

# Switchgear Survival Guide: Ten Tips to Optimize Switchgear and Enhance Reliability

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## Executive summary

Switchgear often fails because it has degraded into unsatisfactory condition prematurely. Performing proper maintenance can reduce the risk of unplanned downtime and extend the useful life of electrical equipment. This paper presents 10 practical tips to optimize the performance and therefore enhance the reliability of electrical switchgear equipment.

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# 1.0 Abstract

With increasing dependence on computers and automated processes, most modern facilities cannot afford downtime. According to studies published by the Hartford Steam Boiler Insurance Company and FM Global, “Electrical equipment failures account for millions of dollars in damage and lost business every year.” Performing proper maintenance on a facility’s electrical equipment can reduce the risk of an unplanned outage and help extend useful life of the asset. In today’s economy, budget constraints on capital improvement projects will mean more reliance on existing equipment maintenance.

**Useful life** can be defined as the duration until the equipment no longer performs its intended function, either mechanically or electrically.

# 2.0 Introduction

Electrical switchgear is composed of passive and active components.

- Passive components include the horizontal and vertical bus structures.
- Active components are the power circuit breakers and fusible switching devices. Their role is to protect the electrical assets downstream, disconnect the circuit, and protect personnel in case of an arc flash event.

Both the passive and active components require regular maintenance to ensure equipment integrity and proper mechanical and electrical functionality, as well as to optimize the equipment’s useful life. A regularly scheduled electrical system preventive maintenance program is intended to detect, repair, or replace affected electrical components, parts, or equipment before they lead to catastrophic damages, significant power interruptions, and loss of business functions.

Circuit breakers will be the primary focus of this paper, as they are the most commonly utilized active component in low and medium-voltage switchgear and switchboards.

- Medium-voltage switchgear can consist of one of three types of circuit breakers; air, vacuum or oil. These circuit breakers are typically draw-out type, a design which facilitates removal from the power source and simplifies maintenance. Air, vacuum and oil circuit breakers require similar maintenance; however each has unique characteristics and testing procedures.
- There are essentially two classes of low-voltage circuit breakers that can be applied in an electrical distribution system: power circuit breakers (ANSI C37.13), or molded and insulated case circuit breakers (UL 489). Pre-1980 circuit breakers utilize older protection technology which require more maintenance compared to post-1980 designs that typically utilize solid-state or microprocessor trip units and enhanced lubricants. Post-1980 circuit breakers tend to be more reliable with regularly performed maintenance.

Industry groups such as IEEE have analyzed factors that affect the condition and performance of circuit breakers, and have published average failure rates for this equipment. However, these average failure rates do not account for the varying degrees of maintenance between different installations. In addition, even the best maintained equipment ultimately degrades and reaches the end of its useful life, albeit a longer life than if not maintained.

Although this paper focuses on switchgear due to its more complex nature, **it is extremely important to note that maintenance on only a portion of the electrical equipment does not guarantee a completely coordinated and reliable power distribution system.** With this in mind, following are ten tips to optimize the life of your electrical switchgear equipment and improve its reliability:

## 3.0 Ten Tips to Optimize the Life of Electrical Switchgear



### Tip 1: Perform Infrared Inspections

Although not a substitute for a maintenance program, thermal imaging (infrared) is a valuable tool that can be done while the equipment is energized. If done safely and properly, an infrared inspection can identify loose bus connections before they result in a full or partial equipment outage. Maintenance can be scheduled to correct the identified issue. Having infrared viewing windows installed allows infrared inspections to be done quickly and safely.

### Tip 2: Exercise Circuit Breakers Annually

A simple but very valuable practice is to manually operate circuit breakers once a year. This keeps the contacts clean and helps operating mechanisms move freely.

## Tip 3: Don't Neglect Recommended Maintenance

Switchgear should be cleaned, inspected, tightened, lubricated, and exercised on a regular basis. The frequency of maintenance depends on the environment, the condition of the equipment, and its criticality. Moisture and heat combined with dirt, dust, or other contaminants in the environment will deteriorate the insulation, conductive materials, and protective devices in the equipment at an accelerated rate. These factors should be considered in determining whether maintenance should be performed annually, every 5 years, or somewhere in between. An expert in the maintenance of switchgear can assist in preparing a maintenance plan for each lineup of switchgear.

A thorough on-site maintenance work scope for low-voltage power circuit breakers includes:

- Inspection
- Cleaning and lubricating the primary and secondary disconnects, racking mechanism, and cell interlocks
- Adjustments
- Overcurrent protective device testing
- Insulation testing
- Charge/close/trip circuit testing



## Tip 4: Recondition the Equipment

A more intensive maintenance option for circuit breakers is in-shop reconditioning. The circuit breaker is initially tested against ANSI standards and then completely disassembled, cleaned, and inspected. Damaged parts are refurbished or replaced, and pivot points are relubricated before the circuit breaker is reassembled. The reconditioned circuit breaker, including the new assemblies, is retested against ANSI standards. Reconditioning should be performed when the on-site maintenance work scope cannot bring the circuit breaker within tolerances defined in current industry standards. The use of new or refurbished parts or subassemblies may be required to return a circuit breaker to a reliable operating condition. As part of this service, the trip unit can be retrofitted with a modern digital device.



## Tip 5: Keep Good Records and Trend Performance

Unless maintenance testing has been utilized to track the performance of circuit breakers, degradation of insulation and the moving parts may not be noticed. Switchgear components can be out of design tolerance, however they may be able to stay in that condition for a long period of time and still be functional. By tracking test data, you can get a better idea of the expected life of the equipment and focus your maintenance efforts on the areas that truly need it the most. Some providers of switchgear maintenance, such as Schneider Electric Services, can provide an engineering analysis of the testing data with a recommended plan based on predictive performance.

## Tip 6: Upgrade the Equipment

Facility managers are often faced with the choice of maintaining aging (or obsolete) equipment or replacing it with a new switchgear line-up to take advantage of current technology. Even with annual maintenance, circuit breakers may need additional upkeep or upgrades. Factors to consider include the operating environment, availability of spare parts, reliability, and the cost of ongoing maintenance.

There may also be the need to increase the switchgear's fault or continuous current rating, or the desire to upgrade technology. Recent advances in technology, both in material sciences and in microprocessor based controls, have facilitated the production of more modern circuit breakers with better performance, reduced maintenance requirements and on-board diagnostics, to name a few features. With the advancements in the circuit breaker designs, those with older technology may no longer be considered sustainable solutions. To take advantage of the more advanced technology, the switchgear lineup could be replaced. A more cost feasible alternative would be to leave the switchgear structure and bussing in place and upgrade the existing equipment with the latest state of the art circuit breakers.

When considering whether to maintain, replace or upgrade the equipment, facility managers must take into account the initial capital cost, along with potential disruption to the facility's processes and workflow during the course of changing out the equipment. Unless process loads can be rerouted temporarily during the demolition of old equipment and installation of the new equipment, the cost of lost production can be substantial. Schneider Electric has developed methods for adapting the latest technology circuit breakers into a switchgear or switchboard cell that was originally designed for a variety of OEM circuit breakers. This allows for an upgrade of the active components, while not disturbing the cables and taking on the risk and challenge that may be uncovered during the middle of an outage replacement.



### CASE STUDY



*An automotive facility's personnel were concerned about a lengthy and costly downtime because of outdated switchgear operating in this automotive manufacturing plant.*

The facility's two primary switchgear lineups were installed in the early 1950s. Though they were still operational, the age of the circuit breakers connected to the 2,000 amp bus in both lineups, along with the elevator-like system used to remove them from the switchgear for maintenance, made for an outdated system that raised concerns of reliability and posed an increased risk of hazard for the plant's electricians.

After much investigation, facility management selected a retrofill solution to upgrade all 19 circuit breakers with Square D™ VR medium-voltage circuit breakers. Existing switchgear cubicles were reconfigured to accept the new circuit breakers, leaving the switchgear structure and footprint intact. The retrofill solution also included installation of SEPAM solid-stage digital relays, a new exterior door (where the relays resided) and an interior sub-plate positioned beyond the circuit breaker to minimize possible exposure to the energized bus. The elevator racking system was also replaced with a new cradle assembly for each cubicle. As a result, the physical action of racking out a breaker would be accomplished with the exterior door closed.

With the circuit breakers and relays installed, the plant has a more reliable electrical distribution system. This solution met the facility management's goal of upgrading the equipment, minimizing downtime, and enhancing workplace safety for the plant's electricians.

## Tip 7: Outsource Preventive Maintenance Via a Long-Term Maintenance Contract

To ensure your switchgear is being maintained properly, consider outsourcing to a professional maintenance provider. Very few electrical maintenance or contracting companies can perform all of the required maintenance activities for an electrical distribution system. A professional electrical engineer can assist facility management with the selection of a qualified electrical maintenance contractor. The service provider can help create a maintenance program that includes requirements and frequency of maintenance. A multi-year contract, or service agreement, ensures that maintenance will not be overlooked and helps to ensure work scopes are optimized throughout the duration of the contract.



## Tip 8: Comply with NFPA 70E

The industry standard document for electrical workplace safety is NFPA 70E. This document states that switchgear and other equipment shall be field marked with a label containing the available incident energy or required level of PPE. To obtain the incident energy level, an arc flash analysis must be performed by a qualified and experienced engineer. NFPA 70E also states that proper maintenance is required for the analysis to be effective and recommends following NFPA 70B and manufacturer's recommendations.

## Tip 9: Utilize Predictive Maintenance Tools

Several types of tools and services are available that can be utilized to predict equipment life and maintenance requirements. Some of the tools are on-line monitoring systems that can provide warnings of impending failures. These on-line systems operate 24/7 and have the advantage of recognizing a condition that may not be apparent during a one-time inspection. The following is a listing of common predictive maintenance technologies and tools:

1. **Wireless Temperature Monitoring Systems** provide alarms of high bus connection temperatures, indicating that maintenance should be performed before a loose connection results in a thermal runaway situation.
2. **Partial Discharge Monitoring Systems** are useful on medium-voltage switchgear and connected cables to provide warning of insulation failures. Left unattended, these situations would ultimately lead to an insulation breakdown and potential arc flash.
3. **Power System Assessments** provide means to determine the electrical and mechanical health of the power equipment and power distribution system and how long it will likely continue to function as originally designed and intended.
4. **Infrared Inspections** provide one-shot evaluation of electrical equipment to identify poor electrical contacts or connections, unbalanced electrical loads, and defective components. Infrared viewing windows can be installed on the switchgear to allow these inspections to be performed safely

## Tip 9 (Cont.): Utilize Predictive Maintenance Tools

- 5. Circuit Monitors** are available that offer a full range of power quality features such as waveform capture, wave shape analysis, disturbance recording, disturbance direction detection, and transient analysis allowing facility managers and engineering staff to understand where and when dangerous and destructive transients, sags and swells occur. This allows facility managers to diagnose potential problems to minimize downtime.
- 6. Intelligent Protective Devices** such as electronic trip units or separate monitors can provide intelligent information regarding the health of the circuit breaker. The circuit breaker condition can be analyzed providing advanced planning ability as “condition-based” activity instead of routine maintenance.

## Tip 10: Perform a Short Circuit Analysis and a Time Current Coordination Study

The reliability of switchgear could be compromised if the short circuit rating of the equipment and devices are not equal to or higher than the available fault current. As facilities evolve, changes to the power distribution system occur that could affect the available fault current. Equipment changes by the utility could also have the same effect. Under-rated switchgear components could go unnoticed, at least until a fault occurs.

If the switchgear is rated properly, it should be able to clear a fault with minimal effect upon the switchgear. However, if the switchgear components do not have a proper short circuit rating, there could be catastrophic damage to the equipment and surrounding area. A short circuit analysis will determine if the switchgear is rated properly. A coordination study, if it exists, may also need to be updated. Coordinated circuit breaker settings can prevent unnecessary interruptions of faults by the switchgear that should have been interrupted by a downstream device.

## 4.0 Conclusion

Depending on when your switchgear was installed and how it has been utilized, the equipment may be in a condition somewhere between satisfactory performance and non-functional. A trend towards the latter usually occurs as equipment approaches the end of its expected design life. If maintenance has not been regularly performed, this less-than-satisfactory condition may be entered prematurely, and a shortened useful life of the components may be the result. Electrical equipment and power distribution systems have never been designed to be or intended to remain perpetually energized without interaction by the owner. By implementing the tips covered in this paper, you can maximize the life and reliability of your switchgear.



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