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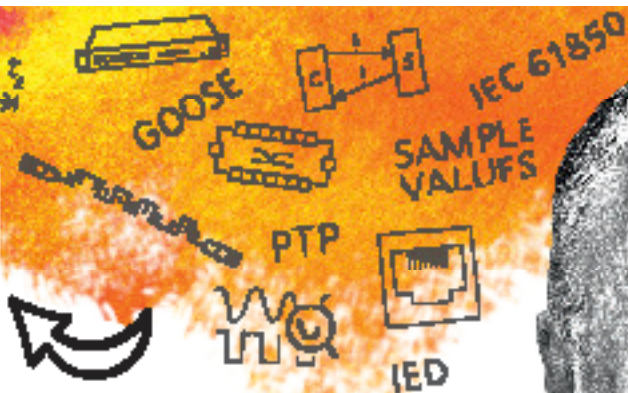


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systems industry.



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BUILDING THE FUTURE: APPRENTICESHIPS FOR AMERICA'S ELECTRICAL TESTING WORKFORCE

BY ROBERT HARRIMAN, NETA

America's power demand is increasing at a staggering rate, requiring more infrastructure and, with that, the workforce to ensure it is built, tested, and maintained to the highest standards. However, this is at odds with America's shrinking labor market, a problem previously highlighted by Steve Park in his *NETA World* article titled "Workforce Development for NETA Testing Companies."^[1] This deficit will be further compounded by an entire generation set to be fully within their retirement window by 2030 (U.S. Census, 2019).^[2]

How does a growing critical industry build, develop, and maintain a workforce in a shrinking labor market? As with many highly technical fields, the

answer is an effective apprenticeship program. Now, the InterNational Electrical Testing Association (NETA) and the U.S. Department of Labor (DOL) have partnered to bring this answer to fruition for NETA Accredited Companies (NACs).

NETA and the U.S. DOL have worked together to ensure a program that has been vetted by electrical testing industry experts and the federal governing body for apprenticeships, bringing together the rigor and excellence needed by the electrical testing industry, while ensuring adaptability for each NAC's unique position.

A few questions remain:

- What are the benefits of an apprenticeship?
- How is NETA supporting the apprenticeship program?
- How do I start an apprenticeship program?

THE BENEFITS OF AN APPRENTICESHIP PROGRAM

Apprenticeship programs have been a tried-and-true method of enhancing an industry workforce since 1937. This sentiment rings true today with the U.S. Department of Labor hosting over 27,000 registered apprenticeship programs across 1,200 disciplines (Bureau of Labor Statistics, 2022).^[3] Between 2015 and 2025, the number of apprentices enrolled in a registered program has increased by 93.72% (Table 1). With so many companies opting to sponsor apprenticeships, what benefits are they receiving?

A Dependable and Competent Talent Pipeline

The current supply of NETA-certified technicians is uniquely precarious, even compared to other highly skilled careers.

Table 1: Apprentice Growth by Fiscal Year 2015–2025

	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Apprentice Count	359,388	395,783	437,826	492,024	548,484	563,268	571,643	593,557	631,404	670,086	696,205
Year over Year		▲10.13%	▲10.62%	▲12.38%	▲11.48%	▲2.70%	▲1.49%	▲3.83%	▲6.38%	▲6.13%	▲3.90%
Growth from 2015		▲10.13%	▲21.83%	▲36.91%	▲52.62%	▲56.73%	▲59.06%	▲65.16%	▲75.69%	▲86.45%	▲93.72%

SOURCE: APPRENTICESHIP USA^[4]



PHOTO COURTESY AVO TRAINING INSTITUTE

As Fiona W. (2025)^[5] put it: *NETA accreditation requires not just electrical engineering knowledge but specialized training in high-voltage testing, relay protection systems, and commissioning protocols that can mean the difference between reliable power and catastrophic outages. Industry analysts describe the certified technician pipeline as experiencing a ‘supply chain crisis’ of human capital — a scarcity that translates directly into pricing power and competitive moats...*

Having programs in place to ensure these demands are met is key to driving forward in a growing industry.

An apprenticeship program addresses this issue in two ways:

1. First, it provides a vetted and approved framework for how your apprentices will be trained through a four-year program with a hybrid learning approach of on-the-job training (OJT) and classroom instruction, also known as related instruction (RI). This structure ensures apprentices learn the necessary skills and achieve specific knowledge checks throughout the program.
2. Second, it provides additional exposure through federal and state resources to fill vacancies in your apprenticeship program and in your company.

Lockheed Martin expressed the advantages apprenticeships have had for their company, especially in gaining exposure to a population of young adults who may not be seeking traditional four-year degree programs, enabling them to tap into another avenue for recruiting future talent (*Apprenticeship.gov*, 2017).^[6]

Reduced Cost to Train New Technicians

NACs are not only working with a limited pool of new technicians but also with the burden of providing the highest quality technical and safety training. Depending on a technician’s knowledge before joining a NAC, education costs can range from \$1,500 to over \$10,000. Companies that have a Registered Apprenticeship Program (RAP) will have access to a multitude of resources available to them at the federal and state levels. These resources can range from grants directly to training costs of an apprenticeship program, to tax incentives to reduce a company’s burden of training a new employee (*Apprenticeship USA*).^[7]

NETA’S ROLLOUT AND SUPPORT

Over the last 10 years, NETA’s Training Committee has worked to create an outline that captures rigorous adherence to safety and technical capability, while also allowing the necessary customization that may

be needed for NETA's various members. Ultimately, it leads to the Electrical Testing Engineering Technician Apprenticeship category, with an approved outline known as a National Guideline to Apprenticeship Standards (NGS).

What Is the National Guideline to Apprenticeship Standards (NGS)?

An NGS is a template of high-quality apprenticeship program standards submitted by a trade, industry association, or other organization with national scope. Companies or organizations that choose to adopt NGS as their apprenticeship program may register with a state or local affiliate as long as they meet any additional requirements. When adopting the NGS, the company or organization may choose to modify or use an unmodified version of the NGS (*ApprenticeshipUSA*, 2022).^[8] The NGS will give NACs the ability to meet the standards of becoming an electrical technician, adapting to their company's needs or to the specific requirements of their state, while also having direct input in managing their apprentices.

complete a boilerplate, which is the overarching application document, and cover Form ETA 671 for the apprenticeship agreement between the company and the apprentice. To acquire a copy of the NGS document (Appendix A), contact NETA's Training Program Manager. Several member companies are already in the review process, waiting for final approval to begin recruiting the first generation of Electrical Testing Engineering Apprentices.

NETA is continuously seeking new learning opportunities to help members achieve the related instruction for apprenticeship requirements. These resources include quality distance-learning options through NETA's online bookstore and learning management system (LMS) or training partners, traditional learning institutions, or industry-led instruction. The goal is to assist NACs in finding a learning partner or pathway that best fits their needs.

WHAT'S NEXT?

NETA intends to continue to provide continuous value to its members, including training offerings related to the apprenticeship. These offerings include increased online training offerings through NETA's bookstore with our approved training partners, linking members to industry-leading training that meets apprenticeship requirements, or assisting our members in finding institutional learning partners.

CONCLUSION

As the electrical testing industry continues to grow at an exponential pace, so too must its workforce. NETA is helping the industry address this growth with its National Guideline of Apprenticeship Standards for an Electrical Testing Engineering Technician Apprenticeship. This program will provide NETA Accredited Companies with additional exposure through federal, state, and local resources, a professionally reviewed outline that has been directly compared with testing standards, and by opening the opportunity for these companies to apply for federal and state financial opportunities to supplement the burden of training the next generation of electrical testing technicians.

If you are interested in becoming a sponsor for the Electrical Testing Engineering Technician Apprenticeship, have any additional questions, or



NETA is continuously seeking new learning opportunities to help members achieve the related instruction for apprenticeship requirements.

Where Does the NETA Apprenticeship Program Currently Stand?

The NETA NGS (Appendix A) is fully available for your company to begin the sponsorship process with the U.S. Department of Labor and your state's apprenticeship office. Having a complete outline will allow for an expedited sponsorship application process. At a minimum, a company applying for apprenticeship sponsorship should expect to

have any recommendations, please contact NETA Training Program Manager Robert Harriman at Rharriman@NETAworld.org.

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ROBERT HARRIMAN is the Training Program Manager at the InterNational Electrical Testing Association (NETA). He has been in public sector training management and program operations for over 13 years. Harriman has held roles as a leadership instructor and program manager for Weapons of Mass Destruction & Hazardous Material Reconnaissance training and hazardous material response operations and training for the U.S. Army. In his current role at NETA, he brings expertise in learning methodologies and program management to analyze and implement the association's training initiatives. Harriman has 13 years of military service and still serves as a Sergeant First Class (SFC) with the Army Reserve. He earned a BAS in technical management at the American Military University.

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LEADERSHIP DEVELOPMENT FOR AN ETA-ACCREDITED COMPANY

BY STEPHANIE McLAUGHLIN,
Hood Patterson & Dewar

Before joining Hood Patterson & Dewar (HP&D), I worked in the luxury automotive industry, where I managed an instructional design team for an organization responsible for the distribution, marketing, and customer service for their brand of products in the United States. Our team was responsible for all online and in-person sales and leadership training curricula for their dealerships in the country.

Our CEO at the time believed that customers were looking for luxury vehicles as well as luxury experiences in sales and service. He believed that



Figure 1: The Employee Journey

cultures within the dealerships determined whether customers would experience the level of luxury they expected. He also believed that the leaders within the dealerships were directly responsible for creating the necessary cultures. Therefore, he envisioned a leadership program built specifically for these leaders. Thus was the launch of the “Driven to Delight” mantra that would become the guiding principle for us in the leadership training department.

Personally, I have experienced great leaders as well as...we’ll say not-so-great leaders. Intuitively, I enjoyed my work and felt more engaged under the great leaders. After seeing the success of this leadership program and the impact of leaders who engaged themselves and committed to creating Driven to Delight cultures, I became a believer in the importance of providing leaders with development opportunities.

Everyone at Hood Patterson & Dewar is a leader. Whether they’re leading themselves, a project, or a team — everyone is leading something. At HP&D, we have utilized various approaches in providing leadership development opportunities.

This article shares what we have done — and are still doing. I hope that at least one of these ideas will inspire you and that you can leverage them in your organization. In the world of training and development, there are always new things to learn from each other and new ideas to explore.

LEADERSHIP TRAINING TOPICS

When we created our employee development program, The Employee Journey, leadership development was identified as one of the main elements. Our intent was to provide leadership development opportunities to all employees, including current managers, emerging leaders, and individual contributors.

In collaboration with senior leaders, we determined it would be beneficial to create a list of leadership training topics for the leadership development program. Here is our brainstorming list in no particular order:

- Coaching and providing feedback
- Mentoring

- Hiring and interviewing
- Managing vs. leading
- Motivation and engagement
- Change management
- Strategic growth
- Managing effective meetings
- Having tough conversations
- Strengths-based leadership
- Developing others
- Leading in a volatile, uncertain, complex, and ambiguous (VUCA) environment
- Conflict resolution
- Leading innovation
- Goal setting
- Problem solving
- 360-degree leaders
- Effective communication
- Delegating and empowering
- Growing a team
- Emotional intelligence (EQ)
- Building trust and relationships
- Tactical management topics
- Time management
- Team health and organizational health
- Servant leadership
- Evaluating others

We decided to create a series of training courses for each topic, and so far, we have created courses on approximately 60% of these, with plans to develop the rest.

DEVELOPMENT MEDIUMS

Once we had our brainstorming list, we needed to determine how we would deliver the content to our learners. The mediums we have used so far include:

- Leadership mentoring
- In-person training, including:
 - Lunch and learn (L&L) training classes
 - Standalone leadership workshops
 - Leadership cohorts
- Online training (eLearning)
- Core competency books (CCBs)
- Young professionals groups

Leadership Mentoring

All new leaders are matched with experienced leaders to answer any questions and provide any guidance or advice while they transition into their new roles. This leadership mentoring program is designed to last for the first year. We have found that it is essential to provide new leaders with a mentor who can guide them effectively during this transition process. All of our leadership mentors are volunteers who want to help, which means they are much more likely to take it seriously and actively reach out to their mentees.

As Employee Development Director, I reach out periodically to the mentor and the mentee to confirm how the process is progressing. We have received fantastic feedback from mentees as well as mentors, including this quote from one of our



Leadership Workshop: "We're All Leaders"

Training Medium	Short Description	Pros	Cons
Lunch & Learn Training Classes	1-hour training session focused on a specific leadership development topic held in-person or live online	<ul style="list-style-type: none"> ■ Relatively short. ■ Learners can attend virtually. ■ Easy to record. 	<ul style="list-style-type: none"> ■ Typically do not include much or any discussion or application time. ■ Online learners may be tempted to multitask.
Standalone Leadership Workshops	A full-day in-person class focused on a variety of leadership development topics	<ul style="list-style-type: none"> ■ Can include a variety of topics along with discussion and application time ■ Because people are in person, they are more likely to be focused on the training. 	<ul style="list-style-type: none"> ■ Since learners only meet once, they do not benefit from the repetition and reinforcement that happens during cohort programs.
Leadership Cohorts	Multiple full-day classes held in-person focused on a variety of leadership development topics, generally recurring for a specific length of time, typically months or years long	<ul style="list-style-type: none"> ■ Same pros as a standalone leadership workshop, but learners also benefit from the repetition and reinforcement that occur when the same people meet multiple times. 	<ul style="list-style-type: none"> ■ Learners require a much longer time commitment, which can be difficult to achieve.

new leaders: “I **cannot** stress how important it has been to have someone I can confide in and get advice from. This year has brought many new challenges, and I’ve been grateful to have help.”

In-Person Training

Leadership training lends itself well to in-person, live delivery, as it often involves discussions around real-world scenarios. Within HP&D, we offer lunch and learn (L&L) training classes, standalone leadership workshops, and leadership cohorts. Each medium has specific times when it is the best fit within the program, and we use each one as appropriate. Above is a bit more about each one.

Online E-Learning

Our learning management system (LMS) allows employees to complete eLearning courses virtually.







We offer a variety of courses, including a training library dedicated solely to leadership development. Many of our leadership training courses are recordings of leadership L&L courses. We have found this is an efficient way to deliver a training course in multiple mediums, allowing learners to select the medium that works best for them. Our training libraries also include eLearning courses focused on technical, safety, and general topics.

Core Competency Books

Our core competency books (CCBs) provide new leaders with a comprehensive list of the tasks that must be completed during the transition and a list of leadership and people management skills to be mastered throughout their tenure in the position. Each role has a unique CCB. These books empower employees to take the reins of their onboarding

Libraries

Default ▾

 <p>General Company Training Library</p> <hr/> <p>27 Items</p>	 <p>Leadership Training Library</p> <hr/> <p>10 Items</p>	 <p>Safety Training Library</p> <hr/> <p>25 Items</p>	 <p>Technical Training Library</p> <hr/> <p>32 Items</p>	 <p>Young Professionals' Group Meetings</p> <hr/> <p>12 Items</p>	 <p>Egnyte Training Library</p> <p>This library contains the recordings of the Egnyte trainings.</p> <hr/> <p>4 Items</p>
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Online Training Libraries

and professional development, serving as a valuable tool for mentors and supervisors to facilitate development discussions throughout the employee's career.

Young Professionals Group

The Young Professionals Group meets monthly, offering young and young-at-heart professionals an opportunity to gather and discuss a relevant business topic. Each month, we invite a different leader to share their career journey and speak about a topic that's important to them.

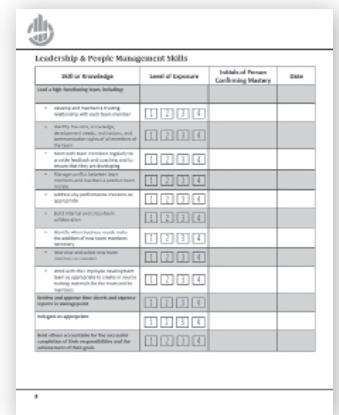
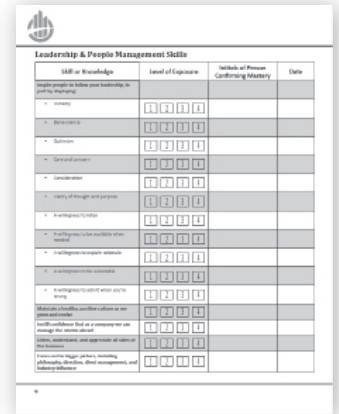
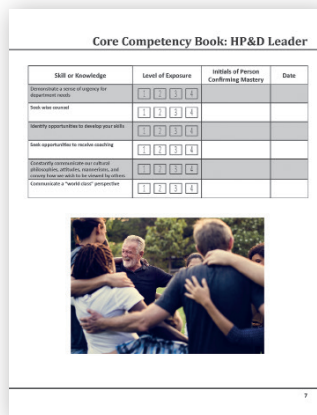
For example:

- The HP&D President talked about servant leadership.
- The VP of Operations spoke about the importance of seeing the bigger picture.
- The CFO demonstrated how to interpret financial documents.
- The HP&D CEO and President shared the best career advice he ever received.
- The Safety Director talked about how safety processes can impact a company.
- The Regional Area Manager for Virginia shared his career journey and the project management lessons he learned along the way.
- The Sales Manager spoke about the importance of client experience and communication

The purpose of these meetings is to connect experienced leaders with others within the organization, including new leaders, emerging leaders, less-experienced employees, and individual contributors. Since we believe that everyone leads



Young Professionals Groups



Screenshots from HP&D Leaders CCB

something or someone, we created this group to cultivate the leadership skills that are vital to our success.

All meetings include a Teams link, allowing anyone to join from anywhere. We recently began recording these meetings so people can watch them later if they are unable to join live.

GETTING STARTED

When starting new leadership development initiatives, one of the biggest decisions to make is whether to utilize internal resources or leverage external resources. If you decide to begin creating leadership development opportunities internally, I encourage you to select someone who can dedicate themselves fully. In a testing firm, it can be challenging for a billable employee to work on non-billable projects, such as creating a training course



When starting new leadership development initiatives, one of the biggest decisions to make is whether to utilize internal resources or leverage external resources.

or leading a small group. A dedicated resource is more likely to execute your expectations.

When internal capacity is limited, utilizing external resources is a great way to get started. Numerous providers are available, including LinkedIn Learning, Dale Carnegie Training, and John

Maxwell Leadership Training, among others. While some free materials are available, many external providers require compensation.

Personally, I prefer a hybrid approach to leadership development. Internally, we develop the courses and lead the small groups that require the most customization to fit our culture. We focus on servant leadership, which is leading by caring for others. Since this has been key to our success, we have found we are best suited to creating materials around this topic and leading small group discussions.

However, there are times when an external leadership resource is the most sensible choice. For example, when we receive training on a specific assessment tool, such as DISC, or a straightforward topic, such as coaching, external resources can provide fresh perspectives and convey this information effectively.

CONCLUSION

At the end of the day, my best advice is just to get started. We started slowly; now we have multiple initiatives all moving forward concurrently.



STEPHANIE McLAUGHLIN is Director of Employee Development & Marketing for Hood Patterson & Dewar, where she led the development and implementation of HP&D's employee development program that supports employees in offices in five states, including a large team of registered Professional Engineers (PEs), degreed engineers, and career test technicians. Stephanie specializes in analyzing learners' needs and then designing and developing components to meet those needs. She has experience creating development initiatives in the automobile, hospitality, and cloud computing industries, as well as developing initiatives for Gwinnett County (Georgia) Public Schools. Stephanie earned a BS in technical and professional communications at Southern Polytechnic State University and an MBA from Georgia Institute of Technology as well as an education certificate from Brenau University.

BATTERIES: WHAT ARE THE OPTIONS?

BY ANDREW SAGL, Megger

As the world increasingly turns to renewable energy sources and grid-scale energy storage, understanding the various battery technologies available is beneficial. Each type of battery offers unique characteristics that make it suitable for specific applications, from grid stabilisation to backup power systems. This article explores the main types of stationary batteries, their underlying chemistry, typical applications, and the pros and cons of each technology.

Before looking at individual battery types, however, a general note may be useful. All batteries are electrochemical devices, and they are inescapably subject to the laws that govern the rate of chemical reactions. In particular, all batteries are affected by temperature. High temperatures will lead to shorter battery life, while low temperatures will reduce capacity and performance. Batteries that are required to operate in either unusually hot or cold conditions must, therefore, be chosen and sized with particular care.

LEAD-ACID BATTERIES

Lead-acid batteries are one of the oldest and most established rechargeable battery technologies. They have been used for over a century in a wide

range of applications, from automotive starting to uninterruptible power supplies and off-grid energy storage.

Chemistry

Lead-acid batteries consist of lead dioxide (PbO_2) positive plates and sponge lead (Pb) negative plates, immersed in a sulphuric acid (H_2SO_4) electrolyte.

Types

1. **Vented lead acid (VLA).** Also known as flooded lead-acid batteries, these require regular water top-offs.
2. **Valve regulated lead acid (VRLA).** These sealed batteries, including absorbent glass mat and gel types, require regular testing as they work in an electrolyte-starved mode.

Typical Applications

- Backup power for telecommunications and data centers
- Off-grid and grid-tied renewable energy systems
- Uninterruptible power supplies (UPS)
- Electric vehicle charging stations
- Petrol and diesel vehicle starting

Pros

- **Well-established technology with a long history.** This means there's a wealth of knowledge and experience in its use and maintenance.
- **Low initial cost.** Lead-acid batteries are often the most economical choice for short-term energy storage needs.
- **Highly recyclable.** Nearly 100% of a lead-acid battery can be recycled, making them an environmentally responsible choice.
- **Reliable and tolerant to overcharging.** When properly managed, lead-acid batteries can withstand occasional overcharging without significant damage.

Cons

- **Lower energy density compared to newer technologies.** More space is required to store the same amount of energy as more advanced battery types.
- **Shorter cycle life, especially if discharged deeply.** Regular deep discharges can significantly reduce the lifespan of lead-acid batteries.

LITHIUM-ION BATTERIES

Due to their high energy density and efficiency, lithium-ion batteries have revolutionised energy storage. They've become increasingly popular in grid-scale energy storage, electric vehicles, and portable electronics.

Chemistry

Lithium-ion batteries use a lithium compound as the positive electrode and typically graphite as the negative electrode. The electrolyte is a lithium salt in an organic solvent.

Types

1. **Lithium nickel manganese cobalt oxide.** Offers a good balance of energy density and power.
2. **Lithium iron phosphate.** Known for its safety and long cycle life.
3. **Lithium nickel cobalt aluminium oxide.** Provides high energy density.
4. **Lithium manganese oxide.** Offers good thermal stability and safety.

- **Long cycle life.** Many lithium-ion batteries can withstand thousands of charge-discharge cycles, making them cost-effective in the long run.
- **Low self-discharge rate.** Lithium-ion batteries can hold their charge for longer periods when not in use, making them suitable for use in intermittent applications.
- **No memory effect.** Unlike some older battery technologies, lithium-ion batteries don't need to be fully discharged before recharging.
- **Fast charging capability.** This is particularly beneficial for applications requiring quick turnaround times, such as electric vehicles.

Cons

- **Higher initial cost.** Although prices are decreasing, lithium-ion batteries are still more expensive upfront than lead-acid batteries.
- **Potential safety concerns (thermal runaway).** In rare cases, lithium-ion batteries can overheat and catch fire.
- **Require sophisticated battery management systems.** Complex control systems are needed to balance cells and prevent overcharging, over discharging, and overheating.
- **Performance degrades at high temperatures.** Exposure to high temperatures can accelerate capacity loss and reduce the battery's overall lifespan.

FLOW BATTERIES


Flow batteries are a unique type of rechargeable battery where the energy is stored in a liquid electrolyte. They offer the advantage of decoupling power and energy capacity, making them highly scalable for large-scale energy storage applications.

Chemistry

The most common type is the vanadium redox flow battery (VRFB), which uses vanadium ions in different oxidation states. Other chemistries include zinc-bromine and iron-chromium.

Typical Applications

- Large-scale grid energy storage
- Renewable energy integration
- Microgrid and off-grid systems
- Industrial and commercial energy management



All batteries are electrochemical devices, and they are inescapably subject to the laws that govern the rate of chemical reactions.

Typical applications

- Grid-scale energy storage and grid stabilization
- Electric vehicles and hybrid electric vehicles
- Residential and commercial energy storage systems
- Portable electronics and power tools

Pros

- **High energy density.** This allows for more compact and lightweight energy storage solutions, which is crucial for applications like electric vehicles.

Pros

- **Long cycle life.** Flow batteries can typically withstand tens of thousands of charge-discharge cycles without significant degradation.
- **Can be fully discharged without damage.** Unlike many other battery types, flow batteries are not harmed by complete discharge.
- **Easily scalable by increasing tank size.** Using larger electrolyte tanks can increase energy capacity without changing the power components.
- **Lower fire risk than lithium-ion.** The aqueous electrolytes used in most flow batteries are non-flammable, reducing safety concerns.

Cons

- **Lower energy density.** Flow batteries require more space than technologies like lithium-ion to store the same amount of energy.
- **Complex system.** The need for large electrolyte tanks makes flow batteries more mechanically complex than solid-state batteries.
- **Higher initial costs.** The complexity of flow battery systems often results in higher upfront costs, although their long lifespan can offset this.
- **Potential for electrolyte leakage.** Proper containment and maintenance are crucial to prevent environmental contamination from electrolyte leaks.

SODIUM-ION BATTERIES

Sodium-ion batteries are an emerging technology that offers a potentially more sustainable alternative to lithium-ion batteries. They use abundant, low-cost materials and could significantly improve future energy storage applications.

Chemistry

Sodium-ion batteries use sodium ions instead of the lithium ions used for charge transfer in lithium-ion batteries. The cathode is typically a layered metal oxide, while the anode is often hard carbon.

Typical Applications

- Grid-scale energy storage
- Residential and commercial energy storage
- Electric vehicles
- Portable electronics (in development)

Pros

- **More abundant and cheaper raw materials.** Sodium is much more plentiful than lithium, potentially leading to lower costs and more sustainable production.
- **Potentially more environmentally friendly.** The materials used in sodium-ion batteries are generally less toxic and easier to recycle than those in lithium-ion batteries.
- **Can be fully discharged for safer transport.** Unlike lithium-ion batteries, sodium-ion batteries can be completely discharged, simplifying shipping and storage logistics.

Cons

- **Lower energy density compared to lithium-ion.** Sodium-ion batteries may not be suitable for applications where weight and size are critical factors.
- **Technology still in the early stages of commercialisation.** As a relatively new technology, sodium-ion batteries have yet to demonstrate their long-term reliability and performance in real-world applications.
- **Limited track record in large-scale applications.** The lack of extensive field data makes it challenging to predict long-term performance and potential issues.

NICKEL-BASED BATTERIES

While less common in new installations, nickel-based batteries still find use in some stationary applications. They offer reliable performance and can handle harsh environmental conditions.

Chemistry

Nickel-based batteries use nickel oxyhydroxide (NiOOH) as the positive electrode. The negative electrode and electrolyte differ between types. During discharge, the nickel oxyhydroxide electrode is reduced to nickel hydroxide, while the negative electrode is oxidised. This process is reversed during charging.

Types

1. **Nickel-cadmium (NiCd).** Known for durability.
2. **Nickel metal hydride (NiMH).** Offers higher energy density than NiCd without the use of toxic cadmium.

Typical Applications

- Industrial backup power systems
- Railway signalling
- Aircraft starting and emergency power
- Remote telecommunications systems

Pros

- **Robust and durable.** Nickel-based batteries can withstand harsh conditions, including physical stress.
- **Good cycle life.** When properly maintained, nickel-based batteries can last for many years and thousands of cycles.

Cons

- **Lower energy density than lithium-ion.** This makes them less suitable for applications where space and weight are at a premium.
- **Memory effect (especially in NiCd).** Partial discharge cycles can lead to a loss of usable capacity, requiring periodic full discharge cycles.
- **Environmental concerns with cadmium in NiCd batteries.** The toxic nature of cadmium has led to restrictions on using NiCd batteries in many regions.

THE IMPORTANCE OF PROPER TESTING

Each of these battery technologies requires a specific testing regime to ensure optimal performance, safety, and longevity. Testing methods and frequency vary significantly between battery types. For example:

- Lead-acid batteries often require regular specific-gravity measurements, capacity testing, and ohmic testing to assess their state of health.
- Lithium-ion batteries benefit from sophisticated state-of-health monitoring and impedance testing to detect early signs of degradation.
- Flow batteries may need electrolyte composition analysis in addition to standard electrical tests to ensure optimal performance.

Proper testing is essential not only for maintaining battery performance but also for ensuring the safety and reliability of energy storage systems. Regular testing can help identify potential issues before they lead to failures, optimise battery management strategies, and extend the overall lifespan of the energy storage system.

CONCLUSION

Stationary batteries are diverse, with each technology offering unique advantages and challenges. As energy storage capabilities advance, we'll likely see further innovations and improvements in battery technology.

Understanding the characteristics of the various battery types is central to selecting the right technology for a specific application. Equally important is implementing appropriate testing and maintenance regimes to ensure these batteries perform optimally throughout their lifecycle.



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ENLIGHTENING THE MINDS OF THE ELECTRICAL INDUSTRY'S NEXT GENERATION: THE NFPA ELECTRICAL CYCLE OF SAFETY

BY COREY HANNAHS,
National Fire Protection Association

Whether the path you are forging in the electrical industry leads you to a role as an engineer, electrician, or inspector, one commonality is that your education will be based heavily on NFPA 70®, *National Electrical Code*® (NEC®). But does the NEC provide all that is needed to achieve comprehensive electrical safety?

Electrical safety based on NEC requirements must be the foundation for a safe electrical installation. However, in the days and years following installation, electrical systems require constant maintenance to remain safe, reliable, and functional, while also mitigating risks to the people who work on these systems. To meet all these needs, we must, of course, utilize the NEC, but we must also be educated about other codes and standards that play a critical role.

Enter the NFPA® Electrical Cycle of Safety™ (ECoS™), which incorporates the NEC; NFPA 70B®, *Standard for Electrical Equipment Maintenance*®; and NFPA 70E®, *Standard for Electrical Safety in the Workplace*® to assist in achieving holistic electrical safety. With an influx of new workers, now is the time to take the electrical industry's next generation

of workers and the installations they work on to a higher level of safety by educating them on the full ECoS.

INSTALL: NFPA 70, NATIONAL ELECTRICAL CODE (NEC)

When you start in the electrical industry, you are introduced to the NEC very early in your career. Why? Because without it, you cannot perform a safe electrical installation. You must be able to work with your hands and tools to do the job, but understanding NEC requirements and how they apply helps you do the job right.

Electrical apprenticeship programs, generally four or five years in duration, focus heavily on building the curriculum around the NEC and how it applies to the different types of theory and installations that are presented in the classroom and labs. Many electrical inspectors start as electricians who came through the ranks as apprentices, where the NEC was instilled in them. Electrical engineers must take specific courses to be able to apply NEC requirements in their designs and applications.

All of these roles play a significant part in providing a safe installation for the eventual occupants of the building, and understanding and applying the requirements of the NEC is critical to performing that role. A safe installation that is grounded in the NEC must be the initial step in achieving holistic electrical safety, but it's only the first part of the ECoS.

MAINTAIN: NFPA 70B, STANDARD FOR ELECTRICAL EQUIPMENT MAINTENANCE

After the initial installation of an electrical system or electrical equipment, proper maintenance is required to ensure it stays functional, reliable, and safe to use and operate. If you ask the manager of ten facilities how they perform maintenance on their electrical equipment, you are likely to get ten approaches. This isn't entirely bad because it means that some form of maintenance is indeed being done, and some of the processes and procedures are likely being done well.

But comprehensive electrical maintenance requires a level of structure that isn't always easy to understand



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as we develop a specific plan. NFPA 70B provides a structure for designing a comprehensive electrical maintenance program (EMP) that includes manufacturers' recommendations as well as specific NFPA requirements. Because the equipment, processes, and procedures within any business are unique, each EMP will be designed to the specific needs of each particular facility. A well-designed EMP with properly timed maintenance intervals allows a facility to take a proactive approach to safety by choosing when shutdowns for maintenance will occur rather than reacting to an unexpected equipment breakdown.

Reactivity can increase costs due to production downtime and difficulty finding and purchasing replacement parts. It can also increase the level of risk to employees who are working under duress to get production back up and going. How a facility addresses electrical maintenance can also directly impact the safety of its workers because working on poorly maintained equipment escalates the level of risk for employees.

PROTECT: NFPA 70E, STANDARD FOR ELECTRICAL SAFETY IN THE WORKPLACE

It's probably a fair statement to say that before anyone can ensure the safety of others, they must first ensure their own safety. Even on airplanes, we

are instructed to put our oxygen masks on before assisting others. As those in the electrical industry work diligently to provide a safe installation and ongoing maintenance, we would be remiss if we didn't consider how we protect the hands-on workers who provide these services.

NFPA 70E requires employers to develop an electrical safety program (ESP) that helps evaluate the risk to employees who are performing electrical work and provides safe work practices to mitigate those risks. NFPA 70E is closely tied to the Occupational Safety and Health Act (OSH Act), which is administered by the Occupational Safety and Health Administration (OSHA). In essence, OSHA enforces federal regulations that tell employers what they **must** do to keep their employees safe, while NFPA 70E provides the safe work practices that establish **how** to do it.

But the onus of NFPA 70E is not only on the employer. While the employer carries the heavy load of developing an ESP that aligns with their company's needs based on the work that they perform, the employee has the duty to follow those rules once they are established.

Through all of this, NFPA 70E provides wide protection to the business and the employee. It helps protect the business by establishing an ESP

that keeps its employees safe and meets the federal regulations employers are responsible for to avoid costly OSHA citations. NFPA 70E also helps protect employees who know their limitations, can assess their risks, and follow the safe work practices required to mitigate those risks.



Figure 1: NFPA Electrical Cycle of Safety™ (ECoS™)

NFPA® ELECTRICAL CYCLE OF SAFETY™ (ECoS™)

After a high-level overview of the NEC, NFPA 70B, and NFPA 70E, it is easy to see how they collectively fit into the ECoS model to provide the highest level of electrical safety. Achieving the highest level of electrical safety isn't about just installation, maintenance, or protecting business and workers; it's about all of these things. Each component of the ECoS is as important as the next, and if even one is missing, it could result in preventable incidents that put people, property, and critical processes at risk.

Starting with a safe installation based on the requirements of the NEC is the foundation for the ECoS. What is unique about the NEC, as compared to NFPA 70B and NFPA 70E, is that it is often incorporated by reference (IBR) into state and local laws and then enforced by governmental agencies. This is where electrical inspectors act in the role of the

authority having jurisdiction (AHJ) to ensure that the proper permits have been obtained for electrical work being performed within their area and that the work being done meets the NEC requirements. The NEC is enforced on some level in all 50 states. This indicates that a strong tie has been established with the installation portion of the ECoS.

NFPA 70B and NFPA 70E are a little different. They are not mandated by law, even when incorporated by reference, so enforcement takes a slightly different path. NFPA 70B spent 50 years as a recommended practice before officially becoming an enforceable standard in January 2023. Therefore, there had never been an opportunity for an IBR of this standard.

While there are no known cases of NFPA 70B being used in an IBR application during its short time as a standard, many businesses have chosen to implement and enforce the use of NFPA 70B because of the benefits they see in doing so. For example, developing and enforcing an EMP benefits a business by ensuring that electrical equipment and systems stay reliable, predictable, and functional while minimizing the opportunity for costly downtime.

NFPA 70B also allows a business to establish a defined "condition of maintenance" for each piece of electrical equipment. Here, NFPA 70B and NFPA 70E are so aligned that it makes it almost impossible to meet the requirements of NFPA 70E — which many businesses follow based on meeting OSHA regulations — without using NFPA 70B. That is because NFPA 70E requires the ESP to include elements that consider the condition of maintenance of equipment before working on it.

As expected, equipment that has had low or no maintenance can significantly increase the risk to employees who must service it. Using the procedures and records that align with an EMP developed under the requirements of NFPA 70B can provide the condition of maintenance for an employee who is following the safe work practices of NFPA 70E and evaluating the associated risk for a particular task.

While OSHA does not enforce NFPA 70E directly, it can be used to help meet OSHA electrical regulations.

CASE STUDY

Think of a scenario where a motor control center (MCC) was installed 20 years ago and has never seen regular maintenance; only specific parts have been replaced as they failed. Let's say there is an incident where an employee is severely burned by being exposed to an arc flash while working on the MCC.

OSHA comes in to investigate the incident, and the business says they follow NFPA 70E strictly. They hand over their ESP, which states — as required by NFPA 70E — that they consider the condition of maintenance before assessing their risk and working on a piece of electrical equipment such as the MCC. OSHA's next request is likely to see the maintenance records for the MCC involved in the incident. The trouble is, there are no known maintenance records for the MCC; we established at the beginning of this case study that regular maintenance had not been performed on the MCC for 20 years.

This road is likely to lead to OSHA citations, hospital bills, potential lawsuits, and a number with lots of zeros at the end. If the business had established an EMP with planned and documented regular maintenance, it might have prevented the incident altogether. Even if the incident still occurred, documentation would likely show that the business provided a significant effort to prevent it from happening. This example highlights how critical it is to utilize all parts of the ECoS.

ENLIGHTENING THE NEXT GENERATION ON THE ECOS

Holistic electrical safety and how the ECOS can provide it were not always taught to members of the electrical industry who are now closer to walking out the door than coming in. With the current changing of the guard and the influx of new workers to the industry, it is critical to begin enlightening them to using the ECoS.

Yes, they will learn about the NEC because they need to and always have. But they also need to know how important electrical maintenance is after the initial NEC-based installation. They need to know that working on poorly maintained equipment not only puts business processes at risk, but also puts their personal safety at risk. The next generation must understand that following the safe work practices in NFPA 70E can make the difference in whether or not they go home at the end of the day. The ECoS provides holistic electrical safety, but only if the present and future electrical industry finds a way to effectively implement it.

For more information on the NFPA® Electrical Cycle of Safety™ (ECoS™), including training opportunities, a downloadable fact sheet, and access to a free 75-minute webinar, please visit www.nfpa.org/ECoS.

Important Notice: *Any opinion expressed in this column is the personal opinion of the author and does not necessarily represent the official position of NFPA or its Technical Committees. In addition, this piece is neither intended nor should it be relied upon to provide professional consultation or services.*



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TARIFFS, FAILURES AND THE CASE FOR TECHNICIAN TRAINING IN A TOUGH ECONOMY

BY EMILY ALCANTAR,
AVO Training Institute by Megger

In an uncertain economy, every dollar counts — and for utilities and industrial firms, the temptation to cut training budgets is strong. But when it comes to electrical systems, that's a gamble few can afford.

Electrical failures cost U.S. facilities over \$1.5 billion annually in direct damage, not to mention the ripple effects of downtime, safety risks, and regulatory penalties. A single outage in a manufacturing plant can cost more than \$1 million per hour, and with NFPA 70B now mandating preventive maintenance, companies are under pressure to ensure their systems — and their teams — are up to code.

Compounding the issue is the rising cost of replacement parts. Tariffs on transformers, switchgear, and copper wiring have driven prices up by 20–25%, while global supply chain delays often mean lead times have tripled. For many, replacing aging infrastructure isn't just expensive. It's nearly impossible.

This is where electrical technicians come in. Properly trained technicians can extend the life of existing systems, detect faults before they escalate, and reduce reliance on costly external contractors. In fact, companies that invest in technician training see higher operational resilience, better safety records, and a stronger bottom line.

Another cost to consider is turnover. Replacing a skilled technician can cost more than \$5,000 in





*In today's economy,
training isn't a luxury —
it's a strategic necessity.*

recruitment and onboarding alone, not to mention lost productivity and institutional knowledge. Many employees cite a lack of career development as a key reason for leaving. When companies fail to invest in their people, they risk losing them altogether.

Providing quality technical training can help organizations turn today's electrical challenges into opportunities. Hands-on programs focused on maintenance, diagnostics, testing, safety, and compliance prepare technicians to be the frontline defense against costly failures and tariff-driven delays.

NFPA TRAINING

At the heart of this mission is a simple truth. Electrical training matters for three major reasons: life, health, and safety — for your team and for the equipment they rely on every day.

Training your technicians on NFPA 70E®, *Standard for Electrical Safety in the Workplace*®, and NFPA 70B®, *Standard for Electrical Equipment Maintenance*®, is vitally important. NFPA 70E teaches how to work safely around live electrical

systems, helping prevent arc flash incidents, electrocution, and other serious hazards. NFPA 70B, now a mandatory standard, is focused on keeping equipment in top shape through structured maintenance programs that reduce the risk of breakdowns, fires, and downtime. Used together, these standards help organizations stay compliant, protect their people, and keep operations running smoothly.

In today's economy, training isn't a luxury — it's a strategic necessity.

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