ENHANCING ARC FLASH SAFETY THROUGH CONTINUOUS THERMAL MONITORING AND OTHER RISK MITIGATION STRATEGIES

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Abstract - Arc flash incidents are one of the most significant hazards in electrical maintenance, accounting for approximately 25% of all electrical accidents, with 90% occurring in low-voltage switchgear. The remaining 10% of incidents in medium-voltage (MV) equipment, though less frequent, result in severe safety risks and substantial unplanned downtime, costing companies millions in lost productivity and repairs. Arc flashes generate extreme heat, pressure waves, and molten metal ejection, posing a serious threat to personnel and infrastructure. A few of the major challenges in preventing these incidents are that many occur when equipment is mistakenly assumed to be de-energized, old equipment is at higher risk, and hot spots developing on power distribution equipment emphasizing the need for stringent safety protocols.

Index Terms – Permanent Electrical Safety Device (PESD), Lockout/Tagout (LOTO), Continuous Thermal Monitoring (CTM), Phosphor Thermography

I. INTRODUCTION

Arc flash incidents are one of the most significant hazards in electrical maintenance, accounting for approximately 25% of all electrical accidents, with 90% occurring in low-voltage switchgear. The remaining 10% of incidents in medium-voltage (MV) equipment, though less frequent, result in severe safety risks and substantial unplanned downtime, costing companies millions in lost productivity and repairs. Arc flashes generate extreme heat, pressure waves, and molten metal ejection, posing a serious threat to personnel and infrastructure. A few of the major challenges in preventing these incidents are that many occur when equipment is mistakenly assumed to be de-energized, old equipment is at higher risk, and hot spots developing on power distribution equipment emphasizing the need for stringent safety protocols.

This paper explores key factors contributing to arc flash hazards, with a particular focus on Lockout/Tagout (LOTO) procedures, thermal monitoring, and essential maintenance practices in LV and MV environments. By evaluating technologies such as continuous thermal sensing and applying the Hierarchy of Controls, we highlight the benefits of integrating modern safety measures into standard maintenance procedures. Additionally, we examine industry standards, including IEEE Std. 1584™-2018, and their role in arc flash risk assessment, personal protective equipment (PPE) selection, and mitigation strategies. Through this analysis, we establish a framework for best practices in arc flash risk management and advocate for proactive strategies to safeguard personnel and critical infrastructure.

II. THE HIERARCHY OF CONTROLS

The Hierarchy of Controls is a foundational framework in occupational safety, used to minimize or eliminate exposure to hazards. In industrial electrical environments, where workers routinely interact with high-energy systems, this framework is especially critical. The hierarchy is structured in descending order of effectiveness: elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE). While all levels contribute to safety, the goal is to implement the highest level of control that is feasible to protect workers from electrical hazards such as arc flashes, shock, and electrocution.

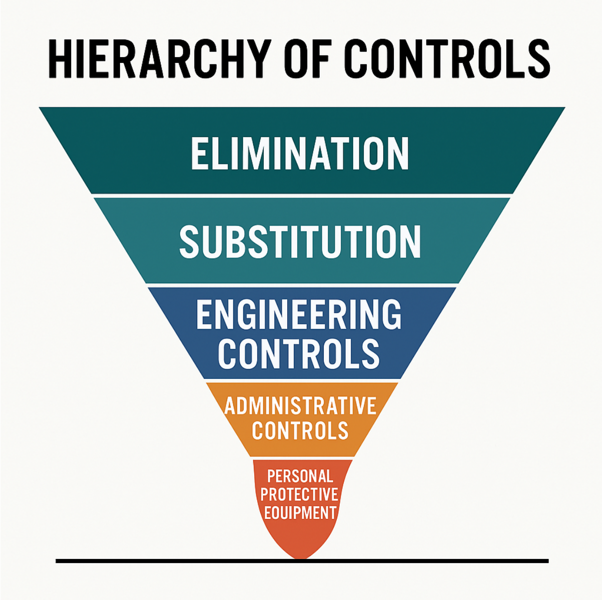

Figure 1 – Hierarchy of Controls Chart

Elimination and substitution represent the most effective but often least practical measures in industrial electrical applications. For example, eliminating energized work altogether by designing equipment to be fully de-energized before maintenance is ideal, but not always operationally viable. Similarly, substituting hazardous electrical equipment with inherently safer alternatives (such as using low-voltage systems instead of high-voltage) can reduce risk but may conflict with process requirements. As a result, industrial facilities frequently rely on engineering controls to bridge the gap between operational demands and worker safety.

Engineering controls involve redesigning equipment or systems to isolate people from hazards. In the electrical domain, this includes arc-resistant switchgear, remote racking systems, and permanent electrical safety devices (PESDs). PESDs, for instance, allow workers to verify absence of voltage from outside the panel enclosure, eliminating the need to open energized cabinets during Lockout/Tagout (LOTO). This reduces the risk of exposure to arc flash and shock—particularly in high incident energy applications where PPE alone would be insufficient. By addressing hazards at the source or along the exposure pathway, engineering controls are a pivotal strategy in modern electrical safety programs.

Administrative controls and PPE represent the lower tiers of the hierarchy and are less effective because they rely heavily on human behavior and compliance. Administrative controls include training, procedures, warning labels, and permitting systems, all of which aim to guide safe practices. PPE, such as arc-rated suits, gloves, and face shields, serves as the last line of defense. While necessary, these controls do not eliminate the hazard; they only mitigate the potential consequences. Consequently, leading organizations prioritize the use of engineering controls like PESDs to elevate safety beyond procedural compliance, embedding protection directly into equipment design.

The Hierarchy of Controls is an essential framework for improving worker safety, particularly in high-risk environments such as electrical maintenance. While the Hierarchy of Controls provides a strong foundation for hazard mitigation, its effectiveness is undermined when procedures are not consistently followed. Safety measures are sometimes perceived as time-consuming or inconvenient, especially during high-pressure maintenance situations. To overcome this, facilities must prioritize tools and processes that align safety with operational ease, encouraging adherence even in unplanned downtime scenarios.

Each category within the Hierarchy of Controls offers a structured method for mitigating risk, but a recurring challenge is ensuring these safety measures are consistently followed. Often, safety protocols are perceived as barriers to productivity, leading to shortcuts that compromise safety. is that any safety measures tend to be seen as things that slow down efficiency. People tend to be lazy and will not always sacrifice the path of least resistance for the safe slower way. This is where we need to utilize tools or other risk mitigation methods to make safety the easier choice. This will ensure safety is the path everyone takes, even in high stressful situations like unplanned downtimes.

III. DESIGN GAPS THAT ENGINEERING CONTROLS MUST ADDRESS

Low-voltage (LV) equipment remains one of the leading sources of arc flash incidents across industrial environments. Its prevalence in day-to-day operations, frequent maintenance interaction, and complex internal layouts contribute to an elevated risk profile. According to a study conducted by a major European OEM, over 600 electrical incidents were recorded annually in Germany alone—excluding undocumented near-misses or unreported events. While advances in equipment design—such as arc-resistant switchgear, arc flash relays, and IP2X-rated barriers—have improved overall safety, these solutions often fail to address the vulnerabilities present in older legacy systems that still make up a significant portion of industrial infrastructure. Although power distribution designs have vastly improved throughout the years with arc flash relays, IP2X barriers, and arc resistant equipment, many incidents occur still to this day. None of this address the safety concerns in the equipment that has been on site for decades.

Figure 2 - Panel-Mounted PESD in Dirty Environment

A primary factor in these incidents is human error, particularly during Lockout/Tagout (LOTO) and verification procedures. Common mistakes include isolating the wrong piece of equipment, failing to follow sequence protocols, using improper tools, or inadvertently contacting energized components. Compounding this is the global shortage of experienced electrical workers, which increases the likelihood of procedural lapses and unsafe practices. Even in facilities with strong training programs, human fallibility remains a persistent threat.

While some facilities attempt to mitigate these risks through the use of physical barriers, such as IP2X mesh or compartmentalized panels, these protections can inadvertently introduce new hazards. For instance, during de-energization verification, workers are often required to remove these barriers to access test points, temporarily defeating the very safety measures designed to protect them. This creates a paradox: safety procedures mandate actions that place workers in harm’s way, especially when PPE alone is insufficient in high-energy environments.

Legacy equipment poses an even greater challenge, as it frequently lacks modern safety design considerations and cannot easily accommodate advanced protective technologies. Simply relying on updated procedures and PPE is no longer adequate in these environments. Instead, engineering controls must be retrofitted or designed to inherently reduce exposure risks, particularly in situations where verification of de-energization is required.

The following case studies illustrate how forward-thinking organizations are bridging these safety gaps by integrating engineering solutions, such as Permanent Electrical Safety Devices (PESDs), to address human error, improve isolation verification, and modernize protection in both legacy and new equipment. These real-world applications underscore the critical need to align safety design with human behavior, operational demands, and system reliability.

Figure 3 - Panel-Mounted PESD with Illuminated LEDs to indicate Voltage Status

Application Summary #1: PESD Trial - Global Pulp & Paper Facility

The following case studies illustrate how engineering controls, specifically PESDs, have been implemented in real-world scenarios to mitigate arc flash hazards and improve Lockout/Tagout (LOTO) effectiveness.

A global pulp and paper manufacturer experienced a tragic incident that has since reshaped its approach to electrical safety. Due to internal workforce shortages, the facility relies heavily on external electrical contractors to perform routine maintenance and isolation procedures. During a standard Lockout/Tagout (LOTO) process, a contracted worker was required to access the busbar section of a panel. To do so, they had to remove the IP2X-rated mesh barrier—a component specifically designed to protect against accidental contact with live parts. This removal was necessary to test for absence of voltage, as required by procedure. During the process, a tool was inadvertently dropped inside the energized compartment, causing an arc flash that resulted in the contractor's death.

This incident exposed critical vulnerability in traditional LOTO procedures, particularly when they require bypassing physical barriers to perform verification. As a proactive response, the facility began evaluating engineering controls that could allow workers to verify de-energization without removing protective guards or exposing themselves to live components.

PESDs (Permanent Electrical Safety Devices) were trialed on key motor drive installations within the TM3 paper machine area. Two test point units were installed—one on the *Hood Layer* motor drive and another on the *Yankee Layer Fan Pump* motor. These PESDs allow maintenance personnel to safely test for absence of voltage from outside the enclosure, effectively eliminating the need to open panels or remove guards.

The trial results have been overwhelmingly positive. Site personnel reported that the units are both practical and highly functional, with benefits including enhanced safety, faster isolation verification, and reduced procedural risk. By removing the need to breach enclosure integrity, PESDs have helped the facility strengthen its safety culture and reduce the likelihood of repeat incidents. While only two units have been installed to date due to shifting priorities and workforce constraints, the PESDs have been described as "brilliant pieces of kit" by those on-site—paving the way for broader adoption across the facility.

Application Summary #2: PESD Implementation - Global Chromium Mining Facility

At one of the largest chromium mining operations in the world, PESDs were deployed to enhance electrical safety during Lockout/Tagout (LOTO) procedures. These units were installed on low-voltage (415 VAC) equipment located both in the solar field substations and within the main chromium processing plant.

The PESDs enabled maintenance personnel to **test for absence of voltage from outside the panel door**, eliminating the need to open enclosures during verification and thereby:

- **Reducing Arc Flash Risk**: By being able to prove dead from outside the panel door the facility was able to significantly decrease risk of electrical incidents during LOTO.
- **Improving LOTO Efficiency**: The ability to verify de-energization externally saved substantial time in the LOTO process, particularly in high-turnover maintenance areas.
- **Driving Standardization**: Due to these benefits, the facility has since standardized the use of PESDs across all electrical installations, marking a strategic move to embed safety and efficiency into their operational protocols.

Application Summary #3: Use of PESDs for High Incident Energy Applications - Major European Electrical OEM

One of Europe's largest original equipment manufacturers (OEMs) utilizes voltage indicators and test points to safety measure across its panel designs to mitigate risks associated with high incident energy levels during Lockout/Tagout (LOTO).

In several applications, bolted short-circuit current ratings and protection relay settings result in calculated arc flash incident energy exceeding 35 cal/cm^2, levels for which no commercially available arc-rated PPE can offer adequate protection. The PPE gear will not protect against the blast wave that will occur during an arc incident.

To address this critical safety gap, the OEM integrates PESDs to enable personnel to verify absence of voltage from outside the panel, avoiding any exposure to energized components. This approach provides:

- **Elimination of Arc Flash Exposure During Voltage Verification**: By preventing panel door opening, personnel are not placed in proximity to live conductors in extreme energy environments.
- **LOTO Efficiency Gains**: The ability to confirm de-energization externally reduces time spent on LOTO while improving procedural clarity.
- **Engineering Control Over PPE Reliance**: By embedding a design-level safety solution, the OEM shifts toward the top of the Hierarchy of Controls—reducing dependency on PPE alone to mitigate arc flash risk.

Application Summary #4: Mitigating Human Error in Mechanical LOTO - A Platinum Minerals Facility

A leading global producer in the platinum minerals industry experienced a tragic incident that underscored the critical consequences of human error during Lockout/Tagout (LOTO) procedures. In this case, maintenance personnel failed to complete a key step in the mechanical LOTO process: confirming equipment isolation through a control room-initiated start attempt. Instead, they relied solely on engaging a local disconnect switch, which unfortunately malfunctioned and failed to fully de-energize the equipment. Believing the system was safely isolated, several workers entered the equipment area. The equipment subsequently energized, resulting in multiple fatalities.

This event highlighted the vulnerability of relying exclusively on procedural compliance and the potential for oversight—even a single missed step—to lead to catastrophic outcomes. In response, the company began reevaluating its LOTO verification processes and exploring ways to introduce redundant safeguards that can augment human decision-making with visual and sensory confirmation tools.

Two key engineering controls are being actively considered. First, the company is evaluating the installation of voltage indicators with external LEDs on disconnects and motor control panels. These indicators would provide immediate, visible confirmation of voltage presence or absence, allowing personnel to verify isolation before entry—especially critical if a disconnect switch failed. While not a substitute for testing for absence of voltage, this solution offers an added layer of awareness and deterrent against skipping procedural steps.

Second, the facility is investigating the deployment of wearable voltage detection devices. These personal safety tools would alert workers via vibration, light, or sound if they approached or contacted conductors or enclosures that remain energized. While no single technology can replace procedural rigor, these innovations serve as redundancies to catch human error, reduce risk exposure, and improve overall system safety performance in environments where the consequences of mistakes are severe.

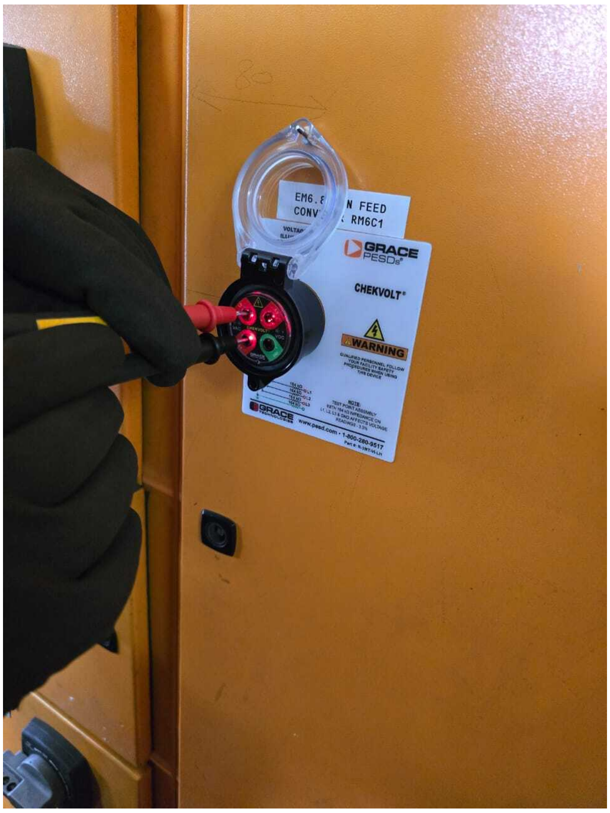

Figure 4 - Panel-Mounted PESD

Application Summary #5: The Consequences of Inadequate Safety Measures

A notable incident occurred at an 11kV oil refinery switchgear, where an incomplete LOTO procedure led an electrician to believe the system was de-energized. Upon opening the panel, residual voltage from an upstream transformer triggered a phase-to-phase fault, causing an arc flash. The worker suffered third-degree burns, and the resulting explosion destroyed multiple switchgear cubicles, leading to a plant-wide shut down for weeks.

Another incident at a 480V motor control center (MCC) in a petrochemical plant resulted in an arc flash after a technician, unaware of a secondary power feed, attempted to disconnect a live circuit. The explosion caused severe injuries and production halts, emphasizing the importance of LOTO verification and continuous thermal monitoring.

IV. THE CASE FOR CONTINUOUS THERMAL MONITORING (CTM)

Traditional thermographic scans, even when performed quarterly or annually, offer only periodic snapshots of equipment condition, leaving critical gaps where thermal anomalies can develop undetected. These gaps significantly undermine predictive maintenance strategies, making them more reactive and reliant on timing and chance. Additionally, in medium-voltage (MV) systems, the limitations of thermography are amplified due to restricted visibility. Despite the use of IR windows, the compartmentalized design of MV switchgear often obstructs the view of key components, leaving potential failure points unmonitored during routine inspections.

In contrast, CTM offers real-time, 24/7 surveillance of critical connection points across both MV and low-voltage (LV) systems. Unlike periodic IR scans, CTM enables continuous data collection and trend analysis under true operating conditions—without requiring panel access or load reduction. It provides immediate alerts for abnormal temperature rises and eliminates the need for intrusive inspections, significantly enhancing personnel safety and asset reliability.

As emphasized in NFPA 70B 2023 Edition, particularly in Annex H and Section 11.17.5, CTM is recommended for high-risk or hard-to-access equipment due to its ability to support a more proactive, data-driven maintenance approach. By deploying CTM, facilities can shift away from reactive maintenance toward predictive and preventive strategies—reducing unplanned outages, improving operational efficiency, and enhancing workplace safety.

Thermography alone is no longer sufficient to meet the demands of modern MV systems. CTM delivers the insight, coverage, and responsiveness needed to protect critical infrastructure and ensure up time in high-stakes environments.

V. THERMAL SENSING STRATEGIES FOR ENHANCED MV SYSTEM SAFETY AND RELIABILITY

While medium-voltage (MV) systems experience fewer incidents than low-voltage (LV) systems, the consequences are often significantly more severe. This is due not only to the higher incident energy typically involved, but also to the broader operational impact—especially when outages affect critical downstream LV production loads. Enhancing safety and reliability in MV environments requires proactive strategies, one of the most effective being continuous thermal monitoring. By detecting abnormal temperature rises early, thermal monitoring helps prevent arc flash events, equipment failures, and potential fire hazards. Key sensing technologies for implementing continuous thermal monitoring include. Here are the three predominant types of continuous thermal monitoring (CTM) systems:

1. Fiber Optic Temperature Sensors
2. Infrared (IR) Sensors
3. Wireless Sensors

While all these sensing methods are acceptable solutions, the application will typically dictate the best option.

Fiber optic temperature sensing is well-suited for higher voltage applications and environments with significant electromagnetic interference (EMI) due to the non-conductive nature of the optical fiber. These systems typically use **phosphor thermometry**, where a phosphor compound—combined with a stabilizing agent—absorbs and emits light in a way that varies with temperature. By analyzing this light response, accurate temperature measurements can be obtained at multiple points without electrical interference. This makes fiber optic sensors ideal for demanding MV and HV applications where traditional sensors may be unsuitable or pose safety risks.

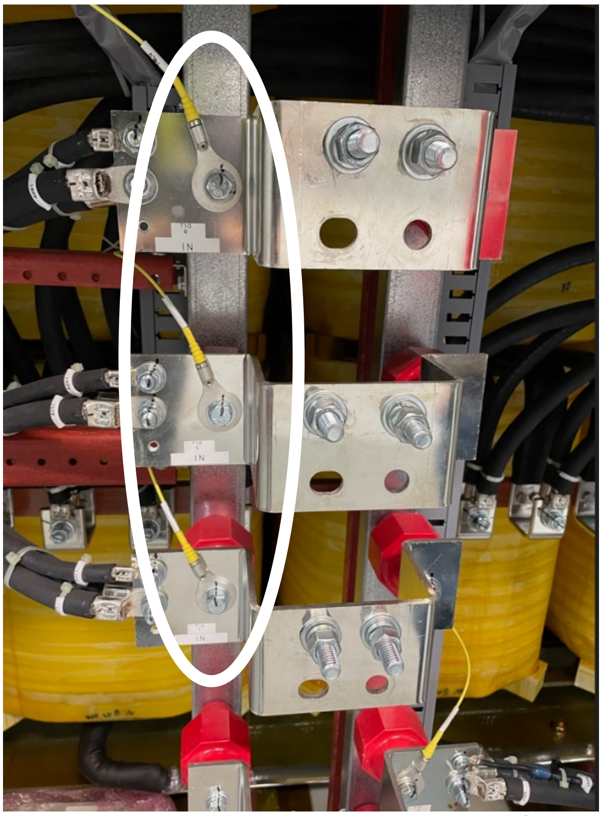

Figure 5 - Phosphor Thermometry with Polymer Optical Fiber

Infrared (IR) sensing provides a non-contact method for monitoring surface temperatures and can be useful for detecting thermal anomalies in accessible areas of electrical equipment. While effective for basic hot spot detection, IR sensors typically measure only specific points or surfaces and may miss internal or obscured heat sources. Their performance can also be influenced by dust, reflections, or ambient conditions. As a result, IR sensing is often used as a supplemental tool rather than a primary method in critical MV applications.

Wireless temperature sensors offer a convenient and sometimes cost-effective solution for retrofitting existing equipment, especially where wired installations are impractical. However, their reliance on batteries or energy harvesting, limited sensing range, and potential signal interference can restrict their use in high-reliability or high-voltage environments. As such, wireless sensors are generally better suited for supplementary monitoring rather than serving as the primary thermal sensing method in MV systems.

VI. KEY RISKS OF UNDETECTED HOT SPOTS IN MV EQUIPMENT: SAFETY AND DOWNTIME

There are two primary concerns when facing the potential of hot spot development in MV apparatus:

- Personnel Safety
- Unplanned Downtime

From a safety perspective, arc flash events in MV systems produce significantly higher incident energy compared to LV systems, posing **increased risks to maintenance personnel**. Verifying isolation, commonly referred to as "proving dead" becomes more critical and time-consuming under these conditions, in accordance with established safety standards and best practices. While essential for ensuring worker protection, this added precaution can impact operational efficiency and contribute to longer outage durations.

The second key issue is the potential for extended, costly **unplanned downtime** when hot spots go undetected. In many facilities, thermographic inspections—often using infrared (IR) windows—are conducted quarterly, biannually, or annually to check for developing issues. While these scans are widely used and often required for insurance compliance, they present critical limitations.

Application Summary #6 – Continuous Thermal Monitoring Enhances Reliability at a Coal Mine Operation in Australia

At a coal mining operation in Australia, quarterly thermographic inspections were conducted on the medium-voltage (MV) switchgear supplying the site's primary production motor, one of the facility's most critical assets. Despite these regular inspections, no anomalies were detected. However, just two weeks after the most recent scan, the motor experienced a catastrophic arcing fault, resulting in an 18-hour site-wide shut down and over $1 million in lost productivity and repair costs. This incident highlights a key limitation of periodic thermography and underscores the potential value of CTM in preventing such high-impact failures.

This approach is sometimes employed to enable scanning without opening enclosures or to minimize the level of arc-rated personal protective equipment (PPE) required. While this enhances safety for personnel, it significantly diminishes the likelihood of detecting thermal anomalies, which are more likely to manifest under full-load conditions. Consequently, the resulting data often reflects a limited and non-representative snapshot of actual operating conditions.

Application Summary #7 - Continuous Thermal Monitoring Enhances Reliability at Arizona Copper Mining Operation

A copper mining operation in Arizona USA, faced persistent overheating in vertically stacked chopper modules within its rectifiers, posing serious risks of thermal failure. Traditional IR thermography proved ineffective due to limited visibility caused by the compact layout, which ultimately resulted in undetected hot spots and repeated capacitor failures.

The site's rectifier stacks are housed within an outdoor walk-in enclosure with five feeder sections containing four stacked chopper modules each. Despite forced-air cooling and copper cooling tubes, airflow within the lower stack positions remained inadequate. Capacitors located between the upper bus components and drawer base were especially vulnerable to heat buildup and had begun splitting due to thermal stress.

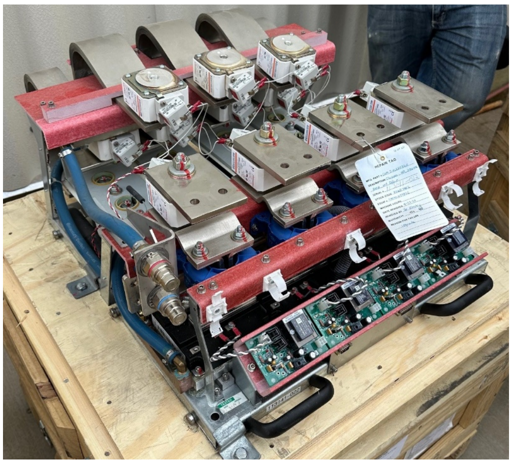

Figure 6 - Single Rectifier

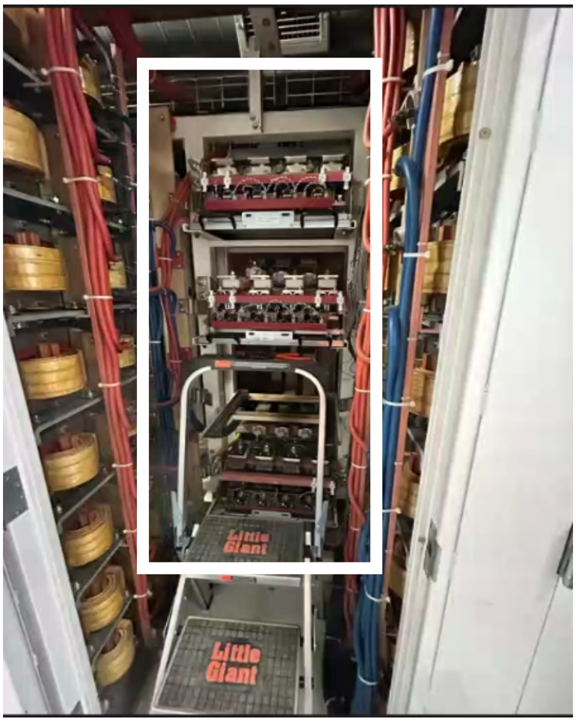
Figure 7 - Stacked Chopper Rectifiers

To address the issue, the facility partnered with its rectifier OEM to deploy a direct-connect phosphor thermometry solution using non-conductive fiber-based CTM technology. This solution was selected for its ability to precisely monitor the exact location of the heat source within this small, complex component. By providing visibility into these thermal elevation trends in real time, particularly in the lower chopper stacks where airflow is limited, the system enables early detection of abnormal temperature rises.

Since implementation, the site has eliminated capacitor-related failures and significantly reduced unplanned downtime by proactively addressing thermal issues—issues that had previously led to costly equipment shutdowns and operational disruptions.

Application Summary #8 – Oil & Gas Midstream Failure Assessment

A new remote electric compressor station was installed which included two 5,000 HP compressors operating at 4,160kV. The system utilized a 3,000 HP starting VFD with two sync-transfer motor starters, all powered by a 15 MVA transformer. The equipment was housed in a new Power Distribution Center (PDC) containing a low-voltage MCC, a UPS, and a station PLC.

A sync-transfer motor starter was comprised of an 800A VFD starting contactor and an 800A fused bypass (run) contactor, physically stacked. Each contactor was isolated from the main bus via an isolation switch located above the contactor compartment. Protection was provided by an arc flash protection scheme and bus over-current protection.

A failure occurred from a single, un-torqued, bolted connection on the lower B-phase termination of the upper VFD contactor (refer to Figures 2 and 3). While the other terminations on the damaged contactor were intact and tight, the lower B-phase termination was loose. The root cause of the loosened bolt was attributed to one or more of the following factors:

1. Over-torquing of the termination, causing it to fail
2. Damage to the flex connection to the contactor
3. Stress on the cable termination lug


Figure 8 - B-Phase Joint Indicating Loose Connection

Despite the damage, the starter remained energized, causing continued heat buildup. The contactor's glass polyester case melted, producing smoke coating the entire upper area of the PDC, approximately five feet above the floor. The resulting soot was greasy and smeared when touched. Additionally, the glastic insulating panels melted, exposing the underlying fiberglass.

The soot generated by the melting components coated the PDC walls, HVAC units, MCC bucket interiors, and other equipment. Cleaning the residue required a team of 40 workers over nine days, during which the facility experienced complete downtime, with no income or productivity. Fortunately, the manufacturer had a direct replacement unit available to rebuild the failed starter; otherwise, the outage could have lasted several weeks.

Eight months before the incident, an IR scan of the equipment showed no signs of failure. Following the event, the engineering team conducted a thorough evaluation which led the company to assess many shortcomings of their remote compressor stations systems. These included bus protection relay settings that lacked the sensitivity to detect increases in current, motor protection relay CT's that were unable to detect current differences, arc-flash sensors that melted due to the heat and could not trip, smoke detectors that were wired but without configured alerts.

The key solution became monitoring the integrity of power terminations and determining the most effective approach to achieve this. The ideal solution would provide continuous or near-continuous monitoring, preferably automated, integrated with a manned system for alarm notifications and event recording, retrofit-friendly, and cost-effective for a large number of terminations.

After evaluating the alternatives, the team concluded that the addition of a CTM system would be the most effective way to ensure the integrity of all MV power terminations and 480V terminations above 100A; basing the 100A threshold on the NESC-2023 Table 410-1 incident energy guidelines. And in the end, they collectively determined the benefits of a CTM system extended beyond just detecting issues; they included real-time alarming, data trending for predictive maintenance, and significantly reducing personnel exposure to live MV energy

These advantages not only would enhance safety but also provide a strong justification for the investment, particularly in environments where terminations are difficult or impossible to access manually.

Figure 9 - MV Drive Switchgear - Double Bus and Switch CTM Deployment

VII. CONCLUSION

Arc flash incidents remain one of the most significant hazards in electrical maintenance, with severe consequences for personnel safety, equipment integrity, and facility operations. This paper has examined the critical factors contributing to arc flash risks, including human error, improper Lockout/Tagout (LOTO) procedures, equipment failures, and the limitations of traditional safety measures. It also highlighted the role of standards such as IEEE 1584-2018, which provides a framework for risk assessment and PPE selection, ensuring workers are adequately protected based on real-world energy exposure levels. Furthermore, integrating advanced engineering controls, administrative safety protocols, and ongoing personnel training significantly enhances arc flash mitigation strategies. By implementing a proactive approach to maintenance, leveraging new safety technologies, and enforcing strict compliance with industry standards, organizations can greatly reduce the likelihood and severity of arc flash incidents.

However, arc flash safety is not a one-time implementation but a continuous process. Electrical systems evolve over time due to equipment aging, modifications, and operational changes, requiring regular updates to risk assessments and maintenance protocols. Facilities must adopt a culture of continuous improvement, where safety measures are periodically reviewed, updated, and reinforced to address emerging risks. This includes enhancing worker training programs, updating PPE requirements based on the latest risk assessments, and ensuring that protective devices such as arc flash relays and circuit breakers are routinely tested and calibrated. Additionally, thermal monitoring technology should be integrated into electrical systems to provide real-time detection of hot spots, insulation degradation, and potential failure points, allowing for preventative action before dangerous conditions arise.

To achieve meaningful reductions in arc flash incidents, companies must take a proactive stance on risk management and safety innovation. This means moving beyond compliance and embracing emerging technologies such as continuous thermal monitoring, predictive analytics, and remote switching mechanisms to minimize direct worker exposure to energized equipment. Additionally, enhanced safety training programs, real-world simulations, and stronger enforcement of safety policies will further reduce the potential for human error, which remains a leading cause of arc flash incidents. Facility managers, safety officers, and electrical engineers must work together to ensure that best practices for arc flash prevention are not just written into policy but actively implemented in daily operations.

Ultimately, the responsibility for arc flash prevention falls on organizations, electrical professionals, and industry leaders to implement and sustain a strong safety culture. By continuously improving arc flash mitigation strategies, integrating real-time monitoring solutions, and enforcing strict compliance with safety standards, companies can protect their workforce and infrastructure from catastrophic arc flash incidents. Now is the time to prioritize electrical safety and take definitive action—through advanced risk management, predictive maintenance, and cutting-edge thermal monitoring technologies, reduction in arc flash risks, safeguard personnel, and ensure the long-term reliability of electrical systems.

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IX. VITAE

Benjamin Hermann is the International Sales Manager at Grace Technologies, where he leads global initiatives to improve electrical safety and maintenance efficiency. With extensive experience working across North America, Europe, Asia, and Latin America, he has helped hundreds of industrial facilities adopt engineered safety solutions such as Permanent Electrical Safety Devices (PESDs) and Continuous Thermal Monitoring (CTM). His work focuses on bridging operational goals with safety compliance, delivering measurable improvements in maintenance workflows and reducing electrical risk exposure for frontline workers.

Through hands-on collaboration with engineering teams, distributors, and plant personnel, he continues to champion safer, smarter practices in electrical maintenance around the world.

Shelly DeGrate is the Industry Strategy Director for Grace Technologies, where she leads the development and commercialization of innovative electrical safety solutions that address the evolving challenges of industrial power systems. A Senior Member of IEEE and Chair of the IEEE/IAS PCIC Standards Subcommittee, she plays an influential role in shaping industry standards that advance electrical safety practices across high-risk environments.

With a strong background in product management, she has led the development and commercialization efforts to advance electrical safety technologies, including continuous thermal monitoring (CTM) systems that reduce arc flash hazards and support predictive maintenance. She is a published author and recognized speaker on CTM, electrical safety, and data-driven maintenance strategies. Shelly holds a BSEE from the University of Houston and an MBA from Texas A&M University. Through her leadership and technical contributions, she continues to drive innovation at the intersection of safety, compliance, and smart power solutions.