inspections often leave large gaps in system knowledge and expose personnel to hazardous conditions. Fortunately, the technology needed to overcome these limitations is already here.

The latest generation of fixed infrared cameras and intelligent software platforms enables continuous, real-time monitoring of electrical panels. These systems support preventive and predictive maintenance, offering actionable insights that reduce downtime, improve safety, and extend equipment life. By automating inspections and integrating with enterprise data systems, they also reduce the burden on maintenance crews and ensure compliance with evolving standards.

Ultimately, the goal of every maintenance program is uptime, and uptime depends on knowing when to act. With fixed infrared systems, organizations gain the foresight needed to replace components before failure, protect personnel from arc flash incidents, and maintain operational continuity. Every time a panel door is opened, it is logged automatically, meaning your records are always up to date. In a time of rising demands and shrinking resources, these technologies offer a path forward that is both practical and transformative.

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ADVANCING MULTI-SENSOR INSPECTION INTELLIGENCE FOR POWER GRID RELIABILITY

BY SHEYNA REIZES, *OFIL Systems*

This article discusses best practices for managing inspection data in electrical utilities, emphasizing the importance of standardized collection, metadata tagging, and compliance with IEEE 1808-2024. It highlights the value of integrating data from multiple sensors, including RGB, thermal, and ultraviolet imaging, with geographic and asset information, and applying structured, industry-based diagnostics. These practices support traceable condition assessments, consistent severity scoring, and risk-informed maintenance planning.

THE CHANGING LANDSCAPE OF GRID INSPECTIONS

The worldwide power grid infrastructure is undergoing significant strain. Aging transmission lines, growing demand, and heightened regulatory expectations converge with environmental stressors, including extreme weather events. Utilities are being asked to deliver improved resilience and reliability while simultaneously optimizing costs and resources.

Traditional inspection practices — visual patrols, thermal scanning, and ultraviolet corona detection — have been integral for decades. Yet these methods have often been fragmented, with data recorded in separate systems, analyzed independently, and interpreted inconsistently across teams. The result is a patchwork of valuable but underutilized information. In an environment where predictive maintenance and regulatory compliance are central, utilities can no longer afford to leave inspection data siloed or subjective.

The move toward standardized, computer-based data management is therefore not optional but essential. Inspection information must be collected in structured ways, combined with contextual metadata, and processed through frameworks that ensure consistency, traceability, and interoperability. Various

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standards now provide clear frameworks for this transition, defining how inspection data can evolve from disparate reports into a strategic asset for decision-making.

ASSET MANAGEMENT METHODOLOGIES

At the core of utility operations lies asset management: the structured discipline of planning, operating, maintaining, and ultimately retiring infrastructure assets in a way that balances cost, risk, and performance. For power systems in particular, asset management is not just about prolonging equipment life; it directly underpins grid reliability and resilience. Poorly managed assets can lead to cascading failures, widespread outages, and regulatory penalties, whereas well-managed assets contribute to stable operations, optimized capital expenditure, and improved public trust.

The sophistication of asset management practices varies considerably across utilities, often reflecting organizational maturity, regulatory environments, and resource availability. In general, these practices can be viewed as evolving through four progressive stages.

1. The most rudimentary stage is reactive replacement, where assets are operated until failure and only then repaired or replaced. This approach is highly unpredictable and expensive. It places operators in a constant firefighting mode, creates risks of collateral damage, and undermines power system reliability because failures occur without warning and may escalate into service interruptions.

2. A modest improvement is the lifecycle replacement strategy, which replaces equipment based on a predefined service life. While this approach introduces planning and budget predictability, it often fails to reflect actual asset condition. Components that still have years of useful life may be retired prematurely, while

others in harsher environments may fail before their planned replacement, again threatening reliability.

3. The third stage, condition-based replacement, integrates inspection and monitoring data into decision-making. Here, equipment is serviced or replaced based on observed degradation, such as hotspots, partial discharges, or mechanical wear. This method reduces unnecessary replacements and helps utilities extend asset life while preventing sudden failures. However, without standardized data collection and interpretation, condition-based practices may still be inconsistent, fragmented, and difficult to scale across large systems.

4. The most advanced stage is risk-based asset management, which considers the condition of the equipment but also evaluates the impact of its failure. In this framework, utilities assess not only what is wrong with an asset but also the consequences if it fails. A cracked insulator in a redundant rural feeder may pose little system risk, while the same defect in a critical substation feeding a hospital demands urgent intervention. By combining condition data with contextual information such as redundancy, customer criticality, and regulatory implications, risk-based asset management allows utilities to prioritize resources where they matter most.

BEST PRACTICES FOR ASSET AND INSPECTION DATA MANAGEMENT AND REGULATORY ALIGNMENT

Effective management of inspection data is increasingly recognized as a cornerstone of utility operations. As grids expand and regulatory oversight grows more stringent, utilities are expected to perform inspections and ensure that the resulting data is accurate, structured, and actionable. Best practices in this area encompass the entire data lifecycle, from field collection through validation, analysis, storage, and long-term use in asset management.

- A key principle is structured data collection. Inspection results should be entered into systems that standardize formats and include relevant metadata rather than captured in free-form reports or images stored without context. Parameters such as asset identifiers, location, environmental conditions, and inspection methods provide the traceability needed for future reference and analysis. Without this context, inspection results lose much of their operational value.

- Equally important is data quality assurance. Utilities must be able to trust their inspection data, which requires mechanisms for validation, error checking, and repeatability. Standardized workflows and consistent methodologies reduce the variability that can arise from inspector subjectivity, shifting the emphasis from individual judgment to reproducible outcomes.

- Interoperability is another best practice that cannot be overlooked. Inspection data should integrate seamlessly with existing enterprise systems such as GIS platforms, enterprise asset management software, and regulatory reporting tools. By ensuring interoperability, utilities avoid the pitfalls of siloed data and can embed inspection results directly into planning, operations, and compliance workflows.

Several industry references provide guidance on how to implement these practices. IEEE Std. 1808-2024, *Guide for Collecting and Managing Transmission Line Inspection and Maintenance Data*, offers a framework for utilities to transition from fragmented or paper-based inspection practices to modern, computer-based systems. It emphasizes structured collection, metadata tagging, quality assurance, and long-term data governance, and has quickly become a touchstone for organizations seeking to formalize their inspection data processes.

Complementing IEEE standards, the EPRI field guidebooks provide practical frameworks for analyzing inspection results and deriving actionable insights. They bridge the gap between raw inspection imagery — whether from ultraviolet, thermal, or visual sensors — and condition assessments that can be integrated into asset management. EPRI's methodologies are particularly valuable for utilities aiming to standardize severity scoring and risk evaluation across teams, ensuring consistent decision-making that extends beyond individual inspector experience.

Taken together, these practices and references demonstrate a shift in the industry: Inspection data is no longer treated as an operational byproduct but as a strategic resource. When managed correctly, it provides traceable, auditable, and actionable intelligence that supports both regulatory compliance and long-term improvements in grid reliability.

SENSOR TECHNOLOGIES IN GRID INSPECTIONS

Inspection practices rely on multiple sensor technologies, each of which detects distinct physical processes in assets.

- **RGB imaging** provides the most familiar perspective: visual documentation of physical condition. It captures issues such as broken hardware, contamination, structural degradation, or vegetation encroachment while offering valuable context for situating other findings.

Figure 1: *RGB Imaging — Insulator Corrosion*

- **Infrared thermography** identifies thermal anomalies, such as heating at joints, loose connections, or overloaded components. These issues may not be visible to the naked eye, but they present as temperature gradients indicating inefficiencies or impending failures.

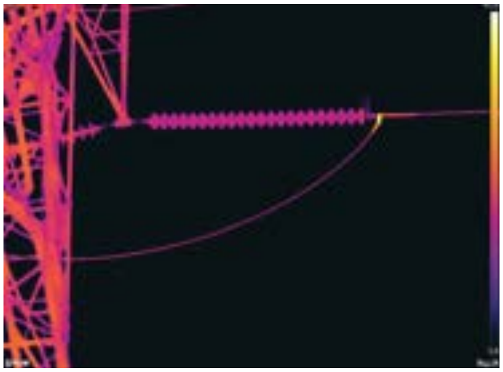

Figure 2: *Infrared Thermography*

- **Ultraviolet imaging** detects corona partial discharges. Unlike infrared, which identifies heating effects, UV reveals electric field phenomena that often precede thermal symptoms. This makes it an essential early-warning tool for insulation degradation, damaged components, improper installation, and contamination issues.

Figure 3: *Ultraviolet Imaging*

Individually, these sensors provide useful but incomplete perspectives. Integrated together, they reveal a more comprehensive picture of asset condition, with each technology validating and contextualizing the findings of the others.

MULTI-SENSOR DATA INTEGRATION

The movement toward integrated platforms now enables UV, IR, and RGB data to be ingested into a single environment, synchronized in time and location, and combined with geographic or asset metadata. This fusion of data types represents more than just convenience. It allows different physical phenomena to be observed simultaneously, providing a layered and more accurate understanding of component health.

UV and infrared imaging, for example, are not interchangeable ways of detecting the same defect; they reveal different underlying processes. Ultraviolet cameras highlight corona discharges and surface discharges, which indicate high electric field stress often linked to insulation degradation or contamination.

Infrared imaging, on the other hand, records thermal emissions, making it particularly effective for detecting resistive heating in conductors, connectors, and other current-carrying parts. A corona discharge identified by UV does not necessarily produce detectable heat, while a thermal hotspot may develop independently of any UV activity. Observing both together provides a far more complete diagnostic profile than either could alone.

RGB imaging plays an equally important role. Inspectors use RGB imagery to identify physical defects, such as cracked insulators or loose fittings, that may explain anomalies captured by the other sensors. This cross-referencing ensures that inspection data is not abstract; it's grounded in a verifiable representation of the equipment.

INTEGRATION OF INSPECTION DATA INTO ASSET MANAGEMENT

The true value of inspection data emerges when it becomes part of the larger asset management framework. On their own, images and sensor readings highlight anomalies, but without context, they remain difficult to prioritize. When inspection results are linked with asset

Figure 4: *Geospatial Risk Dashboard*

registries, network topology, and especially geographic information systems (GIS), they are transformed from isolated observations into actionable intelligence.

GIS integration plays a central role because it anchors inspection findings to the physical structure of the grid. By connecting each detection to a specific tower, pole, or substation with precise coordinates, utilities can organize inspection records in ways that mirror the real-world layout of the system. This ensures that when a hotspot is found or a corona discharge is detected, maintenance crews know exactly where to intervene. Accurate location data is also critical for downstream processes such as issuing work orders, scheduling crews, or planning outage windows. Without geospatial grounding, even high-quality inspection data risks being underutilized.

Beyond basic localization, GIS enables utilities to track asset condition over time. By maintaining a georeferenced history of inspections, teams can monitor how defects develop and whether they stabilize, worsen, or recur after maintenance. Overlays of inspection results across the network can also reveal spatial patterns of degradation — clusters of hotspots along a line segment or concentrations of corona activity in regions with heavy contamination or adverse weather. These patterns provide insights into systemic risks that would not be visible from isolated reports.

By embedding inspection results within asset management planning, utilities create a continuous improvement cycle. Data collected in the field informs daily operational decisions, validates long-term strategies, and feeds into investment optimization. Over time, structured integration ensures that inspections evolve from being snapshots of component condition into a strategic instrument for safeguarding power system reliability.

DIAGNOSTICS AND THE SEVERITY METHODOLOGY

One persistent challenge in inspection data is subjectivity. Visual interpretation can vary not only between inspectors but sometimes even for the same inspector under different conditions, such as lighting, weather, or workload. This variability undermines consistency and makes it difficult to compare results across teams or over time. To address this problem, structured severity methodologies have been developed to convert qualitative findings into standardized, quantitative assessments.

Condition Assessment

The foundation of this methodology rests on two dimensions. The first is condition assessment, which is derived directly from inspection data. Ultraviolet imaging provides evidence of corona activity, infrared thermography identifies overheating at joints and connectors, and visual imagery documents cracks, contamination, or physical wear. On their own, these observations risk being interpreted subjectively; structured methodologies provide guidance on how to classify and score them.

This is where the EPRI field inspection guidebooks have become indispensable. These guides provide utilities with detailed procedures for interpreting inspection results, ensuring that findings are not left to individual judgment. Instead of relying on inspector intuition, evaluators follow a step-by-step framework that translates imagery and sensor readings into standardized categories of severity.

For example, a corona discharge observed at a certain location on a component will correspond to a specific severity class, while thermal anomalies above defined thresholds are mapped to graded risk levels. By anchoring the interpretation process in published criteria, the EPRI guides reduce variability and promote uniformity across organizations.

Importantly, the EPRI methodology does not stop at classification. It also offers actionable insights and recommendations. Each severity level is associated with guidance on what actions should be taken:

- High-severity findings may require immediate intervention or shutdown.
- Medium-severity issues may be scheduled for near-term maintenance.
- Low-severity findings may simply be monitored over time.

In this way, the EPRI frameworks directly link diagnostic results to operational planning, turning inspection data into a driver of decision-making rather than a static report.

Impact Parameters

The second dimension in structured diagnostics is the evaluation of impact parameters.

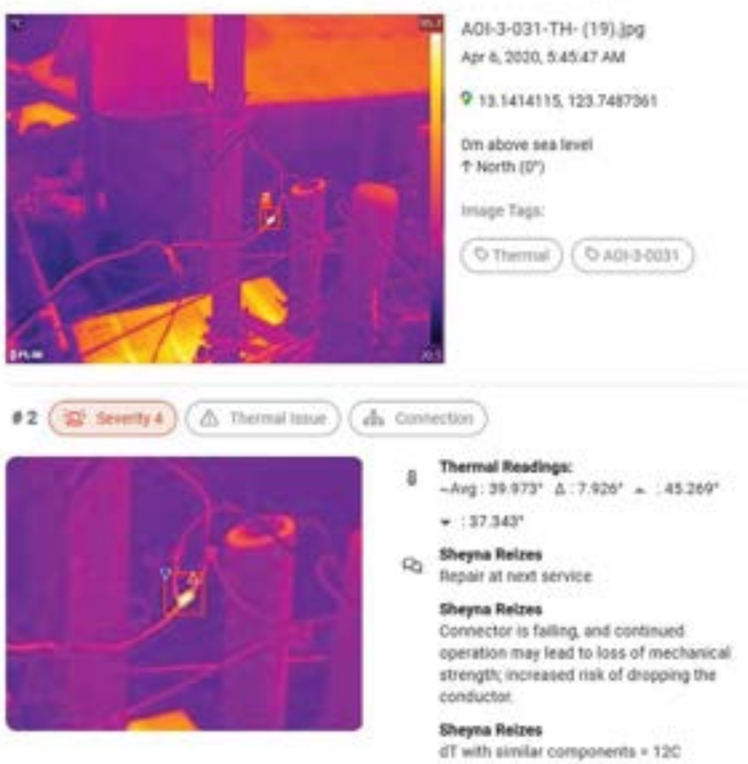

Figure 5: *EPRI-Based IR Inspection Report*

While condition assessments describe what is happening at the component level, impact analysis reflects why it matters. Factors such as customer criticality, system redundancy, environmental exposure, and regulatory implications all influence how a defect should be prioritized. A cracked insulator may carry different levels of urgency depending on whether it is located on a redundant rural line or a substation that supplies critical infrastructure.

Severity Score Matrix

When combined, these two dimensions — condition and impact — form a severity score matrix. Each finding is placed within this framework, resulting in a numerical severity score that balances technical evidence with operational context. This approach reduces ambiguity, ensures traceability, and aligns maintenance actions with real-world priorities.

The benefits extend beyond consistency. Because the methodology is structured and auditable, inspection results can stand up to regulatory scrutiny and internal quality assurance reviews. Utilities can demonstrate that maintenance priorities are based on standardized, industry-validated frameworks rather than subjective judgment. Over time, the accumulation of structured severity scores also enables trend analysis, predictive modeling, and benchmarking across fleets of assets.

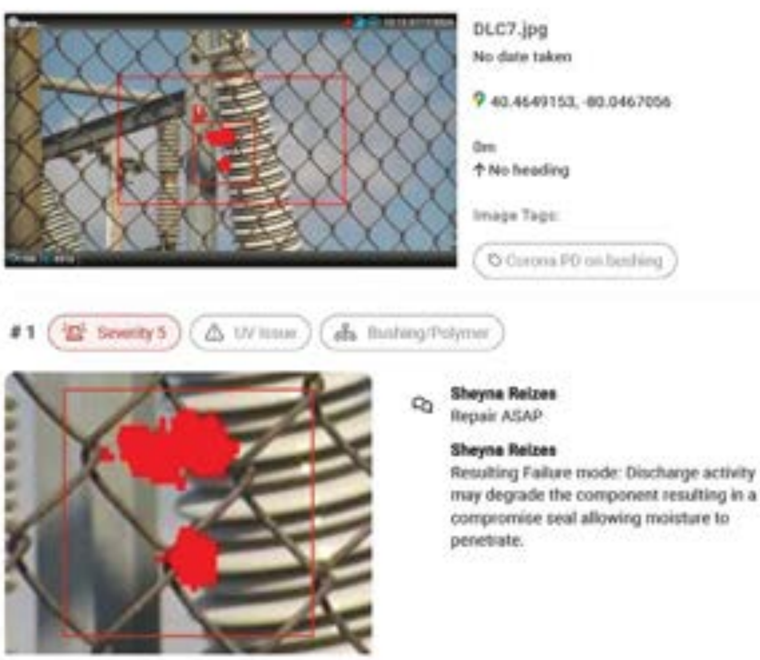

Figure 6: *EPRI-Based Severity Inspection Report*

AI INTEGRATION AND FUTURE DIRECTIONS

Artificial intelligence is rapidly reshaping how inspection data is processed, analyzed, and applied in utility environments. Traditional inspections depended heavily on human interpretation, but AI models trained on ultraviolet, thermal, and RGB imagery now automate much of this work. These models are capable of autonomously detecting anomalies, distinguishing genuine events from noise, and quantifying their frequency and spatial distribution. By automating event detection, AI reduces dependence on subjective human judgment while producing consistent, auditable records that can be tracked across inspection campaigns.

AI's role is also expanding from detection to multi-sensor correlation. By analyzing UV, thermal, and RGB data together, AI can recognize when anomalies across modalities reinforce each other, such as a corona discharge that coincides with resistive heating and a visible crack in an insulator.

Conversely, when anomalies are isolated to one modality, AI can flag them as lower confidence, reducing false positives and unnecessary maintenance. This fusion of data increases diagnostic accuracy and provides a stronger foundation for risk-based asset management.

Geospatial AI

A further step forward is the application of geospatial AI (GeoAI), which integrates inspection findings with GIS and environmental datasets. Once anomalies are geolocated, GeoAI can analyze their distribution in relation to surrounding conditions such as climate zones, pollution sources, or vegetation encroachment. These spatial analyses are particularly powerful when applied to the impact dimension of severity scoring. For instance, a cluster of corona discharges in a coastal region with high salt exposure may indicate systemic vulnerability, while hotspots concentrated near heavily loaded substations can highlight areas of elevated operational risk. By embedding geospatial context into the evaluation, AI contributes to detecting what is wrong and also quantifies why it matters.

Predicative Modeling

Looking ahead, AI will evolve beyond descriptive and diagnostic roles into predictive modeling. Probabilistic risk models, trained on large datasets of inspection findings and failure histories, will estimate the likelihood of asset degradation and failure over time. Instead of merely flagging existing anomalies, AI systems will forecast emerging risks, allowing utilities to intervene before reliability is compromised. This represents a decisive shift toward predictive and risk-informed maintenance planning, where inspection data serves not just as a record of the present but as a tool for anticipating the future.

SUMMARY: FROM DATA COLLECTION TO ACTIONABLE INSIGHTS

Utilities today are collecting more inspection data than ever before. Advanced sensors ranging from ultraviolet and thermal cameras to high-resolution RGB systems produce large volumes of imagery and associated metadata during every inspection cycle. At the same time, drones, mobile platforms, and fixed monitoring systems continue to expand the scope of what can be captured. The result is an abundance of information, but the central challenge has shifted: The critical task now is not collecting data, but extracting insights from it in a consistent, traceable, and decision-oriented way.

Meeting this challenge requires the adoption of new technologies such as computer vision models that detect anomalies, machine-learning methods that recognize patterns over time, and risk-focused AI models that estimate probabilities of failure. When properly integrated, these tools transform inspections from passive observations into predictive and risk-informed decision support.

However, the application of these technologies must be anchored in industry best practices and standards. Frameworks such as IEEE Std. 1808-2024 provide guidance on how data should be structured, validated, and integrated, while the EPRI field guides ensure that diagnostic methodologies remain standardized, auditable, and linked to actionable recommendations.

The ultimate goal is for inspection data to be organized in ways that directly support prioritization. Findings must flow into reports and dashboards that are consistent across inspectors and teams, structured around severity and risk, and designed to inform both operational and financial decisions. Utilities rely on these outputs to guide immediate interventions as well as to plan long-term investments, justify expenditures, and demonstrate compliance with regulators.

By combining structured data management, advanced sensing technologies, and AI-driven analysis, and aligning these processes with recognized industry standards, utilities can transform the growing volume of inspection data into a strategic asset. Done correctly, this approach supports regulatory compliance and enables smarter maintenance planning, optimized investments, and ultimately, improved reliability and resilience of the power grid. NW

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THE MODERN CIRCUIT BREAKER TRIP UNIT: A PROTECTIVE RELAY BY ANOTHER NAME

BY JOEL WILBUR, *CBS Field Services*

Low-voltage protection is undergoing rapid evolution. For decades, microprocessor-based protective relays have been the gold standard for medium- and high-voltage power systems, offering highly configurable protection, metering, and communication capabilities. Meanwhile, circuit breaker trip unit technology remained relatively static for many years, remaining confined to the breaker frame and focused primarily on basic overcurrent functions.

This is no longer the case. The latest generations of trip units have evolved into powerful, intelligent devices with capabilities rivaling — and in some cases, matching — dedicated protective relays. They combine advanced protection, power quality monitoring, event logging, and digital communication, transforming the once stand-alone breaker accessory into an integral component of modern electrical protection schemes.

This convergence brings opportunities and challenges. Engineers, technicians, and facility owners must now treat trip units with the same design, testing, and maintenance rigor as they do with protective relays because, in many cases, a trip unit is indeed a relay by another name.

TRIP UNIT VS. PROTECTIVE RELAY ARCHITECTURE

Trip unit architecture first evolved beyond thermal magnetic overcurrent protection to systems consisting of current sensors, adjustable dial settings, and the introduction of additional features such as short-time and ground fault protection. Later, new microprocessor-based generations added digital displays, metering capabilities, and trip indication/logging, allowing easier event analysis.

In most cases, the entire protection system still existed within the confines of the circuit breaker frame. The newest smart trip units now include voltage and power-based protection options, arc flash reduction protection, zone-selective interlocking, programmable digital

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/SURANTOW

Table 1: *Comparing Traditional Protective Relays and Modern Smart Trip Units*

Feature	Traditional Protective Relay	Modern Smart Trip Unit
Primary Function	Protection, monitoring, control	Protection, monitoring, control
Protection Elements	Wide range: overcurrent, voltage, frequency, directional, differential, etc.	LSIG overcurrent, voltage, frequency, reverse power, directional ground fault, arc flash reduction, ZSI
Measurement Accuracy	High-accuracy current and voltage sensing via external CTs/PTs	High-accuracy current and voltage sensing via internal sensors
User Interface	LCD or touchscreen; relay-specific menus; PC apps	Touchscreen or LCD; breaker-integrated menus; mobile/PC apps
Logic Programming	Fully customizable via relay logic editor	Programmable logic and digital I/O (varies by model)
Communication Protocols	Modbus, DNP3, IEC 61850, proprietary vendor protocols	Modbus RTU/TCP, Profibus, EtherNet/IP, Profinet, IEC 61850, Bluetooth
Event Logging	Time-stamped fault and operations log; waveform capture	Time-stamped fault and operations log, including waveform capture on advanced models
Integration Scope	Switchgear, control systems, distributed I/O	Within the breaker frame and cell, plus integration to switchgear and SCADA
Testing Methodologies	Secondary injection, logic testing, end-to-end testing	Primary and secondary injection, controls testing, breaker timing
Maintenance Requirements	Periodic settings review, firmware updates, functional testing	Same as relay, plus mechanical breaker inspection and calibration
Upgrade Path	Firmware or hardware replacement	Software/firmware upgrades, modular function add-ons
Installation Footprint	Separate from breaker; mounted in control panel	Integrated into breaker; optional remote interface modules

I/O capabilities, communication protocols, and computer-based user interfacing. These capabilities have extended the trip unit architecture beyond the circuit breaker frame and cell to include external components such as control switches, contact inputs and outputs, power supplies, and networking modules.

In comparison, protection relay architecture is quite similar. Instrument transformers provide current and voltage signals. Relays provide metering, computer-based interfacing, and digital, analog, and communication inputs. They record indications and events, produce direct trip commands, initiate communications-based trip schemes, and complete other logic-driven processes. Relays still maintain an edge over trip units in terms of customization, advanced fault recording, and I/O and logic processing, but the differences are becoming indistinguishable.

BRIDGING THE TECHNOLOGY PROFICIENCY GAP

Protection engineers have become well-versed in creating relay protection and control schemes and corresponding settings, and technicians are proficient in testing and troubleshooting these systems. However, even as newer trip units now have the same capabilities as relays, the approach to integrating and testing low-voltage protection systems is comparatively underwhelming.

As with any rapid technological shift, adoption lags capability. Barriers include:

1. **Cost concerns.** Upgrading to more capable devices often carries a higher upfront investment.
2. **Reluctance to change.** Engineers and facility managers may prefer familiar and proven equipment over newer, less familiar, and more complex systems.
3. **Knowledge gaps.** Many engineers and technicians remain unaware of the required settings and the full range of features modern trip units offer.

This last point is particularly critical. Protection engineers integrating new trip units often limit their coordination studies to basic LSIG (long, short, instantaneous, and ground (LSIG)) pickups and delays, unaware of the required additional settings and available advanced functions that could dramatically improve system performance.

As a result, technicians frequently encounter:

- Mismatched settings between studies and available trip unit parameters (i.e., multiples of pickup vs. amperage-based pickup settings
- Desired setpoints that the installed trip unit cannot support
- Missing critical settings entirely (i.e., desired trip curve, external vs. internal ground fault current detection)

When this happens, test technicians must act as both troubleshooters and educators — informing clients and engineers of the discrepancies and working together to develop a solution.

CASE STUDY

On a recent commissioning project at a data center, the main low-voltage switchgear systems were comprised of circuit breakers with ABB Ekip Touch trip units. The commissioning technicians encountered an issue regarding ground fault protection, particularly how the trip unit senses ground fault current. In addition to the standard pickup and time delay settings, there is a setting for external vs. internal sensing. While many trip units rely on phase summation to calculate residual ground current and may even have inputs for an external sensor, they do not have a specific setting to differentiate between the two. The ABB Ekip Touch does. However, this was omitted by the engineer of record in the issued settings.

Although a review of system drawings and visual inspection revealed no external sensors, and a reasonable assumption could be made that the setting should be set to internal, it is ultimately the engineer's responsibility to provide values for all available settings and for the technician to verify them.

Problems like these are an increasingly common occurrence as smart trip units become more widely adopted. Where there once were only basic protection functions and settings, trip units now have dozens of settings, and each one must be accounted for by engineers and technicians alike.

TESTING METHODOLOGIES

The similarity in function between trip units and relays means trip unit testing should mirror relay testing in many respects:

1. Acceptance and commissioning testing
    - Pickup and delay setting verification against coordination studies
    - Functional checks of all protection elements
    - Communication and SCADA point verification
2. Primary injection testing*
    - Confirms sensor accuracy, protection timing, and breaker operation under simulated fault current
3. Secondary injection testing
    - Allows verification of trip unit functions but varies widely in scope between test sets
4. Functional logic testing
    - Essential for advanced trip units with arc energy reduction, zone selective interlocking (ZSI), remote trip, or load-shedding schemes
5. Firmware and settings verification
    - Ensures correct versions and backups are maintained, just as with protective relays

*Some manufacturers are now releasing guidance suggesting that primary injection testing drastically reduces breaker life and is no longer preferred, emphasizing secondary injection as lower risk. An exception to this would be ground fault protection testing in accordance with NEC 230.95.

The standards for low-voltage circuit breaker testing are outlined in ANSI/NETA ATS, *Acceptance Testing Specification for Electrical Power Equipment and Systems*, Section 7.6.1.1 and Section 7.6.1.2. For breakers with smart trip units, instead of focusing on pickup and timing tests, greater emphasis should be placed on testing the integrated protection system in a manner more closely resembling Section 7.9.2, Protective Relays, especially when verifying trip unit communications, digital inputs, contact outputs, and SCADA functions.

BEST PRACTICES FOR RELIABILITY AND EFFICIENCY

1. **Involve protection engineers early**. Ensure all trip unit capabilities are reviewed during design, not just basic overcurrent elements.
2. **Perform settings validation at commissioning**. Cross-check the coordination study with the actual trip unit's available settings.
3. **Train field technicians**. Include both protective relay and trip unit programming in technician skill development.
4. **Document everything**. Firmware versions, settings backups, and communication configurations should be part of the maintenance record.
5. **Use manufacturer tools**. PC software (e.g., ABB Ekip Connect) or mobile apps (e.g., EPiC) can streamline configuration, testing, and upgrades.

CONCLUSION

The evolution of trip units from simple breaker accessories to multifunctional protection devices has transformed low-voltage protection. Modern trip units now rival — and sometimes replace — standalone protective relays in capability, requiring a shift in how they are specified, tested, and maintained. For engineers, technicians, and facility operators, the lesson is clear: If it walks like a relay, talks like a relay, and protects like a relay — it's time to treat your trip unit as one.

Joel Wilbur *is a NETA Level 4 Senior Technician and Regional Manager for CBS Field Services. A Navy Nuke veteran, he has been in the testing industry since 2007.*

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SHUTDOWN PD SURVEYS:

ENHANCING MAINTENANCE WITH CONDITION-BASED INSIGHT

BY SHAHRYAR FARHANG, ANDREA MARTINEZ, and YASH GODHWANI, *Megger*

The rapid growth of electrical systems in the industry is placing increasing demands on infrastructure and on medium-voltage (MV) networks. Utilities and service providers are expected to deliver higher reliability at lower cost. In this environment, unplanned outages caused by insulation failures are no longer acceptable.

Shutdowns remain important opportunities for electrical maintenance, but these windows are narrow and heavily scheduled. To meet modern reliability expectations, maintenance strategies are shifting to be driven by objective data, such as on-line partial discharge (PD) measurement before and after shutdown.

Figure 1: *Contact-Type Sensor, Usually for TEV or Contact-Type Acoustic*

PD surveys address this challenge by providing a non-invasive diagnosis of insulation health. Conducted on-line while the equipment remains energized, PD testing detects the earliest signs of localized insulation weakness. In this way, PD surveys bridge the gap between increasing demands for reliability and the realities of limited maintenance windows in today's electrical world.

PARTIAL DISCHARGE AS AN EARLY INDICATOR

Partial discharge is a localized electrical discharge that occurs within a small portion of an insulation system without completely bridging the electrodes. In practical terms, it is a microscopic breakdown of the insulation material caused by voids, cracks, sharp edges,

surface contamination, or aging stresses. Although each individual discharge carries only a small amount of energy (low-energy arcing), repeated activity progressively weakens the insulation and can eventually lead to catastrophic failure.

Figure 2: *MV Unshielded Cable between Transformer and Switchgear Showing Surface Tracking, Corona Activity, and Degraded Insulation Material*

One critical value of PD testing lies in its role as an early indicator of insulation weakness. Because PD usually appears well before a complete breakdown, its detection provides asset owners with an opportunity to intervene while the defect is still manageable. Identifying PD at an early stage allows maintenance teams to prioritize repairs during planned shutdowns, rather than waiting for an unexpected outage. This makes PD surveys one of the most powerful tools for proactive, condition-based maintenance (CBM) of medium-voltage equipment.

By trending PD activity over time and correlating patterns with asset type, utilities and service providers can detect insulation defects at their inception, verify the effectiveness of corrective actions, and prevent recurrence.

In short, PD is not just a symptom of aging insulation; it is a warning signal that, if captured early, protects equipment reliability, system uptime, and worker safety.

WHY PD TESTING MATTERS FOR MV ASSETS

Medium-voltage (MV) assets — cables, switchgear, transformers, rotating apparatus, breakers, or bushings — are all built around one thing: insulation. When that insulation starts to break down, failure is just a matter of time. The tricky part is that insulation problems are usually not visible from the outside. A splice may look fine, and a transformer may pass a visual check, but inside, tiny electrical discharges are eating away at the insulation. That's where PD testing comes in.

PD testing is essentially the electrical equivalent of listening for a slow leak in a tire. According to IEC 60270, *High-Voltage Test Techniques – Charge-Based Measurement of Partial Discharges*, PD is a localized electrical discharge that only partially bridges the insulation. It doesn't short the system immediately, but repeated discharges erode insulation until one day it fails. Standards such as IEEE Std. 400.3, *Field Testing of Shielded Power Cables with VLF and PD*, recognize PD as one of the most reliable indicators of insulation health. In practice, that means catching issues before they escalate into an unplanned outage.

Figure 3: *PD inside a Cable Termination*

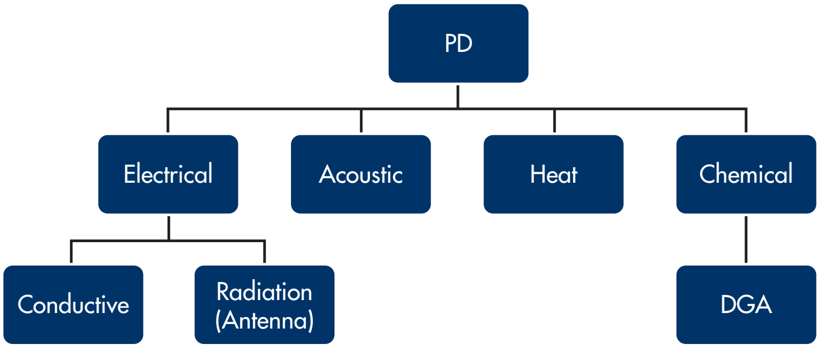

Figure 4: *PD emits various types of energy, and different ways are available to detect PD defects.*

PD ENERGY AND PD DETECTION — PD SENSORS

Partial discharge is both a challenge and an opportunity. On one hand, each discharge event releases energy that gradually degrades the surrounding insulation, leading to long-term deterioration and eventual failure if left unaddressed. On the other hand, this same energy produces electrical, acoustic, and electromagnetic signals that can be detected with specialized sensors. By capturing these signals, maintenance teams can identify and locate insulation defects well before catastrophic breakdowns occur.

For most portable on-line PD measurements — commonly called PD surveys — the primary sensors are HFCTs, TEV sensors, acoustic probes, and capacitive voltage dividers. Together, these tools offer a practical way to capture PD activity across a wide range of MV assets. The main detection approaches are outlined below.

Electromagnetic Radiated and Conducted Signals

- Clamp-on high-frequency current transformers (HFCTs) are widely used in portable PD surveys. Installed on grounding leads, they detect high-frequency PD currents as they return to ground. HFCTs are sensitive, easy to deploy, and suitable for many types of medium-voltage assets.

Figure 5: *HFCT Clamped on the Cable Termination at the Grounded Cable Gland*

- Transient earth voltage (TEV) sensors detect electromagnetic pulses that strike metal surfaces and travel to ground. They are particularly useful for switchgear and other metal-enclosed equipment where internal PD can couple effectively to grounded enclosures.

Acoustic Signals

- PD activity also produces tiny mechanical vibrations, and acoustic sensors — such as ultrasonic microphones or contact probes — capture these sound waves, making them useful for detecting surface PD or corona activity, especially in switchgear or open bus structures. This method is based on the vibration of air molecules caused by PD rather than the electrical signal itself, and the results are very sensitive to the distance from the defect location.

Figure 6: *Acoustic PD Measurement Using an Airborne Sensor*

Ultrahigh Frequency (UHF) Sensors

- UHF antennas detect electromagnetic radiation in the gigahertz range. While their use is less common in portable surveys, UHF detection can be valuable in specific applications such as large substations or gas-insulated switchgear (GIS) yards, where traditional sensors may be less effective.

Installed Capacitive Sensors

- In some facilities, capacitive sensors such as coupling capacitors or capacitive voltage dividers are permanently installed as part of the system design. These sensors provide a convenient way to capture PD signals during routine surveys or continuous monitoring without additional hardware setup.

It is worth noting that ultraviolet (UV) detection methods also exist, but their application is limited to open-air corona or arc tracking. They are generally not used in routine MV PD surveys, so they are not covered further here.

PRE-SHUTDOWN PD SURVEYS

By conducting pre-shutdown PD testing while equipment is energized, service providers can identify insulation defects that are actively developing in medium-voltage assets such as cables, switchgear, transformers, rotating apparatus, and bushings. Because PD activity often begins long before a complete insulation failure, the ability to pinpoint these early warning signals while equipment is still in service provides maintenance teams with critical foresight.

The insights gained from pre-shutdown surveys directly influence outage planning. Instead of approaching the shutdown with only generic work orders or assumptions based on historical issues, teams can prioritize specific components that exhibit measurable insulation stress. For example, a PD survey may reveal localized activity in a particular cable termination or switchgear cubicle, enabling the repair crew to plan targeted interventions rather than broad, time-consuming inspections. This focused approach avoids wasted effort, reduces unnecessary teardowns, and ensures that the most at-risk components are addressed within the limited outage period.

In short, pre-shutdown surveys complement historical maintenance data and transform a shutdown into a more proactive, data-driven event, ensuring that scarce outage time is focused on the most critical areas.

POST-SHUTDOWN SURVEYS

Post-shutdown surveys can help confirm whether maintenance efforts were effective. After repairs, replacements, or cleaning have been carried out, on-line PD testing verifies whether the insulation defects detected during the pre-shutdown survey have been fully resolved. This validation step is critical.

Equally valuable, post-shutdown surveys may uncover new issues that have been introduced during maintenance. For instance, a cable termination installed under time pressure or without proper stress control may exhibit fresh PD activity, even if the original defect was corrected. Detecting such issues before energizing the system prevents premature failures and protects both personnel and equipment from costly setbacks.

Finally, post-shutdown surveys establish a baseline for trending. The PD activity measured immediately after maintenance becomes the new reference point for future condition assessments. By comparing subsequent survey results to this baseline, service providers and asset owners can confidently monitor whether the insulation system remains stable or if deterioration resumes over time. This continuous improvement cycle strengthens reliability, justifies maintenance decisions, and supports long-term condition-based asset management.

In combination, pre- and post-shutdown surveys form a closed-loop strategy: One identifies and prioritizes defects for action; the other validates and documents the effectiveness of those actions. Together, they ensure that shutdowns not only address existing problems but also deliver measurable improvements in system reliability.

CHALLENGES IN ON-LINE PD MEASUREMENT

While on-line PD measurement is a powerful tool for assessing insulation condition under real operating stresses, it is not without challenges. One of the primary obstacles is the presence of electrical noise and disturbances in field environments. Modern MV systems are filled with switching devices, power electronics, and background electromagnetic activity that generate signals in the same frequency range as PD. These external disturbances can easily mask or mimic true PD activity, complicating the interpretation of results.

In practice, this means that weak PD signals — especially those originating from defects located farther away from the sensor — may

Figure 7: *PRPD Patterns Captured with HFCT Confirming a Valid PD Defect*

be hidden beneath stronger noise. As a result, real insulation defects can remain undetected if their discharge activity does not rise above the noise floor. For example, a void discharge inside a cable joint may be overlooked when high background interference from variable frequency drives or corona on nearby hardware dominates the measurement.

Another challenge lies in the variability of PD propagation paths. PD signals attenuate as they travel through insulation, conductors, and grounding systems, and their strength decreases with distance from the source. When combined with strong external noise, this attenuation can further reduce the likelihood of detecting subtle but important defects.

To address these issues, practitioners often use multiple sensors, advanced filtering, and pattern recognition techniques to separate real PD from noise. Even so, interpretation requires experience, and there is always a risk of missing early-stage defects if they are weak or obscured. Recognizing these limitations is critical: While on-line PD testing provides valuable insight, it should be complemented with other diagnostic methods and careful judgment to ensure a reliable insulation assessment.

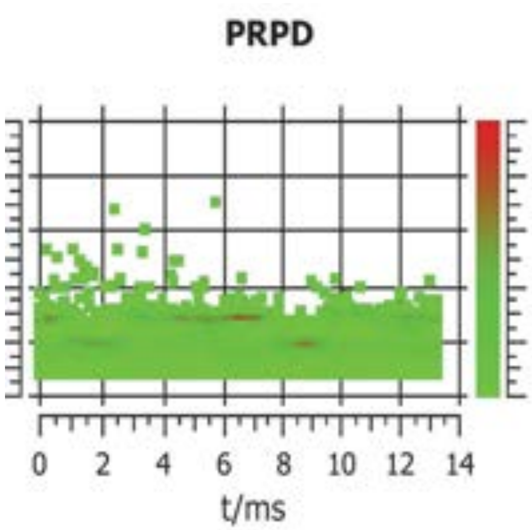

Figure 8: *A PRPD pattern influenced by strong noise and disturbances is difficult to interpret, possibly due to incorrect measurement settings.*

BEST PRACTICES FOR MANAGING NOISE IN ON-LINE PD MEASUREMENTS

The following suggestions can help improve the reliability of on-line PD measurements in the field. It is important to note, however, that most strong PD signals can still be readily detected using basic PD testing tools. These practices aim to improve sensitivity and confidence in detecting weaker or more distant defects.

- Use multiple sensor types (HFCT, TEV, UHF, acoustic) to cross-check findings and strengthen signal validation.
- Optimize sensor placement to reduce attenuation by minimizing the distance from likely PD sources.
- Perform measurements under varying load and operating conditions, since noise levels often change with system state.
- Correlate PD results with other diagnostics (off-line PD, DGA, visual inspection, etc.) for confirmation.
- Trend PD activity over time rather than relying on a single snapshot, which helps distinguish consistent PD signals from transient noise.
- Apply advanced signal processing techniques such as digital filtering, time-gating, or measuring across different frequency bands to suppress repetitive noise and enhance true PD patterns.
- Document findings with clear severity ratings, making results actionable for maintenance teams.
- Always conduct both pre- and post-shutdown surveys to capture the full value of PD testing: prioritizing repairs before an outage and validating them afterward as much as possible.

CONCLUSION

PD surveys are a valuable component of modern maintenance strategies, particularly as the industry demands higher reliability.

Like any diagnostic tool, PD surveys have limitations. Noisy environments can obscure weak or distant PD signals, and in some cases, experienced interpretation is required to distinguish true activity from background disturbances.

Nevertheless, most significant PD activity can be readily detected using standard measurement tools. Best practices employing multi-sensor approaches, trend analysis, and correlation with other diagnostics can further enhance accuracy and confidence in results.

It is important to recognize that PD surveys are complementary to, not replacements for, existing maintenance techniques. They provide an additional layer of insight by often helping to localize anomalies that improves decision-making and reduces the risk of unplanned failures.

Pre- and post-shutdown PD surveys bring measurable value. Pre-shutdown testing supports proactive prioritization, while post-shutdown testing verifies repairs and establishes a new baseline. Together, they transform shutdowns from reactive events into data-driven processes, strengthening reliability in an increasingly electrified world. NW

REFERENCES

[1] IEC 60270, *High-Voltage Test Techniques – Charge-Based Measurement of Partial Discharges.*

[2] IEEE Std. 400.3, *Field Testing of Shielded Power Cables with VLF and PD.*

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Andrea Martinez *is an Applications Engineer at Megger. She obtained her BS and MS in electrical engineering from the University at Buffalo, where she conducted research in partial discharge (PD) analysis in the Energy Systems Integration Lab, resulting in multiple publications and being awarded a National Science Foundation Graduate Research Fellowship Program (GRFP). After graduating, she joined Sandia National Laboratories to continue her research into PD degradation. Martinez then joined Moog to work on actuation test equipment for notable projects, including Artemis and SLS, and served as Moog's Ambassador to the Society of Women Engineers (SWE), where she worked with local schools and SWE chapters to bring engineering to a more accessible level for the Buffalo community. Martinez has been featured on Buffalo Public Schools' Science Week, taught the University at Buffalo's* Louis Stokes Alliances for Minority Participation (LSAMP) *course, and presented at SWE20.*

Yash Godhwani *is the Cable Applications Team Lead at Megger, where he has been contributing for over five years. He holds a BS and an MS in electrical engineering and has extensive experience in transformer testing and substation asset diagnostics. His expertise lies in advanced cable testing and diagnostics, including partial discharge analysis, tan delta, very-low-frequency (VLF) testing, and fault location. Godhwani is an active member of IEEE and CIGRE, reflecting his commitment to advancing industry knowledge and best practices.*

MVA:
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NETA's Corporate Alliance Partners (CAPs) are industry-leading companies that have joined forces with NETA to work together toward a common aim: improving quality, safety, and electrical system reliability.

SCOTT REED

This ongoing *NETA World* series focuses on the thought leadership behind these successful companies. For this issue's CAP Spotlight, we talked to President Scott Reed, who founded MVA in 2014. "Many in the NETA community know MVA Diagnostics for its industry-leading transformer oil testing and analysis. However, fewer realize that the company also operates a full-service field division — MVA Services — that provides on-site solutions for transformer performance and reliability. While MVA Diagnostics focuses on interpreting test data to assess equipment health, MVA Services turns that insight into action by working with NETA members to address and resolve transformer issues in the field."

Reed's role in the IEEE Transformers Committee allows him to provide IEEE updates to *NETA World* readers. He serves as an Executive Officer for the Transformers Committee and will move into the role of Vice Chairman in January 2026. In addition, Reed is Chairman of the IEEE Guide, *Installation and Maintenance of Liquid-Filled Power Transformers*; Vice Chairman of IEEE Std. C57.166, *Acceptance and Maintenance of Insulating Liquids in Transformers*; and Vice Chairman of C57.637, *Guide for the Reclamation and Reconditioning of Insulating Fluids*. Reed holds three U.S. patents, presents and serves on the Transformer Panel at PowerTest conferences, and has published numerous papers for the industry. He received his BS in electrical engineering from North Carolina State University with a concentration in Power.

MVA's Newly Constructed Oil Laboratory Facility and One of Its Vacuum Oil Processing Rigs

NW: Is this a good time to be in the electrical power testing business?

Reed: If you look at the history of the electrical power industry, only a few periods mimic the level of change we're going through today.

- The first major transformation was the electrification era in the late 1800s. This was the period of Edison, Tesla, and Westinghouse, where direct current gave way to alternating current, allowing the transmission of electricity over long distances. This was the birth of the industry as we know it. It was disruptive, creating new industries, and it fundamentally reshaped society.

- Next came the power demand era: Post–World War II expansion through the 1970s saw the onset of industrial factories and suburban homes with appliances and air conditioning. Utilities were forced to add generation and expand their transmission networks to meet the power demand. It was this moment in history when society no longer accepted outages. Reliability was expected, leading to the development of testing standards and maintenance practices to meet the public's expectation to eliminate all outages.

- The third surge arrived in the early 1990s when utility deregulation began and digitalization arrived. Utility monopolies were forced to compete, allowing independent power producers to form. This era also saw the introduction of digital relays and SCADA systems, replacing electromechanical relays and analog equipment.

Fast forward to today, and we are experiencing all three of those transformations at once.

1. Like the late 1800s, we're seeing new technologies from renewables, storage, distributed generation, and microgrids that are disrupting and fundamentally changing our approach to generation.

2. Like the post-war era, we're seeing explosive demand growth from EV charging networks, an electrified industry, and especially AI data centers and cloud computing. This growth burdens capacity and forces new transmission and distribution construction.

3. And like the digital revolution of the 90s, we are again changing how the grid is operated, controlled, and managed. Only now, it's being done with predictive analytics, advanced monitoring, AI, and cyber-physical integration.

This is an unprecedented era. The grid is growing and being reinvented. For those of us in high-voltage testing and services, this is a once-in-a-lifetime opportunity. Electrical testing has never been more critical, and the transformation ahead will define the industry for the next 50 years, just as those earlier eras did.

***NW:* What is the biggest challenge facing your company?**

Reed: There is a myriad of challenges in our industry. Supply chains are strained trying to supply components, and costs are rising while market pressures force us to stay competitive with pricing. Safety is always an ongoing risk because of the nature of high-voltage work. But without question, the biggest challenge our company faces is attracting and training highly skilled people.

MVA specializes in analyzing transformer oil samples and repairing Extra-High-Voltage (EHV) transformers. Working on 69-kV through 765-kV-class transformers requires an exceptional skill set, demanding theoretical knowledge as well as advanced field experience. Our industry is not for employees with entry-level skills. The technician must not only understand the technical theory, but also needs to have the situational awareness and judgment to work safely around energized equipment. That's not something you can teach in a classroom; it comes from years of mentorship, hands-on experience, and exposure to real-world troubleshooting.

Demand for field services is growing rapidly. Our reputation, safety record, and service quality all depend on the caliber of the employees who work in our laboratory and in the field. I have always said and truly believe that MVA's assets are not found on our balance sheet. They are found in our people. They are the true assets of MVA.

***NW:* What are the biggest challenges facing your customers?**

Reed: Our customers, similar to MVA, are struggling to support the demands and challenges of the expanding grid while continuing to provide maintenance services on aging transformers, breakers, switchgear, and cables. The reality is that everything is more expensive and there are longer lead times for new deliveries. Equipment owners are forced to prioritize which assets are scheduled for replacement and which are prioritized for maintenance and repair.

As an electrical service contractor, whether MVA or a NETA-accredited testing company, it comes down to the available supply of quality people. It has been fascinating to observe the evolution of our industry and the acceleration of demand for services throughout my career. When operating a company, having too much demand for services is a good problem, but it illustrates the importance of continuously developing new employees for our industry. This is where I believe NETA offers tremendous technical support for electrical testing companies to help them expand their workforce.

***NW:* Which industry trends are you keeping an eye on?**

Reed: I am focused on four key areas as I look to the future.

1. **Safety.** Without question, safety is my number one focus for MVA. Providing an environment where employees feel safe and comfortable to point out potential hazards is critical to the success of our organization. It requires investing in proper tools and equipment that minimize the risk of injury. The cost is beneficial financially, too. It protects our safety record, allowing us to continue to work for our customers.

2. **Technology.** As an operator of a service company, I am keenly focused on how technology will force our industry to advance forward. AI will drive power demand growth for data centers while also reshaping our industry. AI will increasingly become an important tool as the algorithm will refine over time to help identify pattern recognition from minute changes in operating conditions that can indicate potential issues before they become major problems. It will also become a major tool to help identify systematic issues such as manufacturer-specific failure modes, allowing the owner to proactively perform predictive maintenance to prevent future failures.
3. **Renewables.** Despite decreasing political appetite for renewable energy, demand is still strong. The increase in wind and solar generation and battery energy storage is fundamentally impacting the grid. Power is no longer flowing in one direction to end users. Harmonics, switching transients, and variable loading are introducing additional stresses on transformers, breakers, and protection systems, demanding even more predictive maintenance services.
4. **Workforce.** My expectation is that the demand for qualified workers will continue to exceed available supply. While this is an exciting period in our industry, travel, long hours, and safety risks complicate the ability to hire proficient personnel. MVA just constructed a new facility to handle our oil testing volume and purchased additional oil processing rigs to meet the demands of our customers, but the challenge of finding employees to ensure we can meet our customers' needs is critical. Our focus is on developing our own employees to provide future growth opportunities with more responsibilities, but we will continue to look outside our organization to seek programs that offer employee training as a resource to identify potential candidates. That's why employee retention is so critical to ensure we can meet our customers' needs.

NW: **What do you predict will impact your business in the near future?**

Reed: The next few years are going to be transformative for both our industry and for MVA. The power industry is changing faster than it has in decades, and those shifts will create opportunities and new pressures for our business. The wave of capital investment to replace aging transformers and new load growth will drive demand for our services. The challenge won't be finding work; the challenge will be continuing to operate efficiently while maintaining quality and safety at the level we demand of ourselves.

For MVA, that means more transformers under stress and more demand for diagnostic testing to ensure reliability. These systems can't afford failure. Our services will become increasingly critical to help customers maintain uptime, and the loss of experienced engineers and technicians will continue to impact our customers. As customers lose in-house expertise, they're looking for service partners who can fill that expertise gap, not just perform tests. That's where MVA is strongly positioned. Our combination of lab diagnostics and field expertise makes us a technical partner, not just a vendor.

NW: **If you could change one thing about how your business operates, what would it be?**

Reed: We already collect and process a tremendous amount of test and diagnostic information — oil samples, field test results, and more. We've built a strong foundation with our patented sampling app, and we continue to expand its capabilities. So it's not about changing something wrong — it's about continuing to innovate. MVA is focused on how to be a stronger resource for our customers as we navigate this new era.

SWITCHGEAR MODERNIZATION

BY NATHAN DUNN, *Eaton Corporation*

"I want to talk about the need for switchgear modernization and why it's important."
Nathan Dunn

INDUSTRY TRENDS AND CHALLENGES

Our industry is facing several trends today, including increased energy demand due to the growth in electrification and data center expansion, digitalization including new technologies for relays, and communication and sustainability trends where companies are looking to incorporate new assets at their generation facilities that will alter their network and system.

At the same time, companies are facing their own challenges with aging equipment and a loss of expertise. Finding skilled labor that understands their systems is becoming more difficult, coupled with newer technologies that require investment in employee training, and the need for outside services support increases.

LIFECYCLE FIELD SERVICES

All of this requires services and solutions to support our customers throughout their equipment lifecycle. Lifecycle services can start with a simple assessment, evaluating the current equipment status and creating a prioritization of recommendations. NFPA 70B now requires a similar assessment to determine the condition and criticality of equipment prior to building a maintenance plan.

From the moment new equipment is shipped to site, the services work starts with equipment installation, start-up, and commissioning, followed by preventive maintenance, troubleshooting, and repairs. Services support continues until the equipment's end of life. Switchgear modernization is a way to provide life extensions that give customers another 5, 10, 20, or more years of life for their electrical systems.

SWITCHGEAR MODERNIZATION

Switchgear modernization solutions involve life extension services and upgrades. These solutions include regular maintenance, breaker reconditioning, equipment modification, and equipment replacements. Breaker replacements encompass the same or newer technology that utilizes plug-in kits to reduce installation time. For example, new retrofit kits can replace older breakers with newer technology to enhance the safety and functionality of your equipment.

Modernization solutions including upgrades of existing equipment such as relays and controls is another option. Many customers still have electromechanical relays, but they often want newer technology and increased functionality

PHOTO: ©.ISTOCKPHOTO.COM/PORTFOLIO/CASARSAGURU

that allows those assets to communicate with their broader system to provide more control and monitoring, increasing the overall safety and reliability of their systems.

Customers choose switchgear modernization solutions for a variety of reasons:

- Reduced capital cost. The capital expense for modernizing equipment is lower than the cost for a full replacement, which can be unfeasible due to the equipment location or facility uptime requirements.
- Digitization. Modernization supports customers' digitization initiatives as newer technology can provide increased ability to monitor and control their systems.

> Switchgear modernization is a way to provide life extensions that give customers another 5, 10, 20, or more years of life for their electrical systems.

- Newer technology. Increased maintainability and reliability of their systems as newer technology has more readily available spares and expertise to support.
- Reduced downtime. Electrical equipment can have long lead times, and downtime for a full replacement project can impact a facility, so modernization to just one piece of equipment can decrease the overall project duration and customer impact.

CONCLUSION

When engaging with customers around maintenance, the topic of moving toward predictive maintenance often arises. Lifecycle field services, switchgear modernization, and system monitoring technology and software offer practical solutions that extend asset life, enhance safety, and support predictive maintenance. By integrating advanced technologies and data-driven tools, companies can modernize their systems, improve operational efficiency, and build a more resilient, sustainable electrical infrastructure for the future. NW

***Nathan Dunn** is the Product Line Manager – Field Services and Aftermarket at Eaton. He began his career 20-plus years ago as a field engineer at General Electric, moved to Schweitzer Engineering, and returned to GE performing various commercial and product leadership roles for distribution and industrial solutions and products prior to joining Eaton. Dunn earned a BS in electrical engineering at the University of Pittsburgh-Johnstown and an MBA from the University of Maryland Robert H. Smith School of Business.*

Editor's Note: This article is a transcription of a presentation at the 2024 EPIC Conference.

MIDDLE EAST AND NORTH AFRICA POWER SYSTEMS:

CHALLENGES AND REGIONAL SOLUTIONS

BY KHALED SHADI MORSHED, *Commissioning Services International*

With our increasing dependence on electricity in nearly every aspect of life, it has become essential for responsible authorities to improve the reliability of electrical power networks to reduce power outages and ensure a stable energy supply.

Reliable electrical networks are crucial in society because they are involved in many aspects of life, including healthcare. Power outages in hospitals can lead to life-threatening situations, including patient deaths. Therefore, power generation and utility companies must anticipate potential problems that could cause outages and implement solutions proactively before any interruption occurs.

This article focuses on the environmental challenges in the Middle East and North Africa (MENA) that affect electrical networks and threaten their reliability. Factors such as extreme heat, sandstorms, dust accumulation, and occasional floods can damage equipment, reduce efficiency, and increase the risk of power outages.

MAJOR GRID ENVIRONMENT CHALLENGES IN MENA

Several environmental challenges pose risks to electrical networks in the Middle East. High temperatures, sandstorms, dust accumulation, and high humidity can cause equipment overheating, corrosion, and insulation damage, which may lead to malfunctions and increase the likelihood of power outages.

High temperatures

The Middle East and North Africa (MENA) region is among the most exposed areas to high temperatures, particularly during the summer, when temperatures can exceed 45°C (113°F). Climate studies indicate that the region's average temperature has risen by approximately 2°C (35.6°F) over the past decades. These extreme temperatures impact not only human comfort but also infrastructure, industrial operations, and electrical systems.

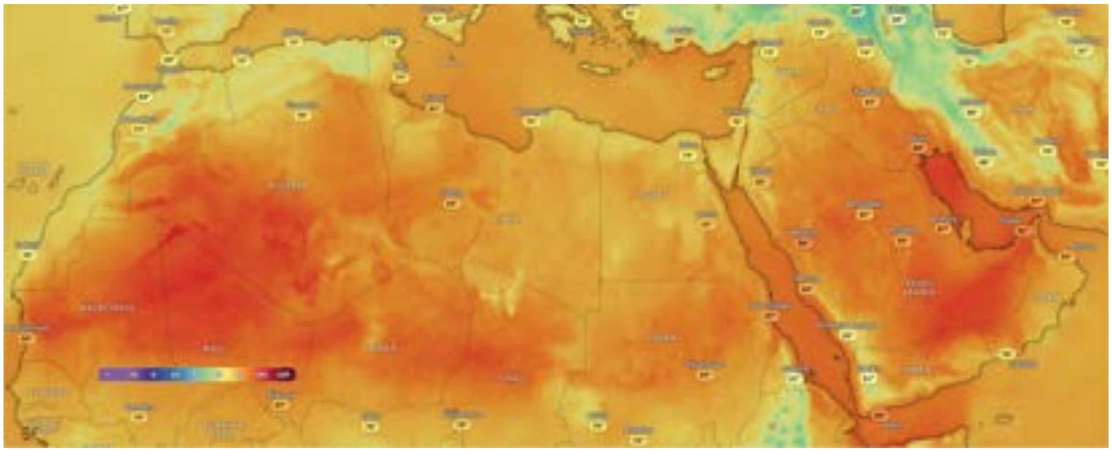
Historically, people adapted to the heat using traditional methods, such as building homes from clay and stone with small windows and high ceilings to reduce sunlight and improve airflow. Sleeping on rooftops, using handmade fans, drinking cold water from clay pots, and staying in shaded areas were common

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/THOMASKLOC

practices. Today, modern solutions, including air conditioners in homes, offices, and vehicles, as well as weather apps, allow people to manage heat more effectively.

In industrial settings, particularly at power plants, technology has improved safety and operational efficiency. Air-conditioned control rooms and protective tools enable engineers and technicians to perform testing and maintenance under extreme heat. However, high temperatures still pose serious challenges to electrical systems. When temperatures exceed equipment design limits, components such as transformers, circuit breakers, and cables experience thermal stress.

For example, extreme ambient temperatures in MENA accelerate the thermal aging of underground cables and transformers. Studies in Oman and Saudi Arabia show that dry soil and elevated summer temperatures reduce cable ampacity and shorten insulation life. Climate-induced heatwaves can cause line sag and



Zoom Earth Weather Map — Temperature, September 9, 2025 increase the probability of outages, threatening system reliability. This creates a feedback loop: Rising heat increases energy demand, which in turn adds to CO_2 emissions, exacerbating the problem further.

Sandstorms and Dust Accumulation

The Middle East and North Africa are known for their desert environments, and many countries in the region experience sandstorms, especially during summer. For example, numerous sandstorms hit Iraq in 2022. At the beginning of April, several storms occurred one after another over two weeks, sending many Iraqi citizens to hospitals.

According to the article published by EcoMENA on November 21, 2024, sand and dust storms have become regular events in the region, and they play an important role in the global dust cycle. They can also temporarily affect the region's radiation balance and lower surface temperatures by scattering sunlight, sometimes by approximately 1°C (33.8°F).

Major local sources of dust in the Arabian Gulf include the Syrian desert, Jordan, and northern Saudi Arabia, while the Sahara Desert in Africa is one of the main global sources of dust, producing millions of tons of fine particles each year, according to EcoMENA.

Sandstorms generally reduce horizontal visibility, and a day is classified as a sandstorm when visibility drops below 1,000 meters. These storms can disrupt daily life, harm the economy, and impact on human health, as they carry fine polluted particles such as bacteria, pollen, heavy metals, and other contaminants that may trigger respiratory issues and allergies. They also pose serious challenges to electrical power systems, as dust and sand can accumulate on insulators, transmission lines, and substations, contaminating surfaces and weakening insulation strength. In severe cases, this buildup can lead to flashovers, equipment damage, and unexpected power outages, jeopardizing the overall reliability of the electrical network.

According to Shenouda et al in "A Review of Dust Accumulation on PV Panels in the MENA and Far East Regions," sandstorms and dust deposition on photovoltaic (PV) modules cause significant energy losses. The findings indicate that solar power plants may lose up to 70% of their generation capacity due to dust accumulation on panel surfaces, blocking solar radiation.

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/TRANSLUCENT-YY

Wadi Rum, Jordan

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/WHITELACEPHOTOGRAPHY

Dubai Skyline from Ras Al Khor, UAE

Humidity

Humidity levels in the Middle East are relatively high because the Arabian Peninsula is surrounded by seas on most sides. High humidity is one of the biggest challenges in the Gulf's coastal region, especially during summer, when temperatures exceed 45°C (113°F) and humidity can surpass 90%, making the air feel heavy and hard to breathe. Although air conditioners have become indispensable in homes, offices, and cars, the extreme humidity still restricts outdoor activities during the day, leading many people to avoid going outside unless necessary or schedule activities such as walking or jogging at dawn or after midnight.

In coastal cities like Dubai, Doha, and Kuwait, summer weather becomes so hot and humid that it feels like being inside a natural sauna. This can happen even when the actual temperature is lower, but the humidity is high. This is due to what is known as the heat index or feels-like temperature.

Excessive humidity can negatively affect electrical systems and equipment. Moisture in the air can lead to condensation on insulators, cables, and switchgear, reducing their insulation strength and increasing the risk of short circuits or equipment failure.

> IN MANY REGIONS, HIGH HUMIDITY COMBINED WITH ELEVATED TEMPERATURES CAN CREATE CONDITIONS THAT AFFECT HIGH-VOLTAGE POWER TRANSMISSION LINES.

In many regions, high humidity combined with elevated temperatures can create conditions that affect high-voltage power transmission lines. This can sometimes result in a buzzing or humming sound from the towers, particularly during humid weather. This occurs due to the ionization of air molecules around the conductors under strong electric fields. If electrical equipment is not designed to withstand corona effects, it may lead to electrical discharge, posing a significant risk to the safety and operational reliability of the power system. These environmental factors, common in MENA, highlight the importance of robust design and preventive measures to ensure grid stability under extreme climatic conditions.

STRATEGIES TO IMPROVE ELECTRICAL NETWORK RELIABILITY IN MENA

Ensuring the reliability of electrical networks under harsh environmental conditions requires effective protection strategies. High temperatures, humidity, sand, and dust can adversely affect transformers, switches, and control systems. Practical solutions to improve equipment performance and extend operational life include the following strategies.

Controlled Room

One of the most effective strategies for protecting electrical equipment is to place it in a controlled environment. Electrical rooms and indoor substations are designed with advanced temperature and humidity control systems to maintain stable operating conditions. Keeping critical components such as transformers, switchgear, and control panels inside these enclosures greatly reduces the risks associated with overheating, condensation, and dust ingress. For instance, high relative humidity combined with dust can cause flashovers across insulators, leading to costly outages. Controlled rooms use HVAC systems, air filtration, and thermal sensors to constantly monitor and regulate the internal environment.

According to the UAE Electricity Wiring Regulations, all parts of an electrical installation must be designed, constructed, and maintained to operate safely under the expected environmental conditions. In the Middle East, these conditions include high ambient temperatures, with outdoor shaded areas reaching 50°C (122°F), outdoor unshaded areas experiencing additional solar heating, and indoor unconditioned areas heating up to 40°C (104°F). Equipment must also withstand frequent dust, occasional sandstorms, coastal corrosion, humidity levels reaching 100% during certain periods, and variable soil conditions.

These harsh environmental factors make the use of indoor substations or enclosed electrical rooms essential. By providing a controlled environment, indoor substations protect equipment from dust, sand, condensation, and heat, ensuring safe operation, reliable power

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/ALACATR

Electrical Room Control Panel

PHOTO: © ISTOCKPHOTO.COM/PORTFOLIO/VALTRON84

Aerial View: Huge Power Plant on the Seashore in Dubai, UAE

supply, and extended equipment lifespan, as has been successfully demonstrated in the UAE and Saudi Arabia.

Protective Molding and Coating

Another essential method for protecting power equipment is the use of protective coatings and cast insulation materials. These layers act as a barrier against the moisture, dust, and chemical contaminants that are prevalent in the desert and coastal environments of the Middle East. For example, polyurethane and epoxy-based coatings are commonly applied to insulators, cables, and circuit boards to prevent tracking, corrosion, and partial discharges. Protective molding around terminals and joints ensures that dust and humidity cannot penetrate the insulation system, preserving dielectric strength.

Research has shown that equipment treated with such protective coatings experiences significantly less downtime and fewer failures, especially in regions with saline humidity (Gulf coastal areas) and dust-laden air (Saudi Arabia, Iraq, Kuwait). By applying these protective measures, utilities can reduce unexpected outages, improve system reliability, and save on costly maintenance. In modern substations, protective coatings are considered a standard preventive measure to ensure stable operation under harsh conditions.

Maintenance

Preventive maintenance is essential for minimizing problems caused by harsh environmental conditions. This involves routinely inspecting electrical equipment to ensure safe and proper operation, identifying any damage or wear caused by factors such as heat, dust, or humidity before they result in serious faults. Regular cleaning also helps prevent the accumulation of dust and sand on insulators and switches, reducing the risk of equipment failures.

Understanding the importance of proactive maintenance, the MENA has integrated

Internet of Things (IoT) technologies into its maintenance programs. This allows real-time monitoring, predictive fault detection, and optimized scheduling, all of which improve system reliability and extend the service life of electrical assets.

Preventive maintenance also plays a key role in enhancing the efficiency and performance of power systems. By systematically inspecting, cleaning, and testing equipment such as transformers, switchgear, and cables, potential issues can be addressed before they escalate into failures. This approach helps avoid unplanned outages, reduces energy losses, and ensures all components operate efficiently. Well-maintained equipment also experiences less wear and tear, lowering resistance and minimizing leakage currents, which directly conserves power. It also prevents emergency shutdowns that consume additional fuel and energy, while extending the lifespan of critical assets and reducing the need for frequent replacements. Overall, preventive maintenance strengthens system reliability, saves energy, and reduces operational costs.

ENVIRONMENTAL STRESSES SUCH AS SAND AND DUST STORMS, EXTREME HEAT, HUMIDITY, AND DROUGHT IMPOSE SIGNIFICANT ECONOMIC BURDENS ON POWER SYSTEMS ACROSS THE MENA REGION.

ECONOMIC IMPACTS OF ENVIRONMENTAL STRESSES

Environmental stresses such as sand and dust storms, extreme heat, humidity, and drought impose significant economic burdens on power systems across the MENA region. The combination of rising temperatures, land degradation, and poor water management has increased the frequency and severity of sandstorms, leading to substantial costs associated with infrastructure damage, energy production losses, and health-related expenses. According to the United Nations World Meteorological Organization (WMO), more than two billion tons of dust are emitted globally annually, over 80% of which originates from the deserts of North Africa and the Middle East. These sand and dust storms affect more than 330 million people in more than 150 countries, causing severe disruptions to daily life and energy sector operations. The economic impact of these storms in the Middle East and North Africa is estimated at US$150 billion, equivalent to approximately 2.5% of the region's GDP. The World Bank estimates that power outages and clean-up operations alone cost the region approximately US$13 billion annually.

High temperatures significantly impact electricity systems in the Middle East and North Africa region, causing increased energy demand during the summer months in countries such as Saudi Arabia and Jordan. This leads to the operation of additional power plants to cover peak demand, increasing operating costs. Thermal power plants also lose efficiency due to higher water and air temperatures, reducing productivity and leading to direct and indirect economic losses estimated at hundreds of millions of dollars annually due to power outages and their impact on the industrial, service, and agricultural sectors.

CONCLUSION

The reliability of electrical power networks in the Middle East and North Africa (MENA) region faces significant challenges due to extreme environmental conditions. High temperatures, sand and dust storms, humidity, and occasional floods create severe stress on power systems, increasing the likelihood of equipment failures, power outages, and operational inefficiencies. As highlighted in reports from EcoMENA and the WMO, these environmental factors not only threaten the stability of energy infrastructure but also impose serious economic and social consequences on the region.

However, advancements in technology are reshaping the way utility companies manage these challenges. The implementation of controlled environments, protective coatings, indoor substations, and AI-driven predictive maintenance has enhanced the resilience of power networks. Early-warning systems and advanced monitoring tools now enable operators to detect potential faults before they escalate, reducing downtime, and minimizing damage.

Looking ahead, sustaining reliable electrical networks in the MENA region will require a balanced approach that combines technological innovation, proactive maintenance strategies, and climate adaptation measures. As environmental stresses are expected to intensify due to climate change, energy providers must continue to invest in smart infrastructure and sustainable solutions to ensure energy security and protect critical sectors such as healthcare, industry, and transportation.

By adopting these measures, the MENA region can better withstand the harsh impacts of its unique climate while securing a stable and efficient power supply for its growing population and economy. NW

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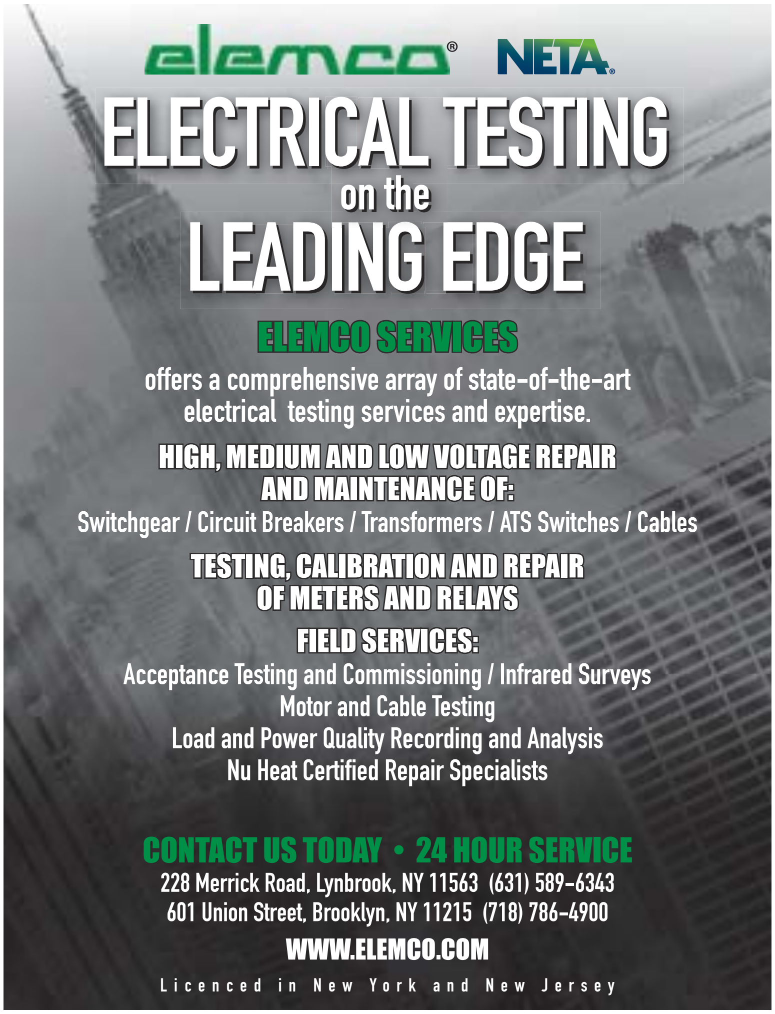


ANSI/NETA STANDARDS UPDATE

ANSI/NETA ETT–2022 REVISION UNDERWAY

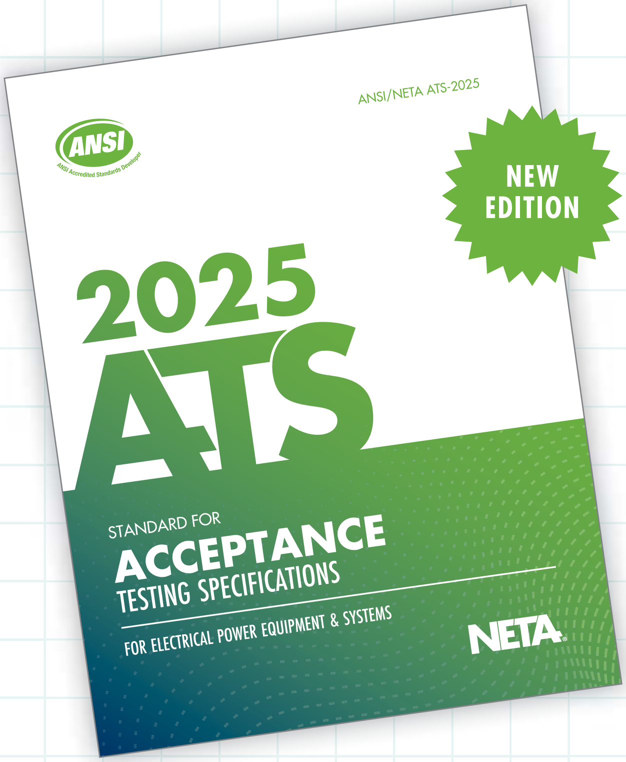
The revision of ANSI/NETA ETT-2022, *Standard for Certification of Electrical Testing Technicians,* is currently underway. The recirculation ballot was issued September 12, 2025, and ended on October 12, followed by the end of the public comment period on October 27, 2025. The updated edition is scheduled for release at PowerTest 2026 and will replace the 2022 edition. Among the key updates is a revised Detailed Content Outline (DCO), which was published in 2023.

The ANSI/NETA ETT standard defines the minimum qualifications for electrical testing technicians, including requirements for certification, training, and experience. It also outlines the criteria for documenting these qualifications and specifies the standards for an independent and impartial certifying body.

BSR/NETA EMW–202X NEW STANDARD UNDER DEVELOPMENT

NETA is in the process of developing a new standard in support of NFPA 70B, *Standard for Electrical Equipment Maintenance,* and validated by the Qualified Electrical Equipment Maintenance Worker (QEMW) qualification exam. This standard defines the minimum requirements for the qualification of QEMWs including training and experience prerequisites, along with the necessary knowledge, skills, and abilities to perform maintenance in alignment with industry best practices, ensuring safety, consistency, and reliability across electrical equipment maintenance practices.

By establishing the BSR/NETA EMW-202X standard and the QEMC/QEMW Program, NETA continues its leadership in supporting the NFPA 70B maintenance requirements and advancing the electrical testing industry.



The recirculation ballot opened October 31, 2025, ending November 30, with the Public Comment Period ending December 15, 2025. The new standard is scheduled for release at PowerTest 2026.

ANSI/NETA MTS–2023 REVISION BEGINS SUMMER 2025

The next revision cycle for ANSI/NETA MTS–2023, *Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems*, will begin in 2025. To support this process, the NETA Standards Review Council will convene a series of Working Groups composed of subject matter experts from across the industry. These Working Groups are to pilot a new approach to early-stage comment review. This beta initiative will also serve to refine procedures in preparation for the upcoming revisions of other ANSI/NETA standards. Details regarding the application process, eligibility criteria, and participation guidelines for future Working Groups will be published on the NETA Standards webpage once available.

The ANSI/NETA MTS–2023 establishes specifications for field testing and inspections to evaluate the continued serviceability and reliability of electrical power equipment and systems. These specifications help ensure that tested equipment operates within applicable industry standards and manufacturers' tolerances and remains suitable for continued operation.

Key updates in the 2023 edition included a comprehensive overhaul of the Cables section and the introduction of a new section addressing Electric Vehicle Charging Systems, reflecting evolving technologies and industry needs. ANSI/NETA MTS–2023 is available for purchase at the NETA Bookstore at *www.netaworld.org*.

ANSI/NETA ATS–2025 NEW RELEASE AVAILABLE IN THE NETA BOOKSTORE

The ANSI/NETA ATS-2025, *Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*, received formal approval from the American National Standards Institute (ANSI) on February 20, 2025.

This standard defines the field tests and inspections recommended to evaluate the suitability of electrical power equipment and systems prior to their initial energization. These specifications are designed to confirm that equipment is properly installed in accordance with design requirements, is operational, and performs within applicable industry standards and manufacturers' tolerances.

The 2025 edition introduces significant new content, including:

- Section 7.28: Battery Energy Storage Systems (BESS)
- Section 7.29: Solar Photovoltaic (PV) Systems
- Table 100.6: Medium-Voltage Cables Acceptance Test Values (Tables 100.6.1 – 100.6.6)
- Appendix B: Guidance for Circuit Reliability Considerations for Medium- and High-Voltage Cable Testing Methods

A noteable revision in the ANSI/NETA ATS-2025 is found in Section 7.4.D.2.a-b., Metal-Enclosed Busways. This update introduces separate formulas for low-voltage and medium-voltage systems and replaces the previous nominal 1,000-foot run length with the actual busway length in feet, enhancing the applicability of testing procedures.

PARTICIPATION

Comments and suggestions on any of the standards are always welcome and should be directed to NETA. To learn more about the NETA standards review and revision process or to purchase these standards, please visit *www.netaworld.org*. To get involved and be considered as a ballot pool member please visit *https://www.netaworld.org/standards/standards-get-involved* or contact the NETA office at 888-300-6382.

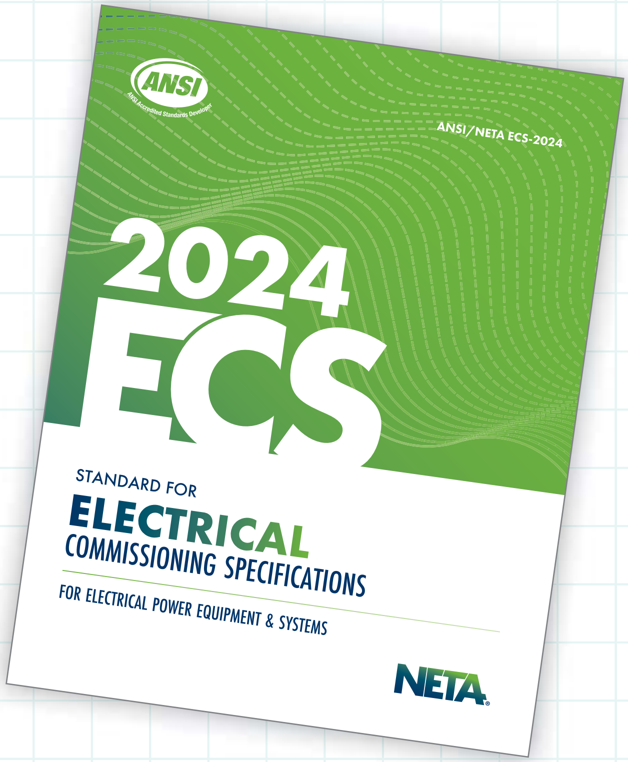
The ANSI/NETA ATS-2025 is available for purchase through the NETA Bookstore, offered in bound print, PDF download, and a Redline PDF (with all changes highlighted) download.

ANSI/NETA ECS–2024

ANSI/NETA ECS-2024, *Standard for Electrical Commissioning of Electrical Power Equipment & Systems*, 2024 Edition, completed the American National Standard revision process. ANSI administrative approval was received on July 2, 2024. ANSI/NETA ECS–2024 supersedes the 2020 Edition.

ANSI/NETA ECS describes the systematic process of documenting and placing into service newly installed or retrofitted electrical power equipment and systems. This document shall be used in conjunction with the most recent edition of ANSI/NETA ATS, *Standard for Acceptance Testing Specifications for Electrical Power Equipment & Systems.* The individual electrical components shall be subjected to factory and field tests, as required, to validate the individual components. It is not the intent of these specifications to provide comprehensive details on the commissioning of mechanical equipment, mechanical instrumentation systems, and related components.

The ANSI/NETA ECS revision includes the following new sections for Source-Specific Systems Commissioning: Photovoltaic (PV), Uninterruptible Power Supply (UPS), and Automatic Transfer Switches (ATS). NW



NFPA 99 UPDATE

BY LEIF HOEGBERG, *Electrical Reliability Services*

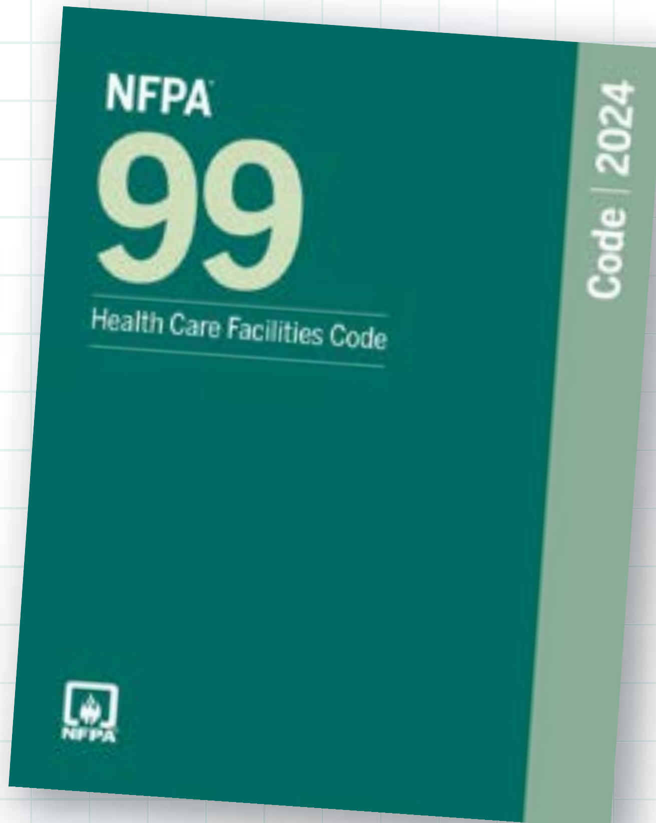
The NFPA 99, *Health Care Facilities Code*: Technical Committee on Electrical Systems (HEA-ELS), met on August 12–13, 2025, at NFPA Headquarters in Quincy, Massachusetts, to discuss new information and actions under consideration for the next edition, planned for 2027.

NFPA 99 establishes criteria for levels of health care services or systems based on risk to patients, staff, or visitors in health care facilities to minimize the hazards and ensure power reliability.

This committee is important to NETA because many NETA Accredited Companies provide testing and engineering services to hospitals and other health care facilities. Patient and worker safety requires electrical equipment and systems to be available and functional, and acceptance and maintenance testing are critical to ensure all equipment and systems function as intended.

The biggest topic, by far, in this meeting was cyber security. Since many electrical devices and systems use software for functionality and communication, this directly touches us in the electrical testing business.

In the future, data and system security, the increasing use of supplemental/alternate power sources instead of or in combination with utility power, and the impact of NFPA 70B on maintenance procedures and intervals in health care facilities are items likely to impact NETA member companies.



No follow-up actions are necessary at this time, other than the required familiarization with the new code once published. NW

Leif Hoegberg *is Director, Engineering & Technical Support at Electrical Reliability Services. In addition to his role as a Principal on the NFPA 99 Technical Committee, he serves on the NETA Board of Directors, the Standards Review Council, and the Training and Finance committees.*

TECH QUIZ ANSWERS

No. 150
ANSWERS

1. b. NFPA 70B. NFPA 70B is a National Fire Protection Association (NFPA) standard that provides guidelines for maintaining electrical, electronic, and communication systems to enhance safety and reliability. NFPA 70B is considered the minimum consensus requirements for safe electrical work practices, and the Occupational Safety and Health Administration (OSHA) can utilize the standard to issue citations.

2. d. Safety and reliability. Maintaining equipment means performing activities to gauge its condition and determine whether it shows signs of decreased functionality. This is directly related to keeping people safe as well as ensuring the equipment can be relied on for continued service.

3. b. Lubricate moving parts. Many maintenance tests are used to gauge equipment performance. However, certain tasks, including lubricating moving parts, improve equipment condition, allowing the equipment to continue to perform properly.

4. a. Visual inspections and walkthroughs. Personnel can use their human senses to observe equipment issues. This includes smells (overheating, ozone, leaks), sounds (crackling, buzzing), and visual observations (physical changes, gauges, and alarms), among others. Site personnel can make this part of their regular checklist.

5. b. Discoloration. Loose connections on current-carrying parts create resistance. When current passes through a resistive connection, it creates heat, leading to discoloration of the conductors over time. Darkening of conductors or nearby insulators would indicate loose connections.

6. c. Deterioration. NFPA 70B points out that equipment failure is possible but can be avoided using maintenance strategies that identify and recognize factors related to deterioration and provide strategies for coping with them.

7. d. All of the above. As a standard, NFPA 70B contains the mandatory language for the development, implementation, and operation of an electrical maintenance program (EMP) and lists the steps required for the most basic approach to building the program. There are various strategies to accomplish the requirements, but all involve this summarized list. The important thing is to have a plan!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HIGH POTENTIAL TESTING JOINS NETA'S ROSTER OF NETA ACCREDITED COMPANIES

HPT Co-Owners (left to right): Dustin Menard, Kyle Fleming, and Doug Williams

Founded in November 2020, High Potential Testing LLC (HPT) founders acquired almost 40 years of combined experience in the industry when they decided to branch off and start their own electrical testing company. HPT is a proud member of IBEW Local 269 and is now a NETA Accredited Company, doing all of its testing to the ANSI/NETA standards.

HPT is a 24/7 full-service testing company that provides acceptance and preventive maintenance testing of low-, medium-, and high-voltage switchgear, breakers, transformers, and cables. HPT has certified thermographers to perform IR scans of electrical equipment, supports 2-hour emergency testing, fault repairs, and temporary power solutions, and offers specialized motor carrier services, hauling electrical components and equipment for remote projects.

HPT's services include infrared thermography, AC and DC load banking, battery testing, high-voltage equipment testing, relay testing, arc flash studies, transformer service and testing, dielectric fluid analysis, load tap changes, circuit breaker testing, power quality recording, ground system testing, and breaker/relay upgrades.

"When we started HPT, we knew that the most important thing we could do for our business was become NETA accredited," says co-owner Doug Williams. "We started on that path immediately by doing business to the standards, and after five years in business, we are so proud to be a NETA Accredited Company and join the ranks of our peers in the industry."

"NETA extends a warm welcome to High Potential Testing LLC," says Dan Hook, President of CBS Field Services and current NETA President. "We applaud the important role our NETA Accredited Companies have in advancing the electrical power systems industry and its safety. Achieving NETA accreditation is something HPT can be proud of, and this recognition is indicative of their accomplishments as an organization." NW

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Sigma-C Power Services Corrections

Correction: In the Industry Topic article "Life After 40: A Critical Look at Electrical Safety's Most Contentious Number," by Matthew J. Robinson, published in the Fall 2025 issue of *NETA World*, Sigma C Power Services LLC was twice incorrectly referred to as Sigma C. The article byline should read: *By Matthew J. Robinson, Sigma C Power Services, LLC.* The opening sentence in the author's biography should appear as follows: *Matt Robinson is the Director of Safety and Training at Sigma C Power Services LLC.* All web and digital versions of this article have been corrected, and NETA apologizes for the error.

Correction: In the NETA News article "Piquette & Howard Electric Service Achieves QEMC Qualification," published in the Fall 2025 issue of *NETA World*, Sigma C Power Services LLC was incorrectly referred to as Sigma C Power Solutions. The opening sentence in the article should appear as follows: *As we began investigating NICET courses and other options, Jim Cialdea at Sigma C Power Services LLC (a partner company to P&H) asked if we would be willing to be part of a pilot program for a new NETA initiative called the QEMC/QEMW (Qualified Electrical Equipment Maintenance Company/Worker).* All versions of this article have been corrected, and NETA apologizes for the error. NW

INFINITY TECHNICAL SERVICES DIVISION ACHIEVES NETA ACCREDITED COMPANY STATUS

Infinity Technical Services Division, Inc. (TSD) strives to help its customers get the most from their electrical equipment throughout its entire lifecycle. From installation and commissioning to maintenance, modernization, and end-of-life planning, TSD provides the expertise and support necessary to ensure electrical systems operate safely, efficiently, and reliably.

TSD's team of experienced professionals is dedicated to delivering an exceptional level of customer service through responsiveness, technical know-how, and a solutions-driven approach. They understand that every client's electrical infrastructure is unique and take pride in tailoring services to meet each customer's specific operational goals, budgets, and timelines.

Whether helping clients establish a proactive maintenance program, enhance safety, or upgrade aging assets with modern technology, Infinity TSD is a trusted partner at every stage of the journey. Their commitment to quality, integrity, and long-term customer relationships drives everything they do. The goal is to give our clients the highest level of confidence in the performance, safety, and longevity of their electrical systems.

"When we first started our company, becoming NETA accredited was one of the major goals we set for ourselves," says President Rich Hicks. "We knew that striving for this achievement would make us better, further develop our service offerings, and help us identify areas for improvement as a company. During this journey, we've attended two PowerTest conferences and have been truly impressed with the wealth of knowledge that NETA and its members bring to the industry. We're honored to be able to say we are members."

"NETA extends a warm welcome to Infinity Technical Services Division," says Dan Hook, President of CBS Field Services and current NETA President. "We applaud the important role our NETA Accredited Companies play in advancing the electrical power systems industry and its safety. Achieving NETA accreditation is indicative of Infinity's accomplishments as an organization." NW

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TAURUS POWER SERVICES RECOGNIZED AS NETA ACCREDITED COMPANY

Taurus Power Services LLC was formed on August 28, 2024. Before this date, the company's test technicians were performing NETA testing services as Taurus Power and Controls Inc., which was established in 1985 and became a full NETA Member in 1999. The company's engineers and NETA Certified Technicians have the training, experience, and certifications to inspect, maintain, and calibrate all types of electrical equipment to the most stringent industry standards.

Taurus offers full-service, third-party, independent testing for electrical power systems and equipment, including maintenance and acceptance testing of low-, medium-, and high-voltage power distribution equipment, serving government, municipal, utility, industrial, and commercial installations, mostly in the Pacific Northwest (Oregon, Washington, Idaho), with occasional national and international opportunities.

Power Services Manager Aaron Statt says, “We are excited for Taurus Power Services to be recognized as an independent entity, succeding Taurus Power and Controls Inc. as a NETA Accredited Company. Our technicians take pride in testing to NETA standards and contributing to a world-renowned organization. The electrical distribution system is the heart of a facility's operation, and we ensure that it's installed correctly, maintained properly, and kept operating as designed. Our goal is to retain our NETA accreditation under the new company name, allowing both Taurus Power Services and Taurus Power & Controls to continue growing. We are confident that operating according to NETA guidelines will allow Taurus Power Services to grow at a rate we would be unable to achieve as an Independent testing entity."

"NETA recognizes the hard work it takes for NETA Accredited Companies like Taurus Power Services to achieve this important milestone," says Dan Hook, President of CBS Field Services and current NETA President. "NETA Accredited Companies play a critical role in securing electrical power system safety and reliability for all, and NETA is a stronger organization because of their dedication to our industry." NW

TAURUS POWER SERVICES LLC POWERED BY

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NETA AWARDS ACCREDITED COMPANY STATUS TO U.S. ELECTRICAL TESTING

U.S. Electrical Testing LLC (USET) specializes in electrical acceptance testing, maintenance testing, and commissioning services for the nation's most recognizable mission-critical facilities, secure environments, commercial and industrial clients, and electrical contractors. The company's capabilities include emergency response, engineering services, and turn-key installation and repair. As a DCSA cleared facility with cleared technicians, USET is eligible to work on classified contracts for the U.S. government. USET is uniquely qualified and trusted to operate in the nation's most secure environments.

Headquartered in the greater Washington DC area, U.S. Electrical Testing offers 24-hour emergency service, with staff on-call 24 hours a day, 365 days a year across the U.S. The company's roster of competent and highly trained technicians and engineers, combined with a network of OEM and aftermarket parts suppliers, enables USET to deliver expertise and reliability-driven solutions to ensure mission readiness.

USET's service offerings — centered around an ever-evolving and improving workflow model that includes planning, scheduling, execution, performance analysis, and reporting — provide objective, third-party independent electrical testing of equipment throughout the entire facility life cycle. From the initial installation and startup phase, through maintenance cycles, and into upgrades and replacements, the company provides the highest quality service at new and existing facilities for its clients anywhere in the world.

"This certification for the company and our NETA-certified electrical test technicians and engineers demonstrates our commitment to providing the highest level of service and quality," says Chris Myers, President of USET. "It sets USET apart from competitors by ensuring compliance verification and giving customers greater confidence in our ability to improve the reliability and uptime of their mission-critical facilities."

"NETA extends a warm welcome to U.S. Electrical Testing, LLC," says Dan Hook, President of CBS Field Services and current NETA President. "We applaud the important role our NETA Accredited Companies have in advancing the electrical power systems industry and its safety. Achieving NETA accreditation is something USET can be proud of, and this recognition is indicative of their accomplishments as an organization." NW

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VARCOMAC ACHIEVES QEMC CERTIFICATION

Left to Right: Bud Huffman, Advanced Distribution & Testing Division Manager; Mike Fones, Senior Vice President of Service; Kelsey Daugherty, Service Operations Manager; Dave Mitchell, Account Executive; and Erik Allen, Critical Power Manager

NETA is pleased to announce VarcoMac as a Qualified Electrical Equipment Maintenance Company (QEMC). The company achieved certification by participating in NETA's new Qualified Electrical Equipment Maintenance Company (QEMC) AND Qualified Electrical Equipment Maintenance Worker (QEMW) program, launched in 2024 to respond to new requirements for electrical equipment maintenance based on NFPA 70B–2023®, *Standard for Electrical Equipment Maintenance®*. The new requirements make proper electrical equipment maintenance mandatory and enforceable.

VarcoMac is a full-service electrical services provider, committed to excellence, safety, and customer satisfaction. The company started as a hometown electrical contractor, and after 40-plus years, is proud to continue its commitment to building and enhancing its communities.

With a team of highly skilled professionals, VarcoMac specializes in a wide range of electrical solutions, from emergency services, power distribution, and low-voltage systems to building automation and preventative maintenance. Their commitment to quality, safety, and customer satisfaction drives them to exceed expectations and build lasting relationships with their clients.

VarcoMac supports the growth and well-being of its staff, fostering a balanced environment where they can thrive professionally and personally. Three of the company's six technicians have achieved Qualified Electrical Equipment Maintenance Worker (QEMW) certification.

"VarcoMac is honored to be a QEMC," says Service Operations Manager Kelsey Daugherty.

"This accreditation is a testament to our unwavering commitment to the highest standards of safety, precision, and accountability. At VarcoMac, we believe that technical excellence and integrity must guide every service we provide. Becoming a QEMC reinforces our mission: to ensure that every maintenance action protects not just the equipment, but the lives and operations that depend on it."

"NETA is proud to recognize VarcoMac as a new NETA Qualified Electrical Equipment Maintenance Company (QEMC)," says Chasen Tedder, NETA QEMC and QEMW Committee Chair. "NETA QEMC-recognized service providers are ensuring their Qualified Electrical Equipment Maintenance Workers (QEMWs) align with new NFPA 70B requirements and lead the way in meeting the growing demand for electrical power system maintenance services." NW

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Hiring a QEMC-certified service provider guarantees compliance with the new NFPA 70B requirements for the company and its Qualified Electrical Equipment Maintenance Worker (QEMW) technicians. Companies interested in becoming a QEMC and/or qualifying their electrical maintenance technicians as QEMWs can contact NETA at QEMC@netaworld.org *to begin the application process.*

BECOME A NETA ALLIANCE PARTNER

If your company is focused on problem-solving and innovating for the betterment of the electrical power services industry, become a NETA Alliance Partner. The NETA Alliance Program is designed for those that work in the electrical testing industry and share in our mission of setting the highest safety standards in the world.

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AEMC INSTRUMENTS REJOINS AS NETA CORPORATE ALLIANCE PARTNER

AEMC® Instruments manufactures professional electrical test and measurement instruments for the industrial, commercial, and utility marketplace.

Founded in 1893, Chauvin Arnoux and its U.S. partner AEMC Instruments (est. 1976) are industry leaders in current measurement probes, power quality and energy analyzers, ground resistance testers (including a revolutionary tower testing system), and insulation resistance testers.

AEMC's full product line also includes clamp-on meters, transformer ratiometers, power quality meters, harmonic power meters, data loggers, multimeters, light meters, micro-ohmmeters, oscilloscopes, cable testers, environmental testers, thermal imaging cameras, and numerous other electrical test instruments.

In addition to their product offerings, AEMC offers seminars and webinars in ground resistance testing, insulation resistance testing, and power quality testing.

AEMC Instruments products are backed by over 130 years of experience in test and measurement instruments and encompass the latest international standards for quality and safety. AEMC Instruments products can be purchased through a worldwide network of distributors and are also offered as custom products on an OEM basis.

"We are honored to join NETA's Corporate Alliance Partner program, standing alongside a distinguished group of companies dedicated to advancing electrical safety, quality, and reliability," says AEMC Marketing Director Kristy Ford. "This partnership reflects our shared commitment to collaboration and to supporting the high standards that NETA champions across the electrical testing industry."

"NETA recognizes the work its Corporate Alliance Partners (CAPs) do for NETA companies and for the industry," says Dan Hook, President of CBS Field Services and current NETA President. "NETA CAPs are industry-leading companies that have joined forces with NETA to work together toward the common aim of improving quality, safety, and reliability. AEMC Instruments was a leading partner for several years, and we are pleased to welcome them back." NW

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AEMC® Instruments was incorrectly identified as a Chauvin Arnoux subsidiary rather than a partner in the print edition. All digital versions of this article have been corrected, and NETA apologizes for the error.

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This qualification program is in response to the recently ANSI-approved NFPA 70B Standard, making proper electrical equipment maintenance mandatory and enforceable. The new program is intended to meet the anticipated demand for vetted, qualified electrical equipment maintenance contractors and workers.

Why become a Qualified Electrical Equipment Maintenance Company?

Facility owners need to provide proof of their maintenance workers' qualifications. Facility owners hiring electrical contractors will choose service providers based on their ability to verify and be assured of the qualifications of a contractor and its workers. The QEMC and QEMW program provides verification of all maintenance worker qualifications.

QEMC Benefits:

Standard Compliance | NETA Verification | Worker Recognition of Expertise

For Contractors - NETA QEMC & QEMW recognition provides a differentiating advantage over competitors.

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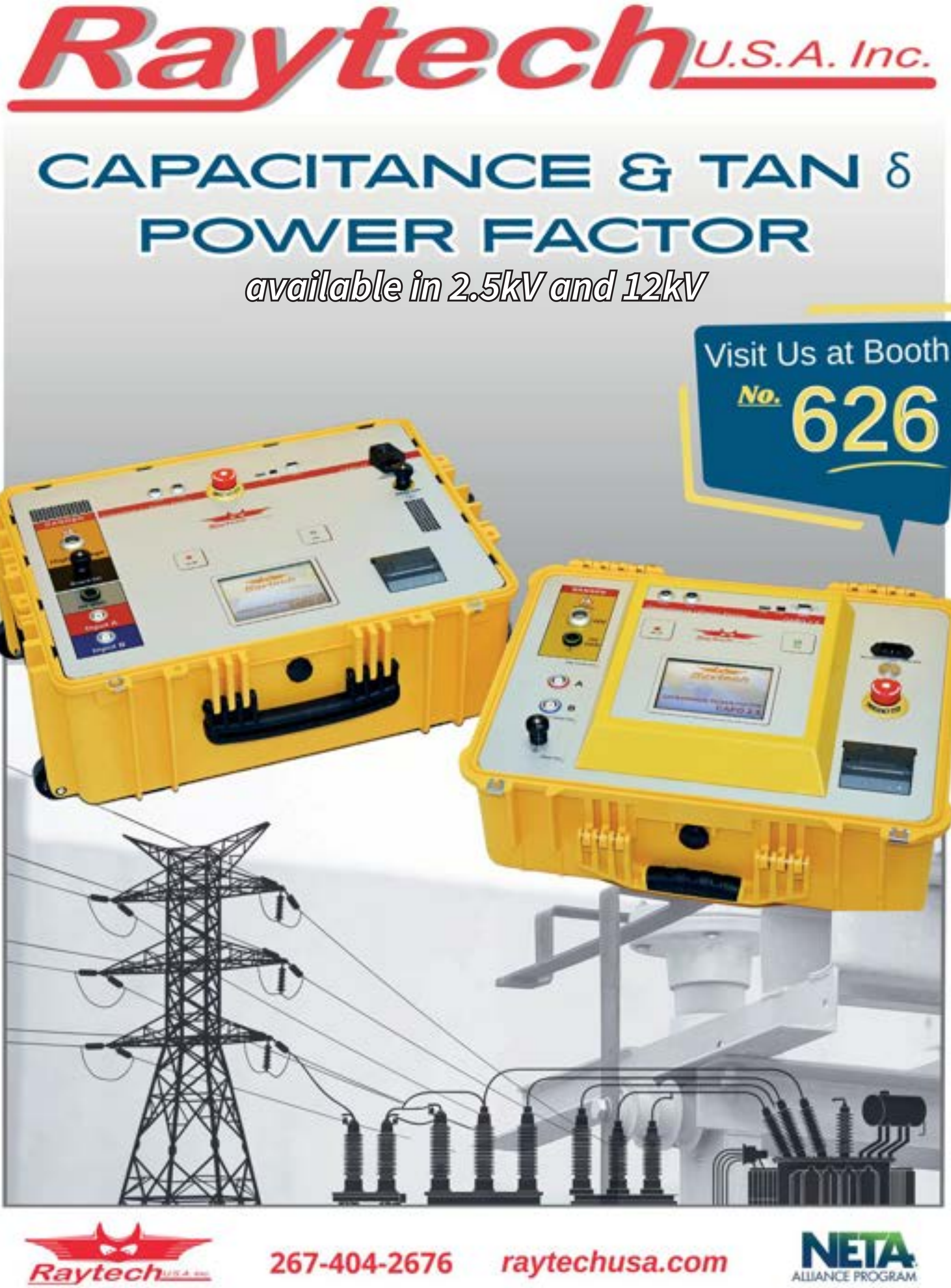

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