White paper

Markets served
Healthcare

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An electrical safety roadmap for healthcare facilities

A unified and comprehensive approach to electrical safety is essential to healthcare facilities. With a "safety by design" methodology, you can support resilient operations, protect people and property and avoid costly oversights that could result in downtime or regulatory penalties.

What is safety by design?

By definition, safety by design is a simple concept. Embedding electrical safety at the foundation of all facility management processes — from pre-design through installation and post-installation — to help manage risk throughout a building no matter who is operating, managing or maintaining its systems.

The structure of this approach is similar to the common practice of building life cycle assessment (LCA), which allows architects and other building professionals to understand the environmental footprint of a facility throughout its lifecycle.

However, instead of modeling energy usage over a 20- to 50-year period to justify decisions taken by architects to improve sustainability, you're examining potential safety risks before construction begins to determine what mitigation measures should be taken.

Safety and return on investment (ROI) go hand in hand

Healthcare facilities are living, breathing buildings and much more complex to maintain than typical commercial structures. Most commercial buildings are designed and built around a 30-year lifecycle during which no major infrastructure changes will occur. However, there are always changes taking place in healthcare facilities – whether it be routine maintenance, a small renovation or a major modernization project.

This means the typical pre-design, installation and post-installation phases will occur multiple times within the lifecycle of a healthcare facility. Addressing safety as a one-off each time a project is carried out is cumbersome and, in the best cases, adds cost and complexity. In the worst instances, it can lead to injury, substantial downtime and regulatory penalties.

Part of the challenge to constructing a successful healthcare facility is balancing competing goals: operational requirements, time to market, cost and labor. Far too often, we see safety accommodations value-engineered out of original specifications in order to accommodate these goals. However, due to the complex nature of healthcare facilities, the consequences of such actions can often directly contradict the intentions of this decision-making process.

Design teams will tend to focus on the tangible, aesthetic elements of a building. While this isn't wrong, it is only part of the process. Essential electrical infrastructure is too often seen as only a commodity. Meanwhile, there are entire teams who work hands-on with the essential electrical system on a daily basis. With this perspective in mind, it's important to have all stakeholders — from building owners to architects, designers, engineers and maintenance staff — involved in the process from day one.

Powering Business Worldwide

Build a culture of safety

Taking a safety-by-design approach is a form of insurance. In an ideal world, a facility would remain completely incident-free throughout its lifetime. In reality, mistakes happen. When they do, you'll be covered because you took precautions beforehand.

Building a culture of safety can prevent such incidents from happening in the first place or make the impact much less detrimental. It is far easier (and economically possible) to implement safety solutions, procedures and practices from the beginning than to overhaul essential electrical infrastructure and employee training programs further down the road.

In addition, if safety considerations are engineered out of a healthcare facility, every single maintenance and modernization task over its lifetime will be more complex to complete safely. This adds valuable labor, time and costs to projects that could have been fairly straightforward if safety by design was prioritized throughout the building development process.

Position safety at the forefront of your organization

Essential electrical infrastructure operates in the background, but impacts every process in a healthcare facility. This makes a robust safety program critical to help prevent or isolate incidents before they have the opportunity to harm people or equipment.

Safety has always been a priority, but will only become more important as healthcare essential electrical systems become more complex through the interconnection of co-generation sources, renewable energy, battery storage and microgrids to support more resilient operations. By embedding electrical safety at the foundation of your organization, you're making a future-proof investment that can go a long way to safely energize healthcare and save lives.

Part 2 Eliminate hazards with technology and design

There are many important technology and design decisions made during the initial phases of a project that directly impact the safety of electrical systems and workers. Our recommended three pillars of success during the design phase of a project include:

1. **Eliminating hazards** by designing electrically safe working conditions.
2. **Implementing designs and technologies** to reduce the likelihood of a hazardous event.
3. **Reducing the potential severity of injuries** should an accident occur when justified energized work is required.

Eliminating hazards by designing electrically safe working conditions

According to National Fire Protection Association (NFPA) 70E Section 110.1, hazard elimination should be the first priority in the implementation of safety-related work practices. The document defines an electrically safe work condition as follows:

"An electrically safe work condition is not a procedure, it is a state wherein all hazardous electrical conductors or circuit parts to which a worker might be exposed are maintained in a de-energized state for the purpose of temporarily eliminating electrical hazards for the period of time for which the state is maintained."

An example of hazard elimination during the design phase would be placing a circuit breaker or fuse and switch in its own enclosure next to equipment, providing electrical workers with a readily accessible disconnect to remove voltage and establish an electrically safe working condition.

While it's always better to wait for a planned outage to work on electrical equipment, that's not always an option. For situations when personnel need to perform energized work, it is important to complete a thorough risk analysis that considers all potential risks (including human error) during the pre-design and design phases of a project. With a clearer understanding of the maintenance and troubleshooting requirements of a defined energized task, you can do more to advance a safety culture at your site, helping to reduce the chances of future shock and arc flash events.

Implementing designs and technologies to reduce the likelihood of a hazardous event

A design engineer's main priority is to bring modern electrical safety technology to the forefront and build systems based on their customers' current and future needs. This often means a willingness to rely on experts, compare solutions from multiple suppliers and keep up to date on industry education.

Innovation doesn't have a timetable; new solutions are almost always introduced to market much faster than the National Electric Code (NEC) can react since it is reviewed and updated on a three-year cycle. As such, the NEC should be referenced as a safety guideline and not for design recommendations. For instance, NEC Section 90.1 explains that it is "not intended as a design specification or an instruction manual for untrained persons." Further, Section 90.1(B) states, "a system meeting the requirements of the NEC may not be adequate for good service or for future expansion."

The following examples illustrate the many layers of safety that can be employed to reduce the likelihood of arc flash, arc blast and/or shock should an incident occur:

- **Electrical one-line diagrams**
One of the most important parts of a facility's electrical infrastructure life begins even before ground is broken. This document is developed and used by engineers, suppliers, inspectors, workers and designers. Workers could be put at risk if one-line diagrams are not maintained with reviewed and updated power system capabilities as they change over time.
- **Barriers**
Adding a local disconnect next to a panelboard or industrial control panel (ICP) that is accessed frequently for service provides electrical workers with clear visible indicators that the panel or ICP has been de-energized when the circuit breaker or switch is in the off position. When required absence of voltage testing is performed, the likelihood of an incident has been reduced.
- **Isolation**
A bypass isolation automatic transfer switch (ATS) is frequently selected for use in healthcare, as well as in other critical applications, because it allows service personnel to bypass power around the ATS through the automatic bypass to ensure that critical loads remain powered without interruption during regular maintenance, inspection and testing as required by code such as NFPA 110. During repair or maintenance procedures, these devices have a compartmentalized design that provides protective steel barriers between workers and energized components to mitigate risk.
- **Visibility**
Equipping a panelboard with a window that allows workers to see the blades being disconnected aids in worker verification reducing the likelihood of an incident.
- **Indicators**
The presence of voltage indicators employed on equipment provides electrical workers a visible indication of which side of the disconnect is energized and which isn't.
- **Equipment and maintenance knowledge**
Information on the condition and maintenance history of equipment can provide electrical workers details that are critical to safety when performing justified energized work. Knowledge of the equipment itself is critical to recognizing hazards.
- **Working space**
Sometimes safety doesn't come in the form of a product; it can simply be in the fact that a design provides adequate working space for the electrical worker to safely perform functions.

Reducing the potential severity of injuries should an accident occur when justified energized work is required.

When justified energized work must occur, it is important to design features into the system that minimize the danger of potential electrical hazards.

The methods of reducing incident likelihood addressed above still apply, but there are additional layers of safety you can incorporate to reduce the severity of injuries to workers should an accident occur:

- **Decrease clearing time**
Placing a circuit breaker with arc reduction maintenance switch technology (or a fuse and switch in its own enclosure) upstream of electrical equipment that requires justified energized work can help reduce clearing times for arcing currents and incident energy exposure.
- **Incorporate GFCI shock protection**
Ground-fault circuit interrupters (GFCIs) are specifically designed to protect people against electric shock from an electrical system and to monitor the imbalance of current between the ungrounded (hot) and grounded (neutral) conductor of a given circuit.
- **Utilize IEEE 1584 and arc flash calculations**
The Institute of Electrical and Electronics Engineers (IEEE) Guide for Performing Arc Flash Calculations offers guidance that impacts the way arc flash hazards in electrical systems are analyzed. More precise calculations help reduce the risk to employees and contractors
- **Leverage arc reduction technologies**
Arcing faults that occur within equipment need to be cleared as quickly as possible. Arc flash reduction technology reduces clearing times of arcing fault currents should a problem occur when working on energized electrical equipment. For example, some arc quenching equipment can extinguish an arc flash in approximately 4 milliseconds.

Collaboration: Key to a better build

A project's success depends on subject matter experts, design engineers and inspectors working together to reach a common goal. However, there is no code guidance for how to best communicate during either the design or build phase. And while every professional is committed to safe systems, silos can form organically throughout the construction process.

Open lines of communication are the best way to design and build systems safely and efficiently. When creating a new system, electrical engineers first design their solutions, then meet with peers and subject matter experts of different disciplines to conduct project reviews at predetermined points throughout the design process. The team looks for errors, omissions and NEC considerations and resolves them well before installation. Catching potential problems in the design phase saves time, money and a lot of headaches.

Build a culture of safety

As mentioned above, the goal of a safety by design approach is to establish an electrically safe working condition for the entire building lifecycle. When designing electrical systems and the devices that go into those systems, a critical goal needs to be simplifying and safeguarding designs, so when systems need service or repair, electrical workers are safe.

Ultimately, every stakeholder across a healthcare operation can benefit from this comprehensive approach to electrical system safety.

Part 3 The importance of the "qualified worker"

A major complexity for healthcare facility management teams is the wide scope of responsibilities they are tasked with. The priority for healthcare facilities management teams is to ensure the wellbeing of patients, staff and maintenance personnel across the entire building spectrum. At the same time, they are responsible for ensuring the building is able to meet leadership goals, whether that be energy efficiency, budgetary compliance or scalability for future needs.

When balancing these goals or performance requirements, it is important that safety is aligned with the overall building lifecycle. Just as a checklist is critical to ensure medical procedures are carried out smoothly, facilities management teams should incorporate an electrical safety preparation checklist before entering the installation phase of a project.

In this checklist, you should ask yourself questions such as:

1. **Are electrical professionals qualified for the task** and trained on involved equipment?
2. **Has the electrical safety been designed** and installed with safety goals in mind?
3. **What electrical hazards exist** and have mitigation steps been taken?
4. **Is the power system prepared** for the unexpected?
5. **Is everyone well-versed on the overall safety plan** for the facility?

Electrical safety during the installation phase of a project hinges on involved personnel and their various responsibilities. This is why having qualified people in place is an important part of the electrical safety preparation checklist.

You can design the best possible healthcare facility with the most modern safety equipment, but these assets need to be in the hands of a qualified professional to achieve the best outcome. These factors make early investments in safety and training critical to ensure long-term building performance and value years down the road.

A new way to prove workers are qualified to work in the complex health care physical environment is ASHE's Certified Health Care Physical Environment Worker Exam. For contractors and subcontractors, earning the certification demonstrates you are ready to work in healthcare facilities. ASHE also recommends that each general contractor/project lead hold a Certified Healthcare Construction (CHC) certification, and that at least one CHC should be part of every health care construction project.

Factory-acceptance testing creates a baseline for success

Across the electrical industry, factory acceptance tests (also known as witness tests) are carried out for critical electrical system components prior to delivery. Much like test driving a car before you buy, witness testing enables customers to ask questions and see equipment operate before it leaves the factory.

During an in-person witness test, equipment is energized, and experts are on hand to answer questions. Customers can see their equipment working with all the circuit breakers and relays operational. Testing occurs in real time, and customers can verify complicated equipment performs as intended. An additional benefit is the ability to document baseline operational data that can be used as a reference point to monitor equipment performance throughout its lifecycle.

Witness testing is not always necessary, and it's not performed on all equipment. When it comes to equipment that involves complicated transfer schemes or programming — like those often used in healthcare applications — we highly recommend witness testing to address any potential complications before equipment is delivered to the jobsite.

Eaton recently developed a solution to help customers virtually verify the capabilities of their products. Unlike a traditional, in-person testing protocol, virtual testing can provide important advantages:

1. **More people can participate remotely** to better understand the equipment and how it operates. There is no limit to how many customer representatives can attend a virtual witness test.
2. **You can see more detail and get closer to the equipment** with camera zoom. When testing low-voltage switchgear in person, for example, the equipment is energized with 480 volts and all participants must be seven to eight feet away. Virtual tests allow customers to safely see up-close equipment details such as nameplate information, HMI screens and more.
3. **Virtual testing saves time and money** by eliminating travel costs and compressing testing schedules. Multiple cameras can be positioned so customers can see a variety of testing aspects at one time.

Some customers will want to come into the factory when when possible. However, virtual testing provides an alternative to keep essential infrastructure projects on schedule and an opportunity to have more people participate.

Complete and maintain one-line diagrams according to industry guidelines

Whether a healthcare facility is old or new, electrical engineers depend on one-line diagrams to track the electrical components that support proper maintenance and safety practices. Serving as a map of the electrical distribution system in a facility, this diagram documents conductors, transformers, overcurrent protective devices (OCPDs) and other electrical devices and safety mechanisms to aid in many areas of design and maintenance while reducing confusion.

Once the installation phase is complete, an updated one-line diagram will serve as the primary resource to calculate short-circuit currents, determine selective coordination and, ultimately, calculate incident energy—making it one of the most important safety documents at a facility's disposal.

Various sections within National Fire Protection Association (NFPA) 70B and 70E suggest or mandate one-line diagram creation and updates. In Section 6.2.2.1, NFPA 70B recommends that one-line diagrams show all electrical equipment in the power system and give all pertinent ratings for voltage, frequency, transformer impedance, available short-circuit current and OCPDs, among others. Further, as stated under NFPA 70E Section 130.5(G), "The incident energy analysis shall be updated when changes occur in the electrical distribution system that could affect the results of the analysis. The incident energy analysis shall also be reviewed for accuracy at intervals not to exceed five years."

But, even with clear NFPA guidelines for the creation and maintenance of one-line diagrams, the process of updating the document can easily be overlooked after a new build. All project stakeholders should understand the importance of these documents and the calculations that stem from the fault-current values they contain.

Additionally, we strongly recommend creating a budget line item to account for the resources needed to record changes and conduct the five-year documentation review. If this important document is not kept up to date, future project management teams will need to spend hours diagramming wiring before they can perform a scope of work, which is a costly expense. In our experience, allocating resources for proper documentation in the near term lessens the chance of a much larger service expense later.

The ROI of prioritizing safety throughout the installation phase

There are always changes taking place in healthcare facilities.

Addressing safety as a one-off each time a project is carried out is cumbersome and, in the best cases, adds cost and complexity. In the worst instances, it can lead to injury, substantial downtime, and regulatory penalties.

During the installation phase of a project, you have the opportunity to establish a baseline for electrical safety that will directly contribute to the success of future projects. A large part of this is ensuring electrical safety measures included during the design phase are not value engineered out of the specification. Another critical step is verifying that all changes made to the original specification are thoroughly documented in an updated one-line diagram, and that equipment is confirmed to function as intended prior to delivery.

Prioritizing these elements will make it far easier to perform safe work down the road when it comes to performing maintenance.

Part 4 An electrically safe workplace

The goal of a safety-by-design approach is to establish an electrically safe working condition for the entire building lifecycle. More common than not, healthcare facility infrastructure is decades old and continuously evolves to meet changing organizational needs. Ensuring safety for the electrical worker in these environments should be a similar, continuous process.

Embracing this process doesn't always require investment in the latest safety products or technologies, but rather a commitment to understanding the measures that need to be taken to protect the electrical worker. Essential electrical infrastructure operates in the background, but impacts every process in a healthcare facility. This makes a robust safety program critical to help prevent or isolate incidents before they have the opportunity to harm people or equipment.

Let's take a look at how you can instill this safety-by-design approach to support safer, more resilient operations during the maintenance phases of a building's lifecycle.

Healthcare electrical preventative maintenance — no longer just a recommendation

The National Fire Protection Association's Health Care Facilities Code (NFPA 99) is one of the industry's most important sets of safety guidelines. It continues to evolve with the latest best practices designed to help reduce fire, explosion and electricity hazards for patients, staff or visitors across all healthcare environments.

The 2021 update to NFPA 99 includes several new additions within its electrical systems chapter (Chapter 6) intended to improve the reliability of healthcare electrical infrastructure. One of the most important changes creates the industry's first framework mandating ongoing equipment inspection, maintenance and testing practices across healthcare facilities.

Under the latest requirements in NFPA 99 Chapter 6, Section 9, all healthcare facilities must now establish an electrical preventative maintenance program for electrical components serving NFPA 99 Risk Assessment Category 1 and 2 spaces, where failure is likely to result in minor or serious injury.

We believe prioritizing this strategic, system-wide application of electrical preventative maintenance is an effective solution for regulatory compliance and ensuring the focus remains on patient care. However, it is important to establish an electrically safe working condition when performing most of these duties.

How do you create an electrically safe working condition?

The electrical industry looks to a few key documents from the NFPA that strategically work together to increase safety for electrical workers by providing guidance and recommendations:

1. **NFPA 70 The National Electrical Code (NEC)** provides installation requirements
2. **NFPA 70E covers** the topic of electrical safety in the workplace
3. **NFPA 70B addresses** electrical equipment maintenance

When it comes to electrical safety during maintenance, NFPA 70E is often the first document that comes to mind. But it should not be the last one. The NEC also includes many provisions important for the electrical worker and complements the efforts of NFPA 70E.

The NEC is an installation code that includes minimum requirements from which the electrical contractor and inspector benefit. These provisions align with a safety-by-design approach because they are designed to support electrical safety for years after the structure is built and in operation. Many of these guidelines don't require the latest electrical products or technologies, but rather address relatively simple steps that need to be taken for safety.

For example, lockout/tagout is a good area to explore to illustrate the potential of how these guidelines work together. NFPA 70E includes practices around lockout/tagout with great detail necessary to help personnel ensure equipment is de-energized before work is conducted and remains that way during work procedures. The NEC complements this practice with installation requirements providing for hardware that is ready to receive lockout/tagout equipment.

However, it is also important to remember the NEC only provides minimum requirements, and you should always consider going above and beyond to ensure safety for those who work in and around electrical equipment. For example, there are many instances where local electrical disconnects could be utilized across healthcare essential electrical systems but are not required by the NEC. These additional measures should be considered when evaluating how to create a safer electrical working condition.

Signs, labels, markings and single-line diagrams

You're probably well aware of the sheer volume of labels, signs and markings present in the electrical industry. Safety is at their core; they are there for all of us — especially those who interact with equipment. The NEC provides guidance on the many places where markings, labels and signs are required to protect the electrical worker.

In addition to the "what" and "how," the NEC also addresses "where" when it comes to this topic: from arc-flash hazard warning labels on gear to cable tray labels and the cables themselves. These labels and markings are there to raise awareness of potential hazards while helping ensure that you are working with the correct equipment and installing it correctly.

Further, electricians and design professionals rely on accurate single-line diagrams to calculate the short-circuit values that ultimately determine incident energy. So, preparing and maintaining this documentation is essential to safety. If you've made infrastructure changes to your electrical system, make sure your drawings and warning labels are updated. And remember to review these documents every five years per NFPA 70E, whether you've made changes or not.

Arc flash and shock protection

NFPA 70E includes requirements for safe work practices to protect personnel by reducing the exposure to (and likelihood of) major electrical hazards, including shock, electrocution, arc flash and arc blast. These requirements rely on installation performed in accordance with the NEC and the maintenance practices prescribed in NFPA 70B. In recent years, it has become clear that routine maintenance plays a critical role in ensuring proper power distribution system performance, and NFPA 70B will soon follow in NFPA 99's footsteps moving preventative maintenance from a recommended practice to a required standard.

Meanwhile, recent changes to NFPA 70E highlight how important it is to design safety into systems and provide detailed guidance for electrical workers. For example, the document addresses when the estimated incident energy exposure is greater than the arc rating of commercially available arc-rated PPE. There is also now guidance for safe work procedures in the absence of voltage testing. In addition, the latest version of 70E recognizes the newly updated IEEE 1584, a resource that the industry will continue to explore and apply to new power system analysis studies.

The NEC also includes provisions to help mitigate the hazards of arc flash and shock for the electrical worker. Arc flash safety is critical; however, the likelihood of electrical shock is often overlooked. In 2020, the International Association of Electrical Inspectors (IAEI) reported that more than 90% of electrical fatalities among US workers are due to electrical shock. Shock protection has been a part of the NEC for years and recent updates continue the growth of protection, leveraging barriers and ground-fault circuit interrupters (GFCIs) to reduce the likelihood of an incident. The most significant change is the expansion of GFCIs beyond 15- and 20-amp circuits and receptacles.

Electrical safety requires ongoing commitment

Whether mandated or elective, electrical system maintenance should never be viewed as a "just-get-it-done" situation due to the safety implications. It is also important to recognize that electrical safety involves much more than just applying a product; it's a regimen of training and procedures implemented in combination with technology that saves lives.

Continuing education is essential for electrical workers throughout every stage of their career. ASHE and many manufacturers offer focused electrical worker training programs that can help ensure you have the practical knowledge needed to handle nearly any electrical project. These training programs provide relevant electrical safety instruction, best practices and the specialized knowledge needed to safely and effectively design, commission, operate, maintain and troubleshoot electrical power management systems throughout every stage of the facility lifecycle.

You should also remember that you can have the most recent knowledge and cutting-edge safety solutions employed in your facility and still strive to establish safer working conditions. A safety-by-design approach is the embodiment of a commitment to constantly improving electrical safety throughout the lifecycle of a facility.

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