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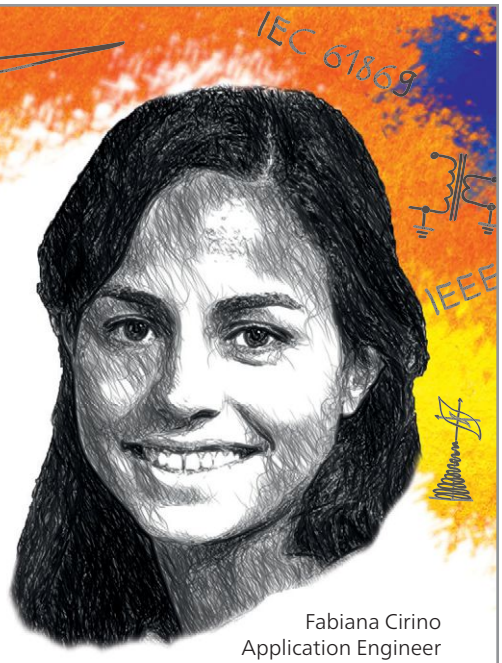

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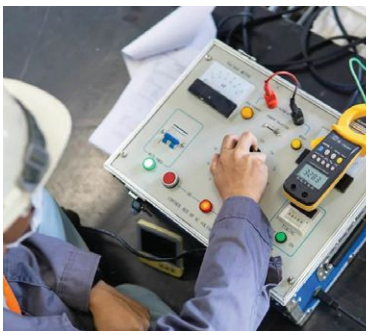

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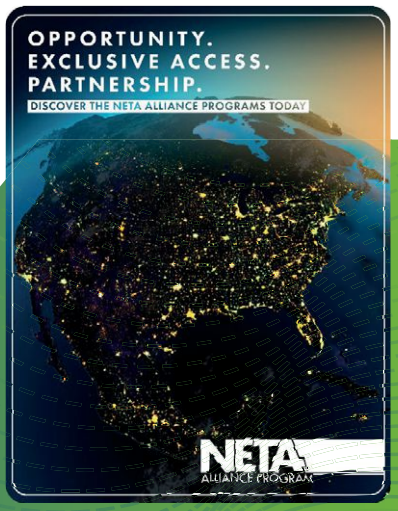

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06 BUILDING THE BENCH: A COMPETENCY-BASED MODEL FOR DEVELOPING ELECTRICAL TESTING TECHNICIANS

By Jakenya W. Hill, Prime Power

10 THE COMPLEXITY OF THE MICROGRID JOURNEY

by Jon La Follett, Mayfield Renewables

14 TROUBLESHOOTING 101

By Tim Shaw, MTA

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BUILDING THE BENCH
A COMPETENCY-BASED MODEL FOR DEVELOPING ELECTRICAL TESTING TECHNICIANS

BY JAKENYA W. HILL,
U.S. Army 249th Engineer Battalion (Prime Power)

The first time I handed a young soldier the leads and stepped back, I learned more about our training program than I did about the equipment. He had passed every classroom block. He could recite the theory. But standing in front of energized gear with a job to do, he hesitated, not because he lacked intelligence, but because nothing in his training had yet asked him to own a result. That gap between knowing and doing is the same gap our entire industry is now staring down, and we will not hire our way out of it.

In the 249th Engineer Battalion (Prime Power), our mission is to generate and distribute commercial-grade power wherever the Army needs it, often under conditions that punish any shortcut. We cannot post a job opening when we are short a qualified technician; we have to build that technician to a standard, and we have to do it predictably. The civilian electrical testing industry now faces the same constraint for the same reason: the demand for qualified field technicians is rising far faster than the supply of people trained to do the work safely and correctly.

Steve Park made this case well in his *NETA World* Fall 2025 article "Workforce Development for NETA Testing Companies," and Robert Harriman built on it with the case for apprenticeship in Winter 2025. This article picks up where they left off and offers a specific, transferable tool: a competency-based development pathway, adapted from how high-reliability organizations build technicians, mapped directly onto NETA's Level 1 through Level 4 progression.

THE PROBLEM IS BIGGER THAN HIRING

The numbers describe a structural shortage, not a temporary dip. The U.S. Bureau of Labor Statistics projects electrician employment to grow 9% from 2024 to 2034, three times the average for all occupations, with about 81,000 openings each year over the decade. The Center for Energy Workforce Development forecasts that 32 million people will need to be hired into energy and infrastructure jobs between 2025 and 2035.

At the engineering end of the spectrum, a joint Kearney and IEEE Power & Energy Society study found the global power sector will need between 450,000 and 1.5 million more engineers by 2030, and that 40% of power-sector executives already report difficulty hiring skilled workers.

Demand is being driven by forces that are not slowing down. The U.S. Department of Energy reports that data centers consumed roughly 4.4% of all U.S. electricity in 2023, a share projected to reach 6.7% to 12% by 2028. Add grid modernization, electrification, and reshored manufacturing, and you have the strongest sustained growth in electricity demand in a generation, all of it requiring equipment that must be tested, commissioned, and maintained (Figure 1).

Projected Employment Growth, 2024-2034

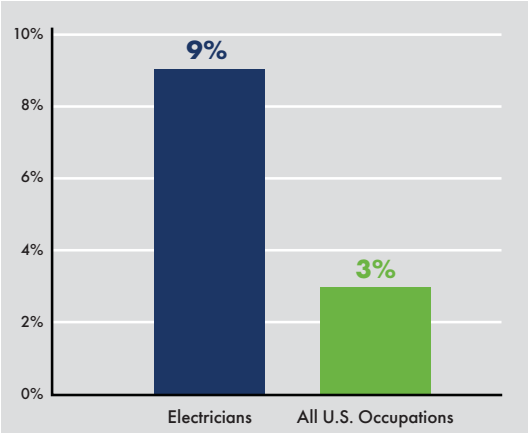

Figure 1: *Electrician employment is projected to grow about three times as fast as the average U.S. occupation, with roughly 81,000 openings every year through 2034. (Source: U.S. Bureau of Labor Statistics)*

Here is the part that should concern every NETA Accredited Company (NAC): Even when candidates exist, the qualified ones are scarce. Industry recruiters report that fewer than 15% of applicants for senior technician roles bring both the required certifications and real mission-critical field experience, and that senior testing and commissioning positions routinely take 60 to 120 days or more to fill. The bottleneck is not headcount, it is competence.

WHY TENURE IS NOT COMPETENCE

The most common way our industry tracks technician development is by time served. A technician has three years, so we assume a certain capability. But time is an input, not an outcome. I have seen soldiers reach genuine field competence in 18 disciplined months, and I have seen others coast for years without ever being asked to perform under real accountability.

This distinction is not academic, it is a safety issue. The Electrical Safety Foundation International reports that 70% of electrical fatalities occur in occupations not classified as electrical work; that is, among workers who were never properly trained for the hazard in front of them. NFPA 70E makes the link between competence and safety explicit: Article 130.5 ties arc flash risk directly to the condition of maintenance of the equipment. In other words, the quality of testing and maintenance is not just a reliability question. It is the difference between a routine work order and an incident.

NETA's own certification philosophy reflects this. The NETA exam is deliberately a field test, not a book test, as it asks whether a technician can answer the question standing in front of the gear without calling a PE. That is exactly the capability a development program has to produce on purpose. It will not appear on its own with the passage of time.

A COMPETENCY-BASED PATHWAY

A development pathway works when each stage is defined by what a technician can demonstrably do, and when every stage maps to an external credential that verifies it. The four stages below align deliberately with the four levels defined under ANSI/NETA ETT, *Standard for Certification of Electrical Testing Technicians for Electrical Power Equipment & Systems*.

Stage 1: Electrical Fundamentals

Before a trainee touches a test set, the fundamentals have to be solid: AC/DC theory, three-phase power, grounding and bonding, instrumentation, and, first and foremost, electrical safety and NFPA 70E. This is the Level 1 Trainee Technician phase, where the individual works strictly under the supervision of a certified technician and is qualified to assure their own safety and little else. The goal of this stage is not productivity; it is to build the mental model that every later test result will be interpreted against.

Stage 2: Apparatus-Specific Theory

Next, the technician learns the equipment itself, transformers, switchgear, circuit breakers, cables, protective relays, and the why behind each test. This is where the ANSI/NETA standards become the curriculum: the Acceptance Testing Specifications (ATS) for new equipment being placed into service, and the Maintenance Testing Specifications (MTS) for equipment already in service. A technician who understands why an insulation-resistance or power-factor result matters has crossed the line from operator to diagnostician. Pairing this stage with the Level 2 Certified Assistant Technician exam, which requires roughly two years of experience plus documented safety and technical training, gives the milestone teeth.

Stage 3: Supervised Field Application

Theory is validated in the field, under a qualified mentor who is watching, correcting, and signing off. This is the stage most often shortchanged, and it is the one that produces the hesitation I described at the start. The technician runs real tests on real equipment, documents the results to standard, and is progressively given more to own, but always with a certified technician accountable for the outcome. In military terms, this is structured on-the-job training (OJT) against a defined task list, not "shadowing."

Stage 4: Independent Qualification

Finally, the technician demonstrates that they can plan, perform, evaluate, and document complex testing independently, and can supervise others doing the same. This is the Level 3 Certified Technician and, ultimately, Level 4 Certified Senior Technician territory, milestones that require five and 10 years of qualifying experience, respectively, along with cumulative safety and technical training hours. At this stage, the technician is not just executing the

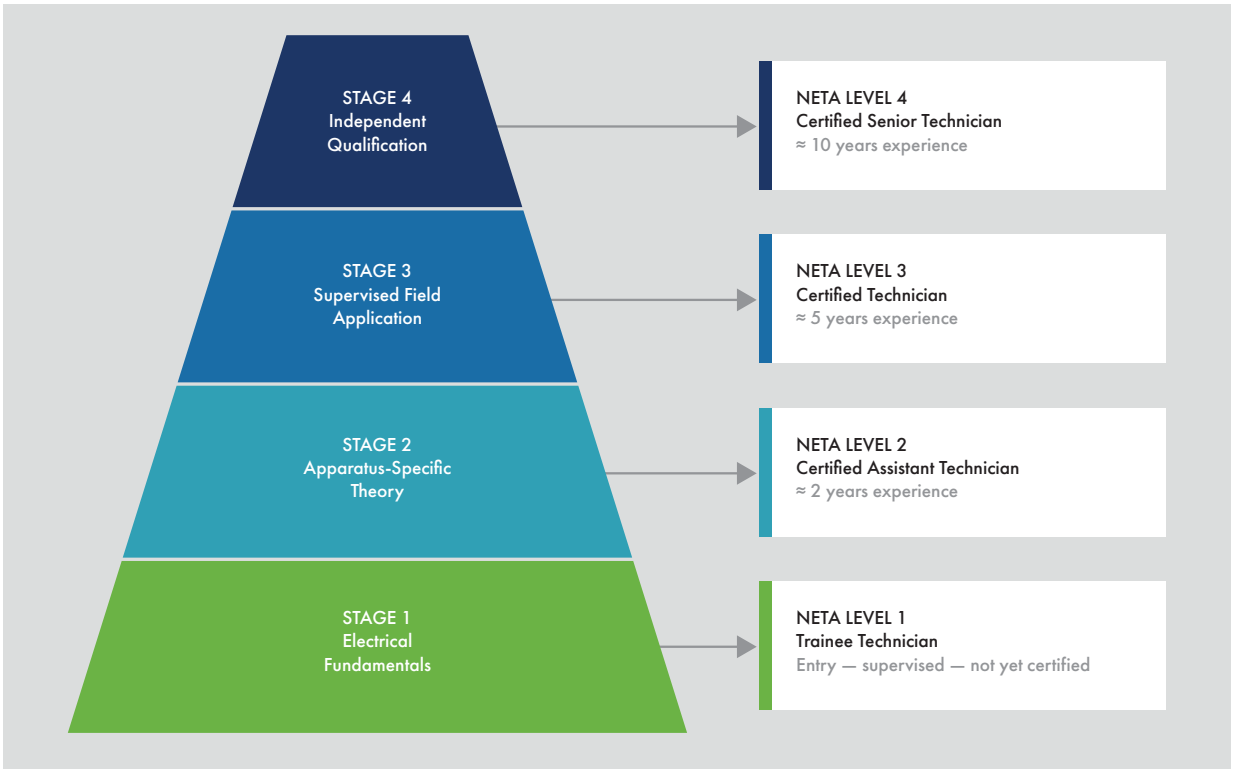

Figure 2: *In a competency-based development pathway, each stage is defined by what a technician can demonstrably do and is verified by the corresponding NETA certification level, not by time served.*

standard; they are the person the standard relies on (Figure 2).

CREDENTIAL THE PROGRESS, NOT THE CALENDAR

The advantage of mapping your pipeline to NETA's levels is that the milestones are externally verified. A technician does not advance because a year has passed; they advance because they passed a proctored, standards-based exam administered through a NAC. That is a defensible, auditable definition of competence, exactly what a safety-critical trade should demand.

Two points are worth making clearly to anyone building such a program:

- **NETA certification and engineering licensure are different ladders, and that is fine.** A NETA Certified Technician is credentialed to perform and evaluate field testing. The NCEES Fundamentals of Engineering (FE) exam, by contrast, is the first step toward Professional Engineer licensure, a separate engineering track administered by a different body. The two are complementary: the certified technician executes and documents the testing; the PE performs the engineering studies behind it. Encouraging a technician with the aptitude and interest to pursue the FE strengthens your bench; it does not replace NETA certification.
- **Recertification keeps competence current.** NETA certification runs on a three-year cycle and is maintained through continuing technical development. A development program should treat recertification not as paperwork but as the mechanism that keeps a hard-won standard from quietly eroding.

MAKE IT STICK

The difference between a training program and a stack of training events is consistency. In the military, we hold that consistency with three tools that translate directly to a NETA company:

- **A standardized task list.** Every technician is trained against the same defined, observable tasks, signed off by a qualified evaluator. This is the single most powerful tool for making competence portable across crews and locations.

- **Deliberate mentorship.** Pairing each developing technician with an accountable Level 3 or Level 4 mentor turns field hours into structured learning instead of incidental exposure. The mentor's job is to make the trainee perform, not to perform for them.
- **Documentation as a habit.** If progress is not written down, it did not happen, and it cannot be audited, transferred, or trusted. A simple qualification record per technician protects the company, the customer, and the worker.

None of this requires a training department the size of a battalion. It requires a defined standard, someone accountable for it, and the discipline to credential progress rather than assume it.

CONCLUSION

The electrical testing industry's workforce gap will not be closed by recruiting alone, because the scarce resource is not people; it is demonstrated competence in a safety-critical trade. NETA has already given us the framework: four certification levels, a body of standards that defines the work, and exams that test whether a technician can perform it. Our job as leaders is to build the pathway that carries a new technician from fundamentals to independent qualification, and to credential each step honestly along the way.

Build the bench deliberately, to a standard, and verify it. The grid we are being asked to test and maintain is counting on the result. ■

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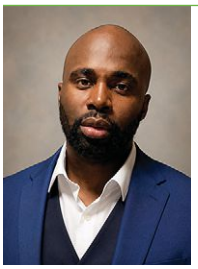

SSG JAKENYA W. HILL *is a Prime Power Production Specialist (12P) and power station leader with the U.S. Army's 249th Engineer Battalion (Prime Power). He is the first NETA Level 4 Certified Senior Technician in his battalion's history and also holds NICET Level III and Observer/Coach/Trainer (OC/T) certification. A distinguished honor graduate of the U.S. Army Senior Leader Course, Hill leads a prime power section, develops and qualifies junior technicians, and is preparing for the NCEES Fundamentals of Engineering (FE) exam.*

THE COMPLEXITY OF THE MICROGRID JOURNEY

BY JON LA FOLLETT,
Mayfield Renewables

Having been involved in hundreds of microgrid projects leads to some emerging patterns. It takes a lot of effort to make a project happen. Oftentimes, projects can go sideways because it takes so many different parties to take a project from ideation to operation. Without a holistic view of the microgrid journey, projects are bound to encounter more challenges than expected.

This is a particularly challenging issue for microgrids when compared to single-asset-class projects like solar-only or baseload prime power applications. Microgrid use cases and component lifespans vary widely.



AUTHOR'S NOTE:
The traditional definition of a microgrid specifies that the system can island from the grid, a requirement to provide power during grid outages, i.e., resilience. In this case, we expand the definition to also include any multi-distributed-energy-resource (DER) system that provides a benefit to the site host. For example, a grid-tied solar-plus-storage system would qualify as a "microgrid" for the purposes of this article. The ability to island has no bearing on the milestones below.

Microgrid projects are new enough that there is insufficient standardization of terminology, scope, and phases in the development lifecycle. A diverse set of expertise is required to design, build, and operate a microgrid.

This article aims to provide a high-level overview of the key phases of a microgrid project lifecycle, focusing on the key milestones rather than giving names to different phases. Our goal at Mayfield Renewables is to begin sketching out a roadmap for the budding microgrid industry by highlighting a few key hazards to avoid and opportunities for value creation.

Despite notorious complexity, there are a few key milestones shared by all microgrid projects: off-take agreement closed, financing closed, notice to proceed for construction (NTP), commercial operation date (COD), and decommissioning.

MILESTONE 1: SIGNED OFF-TAKE AGREEMENT

Having spent a significant amount of my career in the development world, I always smile a little bit on the inside when I see project plans begin with a signed off-taker agreement. It pains me to see zero space to the left of that milestone, because I know how much effort is required to achieve that first step. For every one hundred decent proposals that get put in front of a C&I customer for a microgrid project, at most five to ten will be signed. And that's not to mention all of the less attractive proposals that are rejected out of hand.

Obviously, the key aspect of this stage is providing a compelling value proposition for the off-taker, then negotiating terms that enable enough value for the off-taker, the developer, and the financing party. This can be very challenging because many of those details are unknown at this stage in the project lifecycle. Details impacting project CAPEX and OPEX, such as equipment selection and the cost of capital, are not yet finalized. The developer must negotiate terms that have sufficient margin for those parameters to change a reasonable amount before the project can be financed. However, if later milestones are not carefully considered when negotiating the off-take agreement, key constraints may cause the project to stall several months or even a year later. The terms in the off-take agreement must be acceptable to the financing party. The initial microgrid design must

be constructible at a cost that is consistent with the current assumptions. These are just a few examples.

Key risks to mitigate before crossing Milestone 1:

- Design changes
- Project cost uncertainty
- Unachievable off-taker value proposition
- Project revenue uncertainty, e.g., valid incentive assumptions

MILESTONE 2: FINANCING CLOSED

Once a signed off-take agreement is in hand, the project moves to the second milestone, where preparations are made for underwriting, or financial closure with a capital provider. Most C&I microgrid projects are financed by third parties for various reasons. The site owner may not have the ability to monetize tax incentives. They may not have capital available for the project. Or they may simply be more comfortable investing that capital into their facilities or core business, investments that they are much more familiar with and therefore have higher confidence in the projected returns or payback periods.

Financing entities will generally want to see that you have site control and interconnection approval before playing ball, which is why finding an off-taker is the first milestone. After the deal structure is finalized, the financing terms, including cost of capital, are put in place based on a host of factors that will be considered by the financing party. This part of the process can take several weeks or even months, depending on the complexity of the project and the off-taker.

Once the financing agreements are closed, the project is considered Financially Closed. The financing party will release limited funds to reduce remaining uncertainties and secure funding so that they can give notice to proceed, which brings us to Milestone 3.



Frontwave Arena in Oceanside, California

Key risks to mitigate before crossing Milestone 2:

- Financing costs and other conditions that impact project economics
- Permitting or environmental risks

MILESTONE 3: NOTICE TO PROCEED (NTP) WITH CONSTRUCTION

By this point, underwriting is generally completed, construction financing has been secured, project planning has been done thoroughly and completely, and there is little uncertainty around scope or execution. The project is ready to move forward—or not. From a practical standpoint, this is the last chance to stop it before incurring major expenses.

The name of the game in Milestone 3 is to move as quickly as possible through construction while sticking to the project plan. Scope changes in this phase are the costliest in terms of both time and money. This is when all the preliminary planning, feasibility analysis, etc., really comes to fruition.

The utility will issue permission to operate (PTO) after post-construction witness testing. Note that PTO does not mean the system is fully operable yet. Depending on the financing method, further steps may be necessary before the system is ready to turn on.

Key risks to mitigate before crossing Milestone 3:

- Long lead-times for key equipment (e.g., batteries or thermal generators)
- System designs are feasible and meet key local requirements
- Construction cost and timeline uncertainty

MILESTONE 4: COMMERCIAL OPERATION DATE (COD)

We made it. We're at the finish line, so to speak. The microgrid has been fully installed, electrically



Orcas Center Microgrid in Eastsound, Washington

connected, and approved by the utility. Financing is in place, and any off-taker agreements are active. Tax equity investment needs to close during this phase in order for those investors to qualify for tax credits like the Investment Tax Credit (ITC). There may be a lag period of a few weeks, or longer, between PTO and Milestone 4. It's time to flip the switch and start generating electricity, providing bill savings and backup power, etc.

As the microgrid enters its operating phase, O&M agreements take front stage. Agreements with the site host, equipment vendors, or other stakeholders are in place to ensure the microgrid provides the performance benefits that were promised and will yield the expected financial returns.

Key risks to mitigate before crossing Milestone 4:

- Tax equity investment secured
- Utility requirements satisfied for permission to operate

MILESTONE 5: DECOMMISSIONING

Just kidding about the whole finish line thing. Developers must also peer into the future to consider what happens as microgrid components retire. What's considered end-of-life can vary widely for various parts of the microgrid. Generally, PV modules will be expected to last 25 to 30 years, while inverters, batteries, and AC equipment may last 10 to 15 years. Someone has to pay to retrofit, decommission, and/or recycle equipment, and those costs and responsibilities should be baked into the preliminary planning.

Key risks to mitigate before crossing Milestone 5:

- Unexpected costs
- Environmental regulations

CONCLUSION

The throughline for all five of the above milestones is that complexity leads to financial uncertainty that must be addressed with feasibility analysis and planning. Microgrids are much harder to develop than single-asset-class projects and are relatively new investments for financiers to wrap their heads around. As a developer moves through the microgrid journey, the cost impact of a scope change expands quickly. So, start planning early, get a thorough feasibility study, and make sure all stakeholders are aligned as early as possible. ■



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TROUBLESHOOTING 101

BY TIMOTHY SHAW,
MTA Electrical Engineers

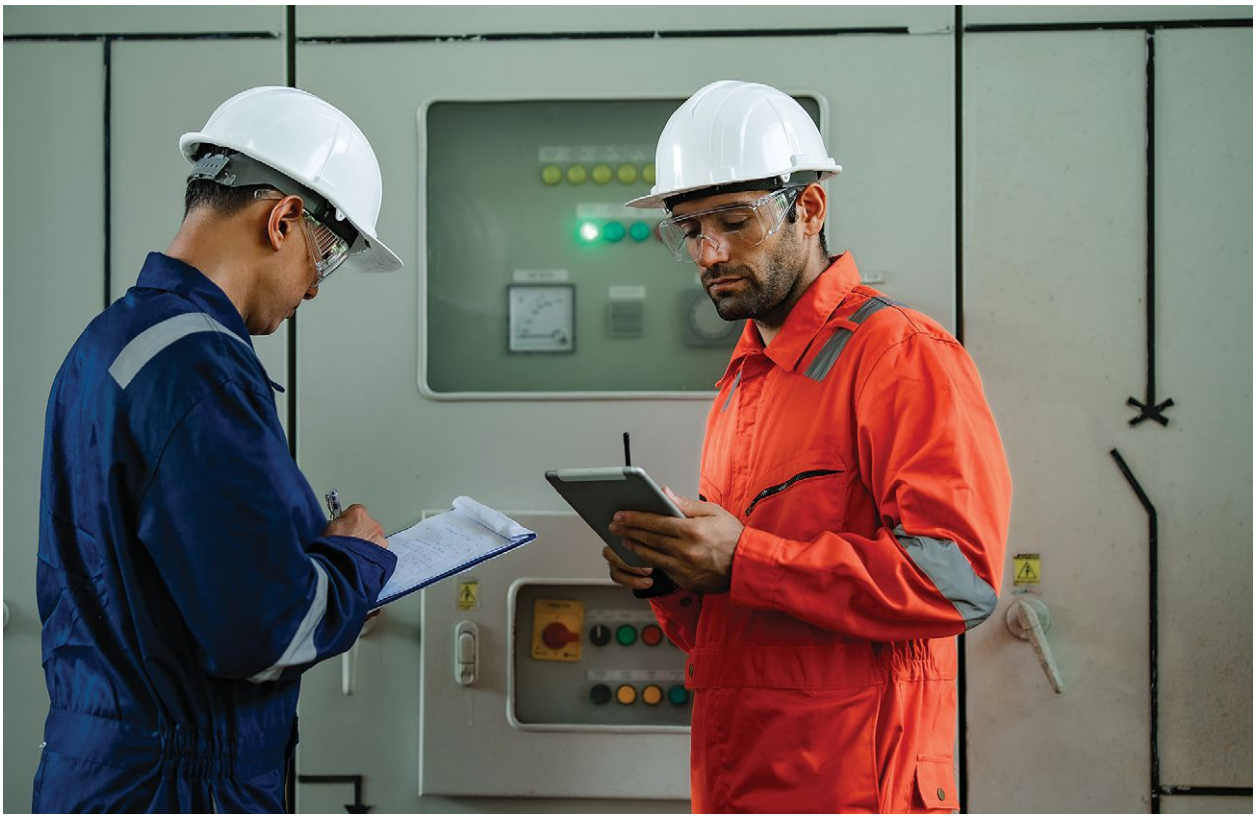
Troubleshooting is part art, part science, pure and simple. Troubleshooting is also universal: Whether it is electrical, mechanical, or something else, the same concepts will always apply.

You must learn three elements of troubleshooting:

1. **Patience.** It takes time to troubleshoot, and you may find yourself at the point of complete frustration, but hang in there; as you narrow the search, the light will get brighter.
2. **Understanding.** Many of the systems you troubleshoot will be different. You may troubleshoot a breaker control scheme one day and an operational control system the next. Despite how different these systems may be, the troubleshooting process will essentially be the same.
3. **Thinking outside the box.** Don't assume that troubleshooting will require a single, conventional solution. There will be times when you will think of something totally unrelated, yet it will give you the clue to solving this problem.

RULES

Next are certain rules that apply to basic troubleshooting:



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1. **Rule One.** You must know how the failed system should have worked. If you don't know how it works, take the time to investigate the technical documentation and drawings, or ask on-site personnel how they believe it should work. Remember, the only dumb question is the one that is not asked.
2. **Rule Two.** The majority of your testing will not be done on the equipment itself. Rather, it will be on paper, suggesting possible issues, prior history, or even hearsay. Your goal is to create a hypothesis, or hypotheses, that can be tested.
3. **Rule Three.** This is an important one—you must try to prove your hypothesis is wrong. Most technicians troubleshoot by trying to prove their hypothesis correct, and when a test proves otherwise, they begin to believe the test itself was wrong. Then they go try to prove their hypothesis is correct with a different test. This only wastes time and builds frustration. Hypotheses need to be tested to failure. You may not have the right idea at first, but as stated by Sherlock Holmes, "When you have eliminated the impossible, whatever remains, however improbable, must be the truth."
4. **Rule Four.** You must have good test equipment—calibrated and ready for use. Using poor test equipment can lead you down a black hole and waste an enormous amount of time. For example, if you are looking for continuity, make sure that your meter works both before and after you test.
5. **Rule Five.** Use your resources. Listen to those who have tested the equipment before. Find out what their experience level is and what they have tested. If you trust their ability, then you have a ready source of information that will enable you to narrow down your search criteria.
6. **Rule Six.** Document everything. Write it down and take photos. Do not leave room for uncertainty. Doubts may surface unless you have proof.

GATHERING INFORMATION

The next part of troubleshooting will be the Who-What-Why-Where and How of testing. These five Ws are not just for journalism; this will provide key information for your troubleshooting techniques.



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1. **Who** was present during the failure? You will need to know who that individual is as well as their partiality and reliability. Case in point: If they were disgruntled, could they have caused the issue(s)? What can they tell you about what was going on and what indications they experienced? Record this information as it may prove useful later.
2. **What** was going on at the time of failure? Was the equipment starting, stopping, running, or just sitting idle? All these points are important in helping you determine which part of the equipment to start your investigation with.
3. **Why** did it fail? Is the equipment 50 years old and already on the brink of failure? Or could it have failed because something new was introduced? You may not be able to answer this question, but defining a problem is the halfway point to finding a solution.
4. **Where** in the equipment did the failure occur? You may think this also involves equipment in motion.
5. **How** did it fail? Did a $3,000 part fail to protect a $3.00 fuse? Did a mechanical problem create an electrical problem or vice versa?

These questions can take as little as 10 minutes, but the information they provide will help you narrow down the scope of the investigation. Remember, these are just suggestions that may or may not apply. Sometimes the issue will be as obvious as a large smoking hole in the equipment where you can see the short-circuit damage.

PREPARE

Now that you have spent the time gathering the findings, let's look at what you need to do to continue the troubleshooting.

1. Gather all available drawings. These are critical because they help you understand where to look further. Experience has shown that many customers don't have the drawings that were provided years ago.
2. Gather all test data that may have been performed on the equipment. If you see a pattern, you may be able to narrow down your search area.
3. Use paper! Write down everything you see or think might be the issue. This also enables others to see your thought process and offer



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ideas. Don't dismiss their ideas, as they may be the ones who can see the forest through the trees. Remember, the longer you troubleshoot, the more likely you are to dig yourself into a trench you cannot see out of.

SIX-STEP TROUBLESHOOTING METHOD

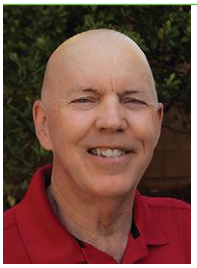
1. Identify the problem. This was done when you answered the Who-What-Why-Where-How.
2. Establish a theory of probable cause. This is your first attempt at troubleshooting. You will write down ideas of what you believe could have caused the problem. Remember: Human elements may be the cause of the issue.
3. Test the theory to determine the cause. This is where you prove your theory wrong. If you keep trying to prove yourself right, you may become frustrated and waste valuable time, instead of accepting that the original idea you came up with is wrong.
4. Establish a plan of action and implement the solution. This is the stage of the process where you must test your ideas. Sometimes it is as simple as determining that the fuse blew. Now you must address the question of WHY the fuse has blown. Sometimes we answer the question only to find new ones hiding behind them. Please also remember: If you are replacing parts, check to be sure you are not installing an old failed part. Blown fuses can wind up back in the new fuses box, so double-check them before you install.
5. Verify full system functionality. After you fix the problem, you must verify that the solution works. Don't just assume that you are done and walk away. You might get a call back in a few minutes/hours/days to say it still doesn't work.
6. Document findings, actions, and outcomes. No job is complete until the paperwork is done. This critical step includes the following:
   a. Document the findings of what failed and why it caused the issue. The customer will want to justify the expense of having hired you to troubleshoot the issue.
   b. This paperwork can be used later to confirm that the issue was corrected or if there is now an underlying issue that will cause this issue to occur again.
   c. This document can also be used to teach others about a particular issue or used as a reference should additional problems occur with the equipment.

Typically, electrical issues are difficult to find but easy to fix, while mechanical issues are usually easy to detect but painful to fix. Every troubleshooting adventure is also a training lesson, not only for you, but for the next technician as well.

If you are just learning to troubleshoot, adopting this policy might help you: When you have an issue, take at least 15 minutes to work through the issue yourself. Don't take more than 30 minutes, though, because at that point you may find yourself in that trench we mentioned earlier. Also consider reaching out to experienced colleagues who can help you gain insight into the issue.

CONCLUSION

No one becomes a troubleshooting expert overnight. It will take time to build your knowledge base so you can see patterns in failures. Be patient with yourself as you build the knowledge and skills to deeply understand the systems and equipment you will be working on. Finally, thinking outside the box allows for creative solutions to difficult troubleshooting problems. ■



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