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Electrical Distribution Maintenance Fundamentals

by David Morte

Executive summary

This paper discusses basic electrical distribution maintenance concepts, including the purpose and characteristics of different types of maintenance, frequency of maintenance intervention, and spare parts policies.

Introduction

Why maintain electrical distribution equipment?

Carrying out maintenance in electrical distribution equipment provides five important benefits.

1. Safety and equipment protection

One of plant managers' most crucial responsibilities is to ensure the sustainable development of their business. Plant managers are obligated to adopt all available measures technically and economically available to them in order to minimize the risk of unwanted events, such as those that harm personnel, assets, or the business.

Some electrical distribution equipment is designed to minimize the risk and severity of accidents or process breakdowns, such as circuit breakers and fuse contactors, for example. The highest priority of maintenance is to ensure that role is performed.

2. Service continuity

Preventive maintenance maximizes uptime. Thanks to scheduled equipment outages, less disruption to activities and less stress is generated. It takes less time to perform preventive maintenance than emergency repair while mitigating the risk of emergency shutdown.

The consequences of even an hour-long production shutdown can be enormous.

Table 1

Financial impact of 1 hour's production shutdown

Source: Contingency Planning Research and Schneider Electric

Application	Loss* in €
Health establishment	Human lives
Stock market transactions	6,500,000
Credit card sales	2,600,000
Petrochemical	100,000
Airfare booking system	90,000
Mobile phone network	40,000
Automobile	30,000
Pharmaceutical	30,000
Food processing	20,000
Cement	15,000

(*) Direct and indirect costs of non availability

3. Energy-efficient equipment

Research shows that unmaintained devices are not as energy efficient as well-maintained equipment. Over time, normal wear and tear causes stress to components, which can result in diminishing device energy efficiency. Less wear and tear on the equipment means less wasted energy while in operation. Simple maintenance is commonly scheduled to be conducted during off-peak business periods.

4. Efficient spare parts management

Spare parts alone can amount to half of total maintenance costs. These costs can be cut by substituting reactive maintenance with preventive maintenance, in order to reduce the number of faults within complex parts or systems. As a result, more money and time can be spent improving the production process.

5. Optimized total cost of ownership (TCO)

Considering the significant costs of equipment acquisition (CapEx), plant managers want their electrical distribution equipment running well for as long as possible.

Moreover, business operations must run as well as possible at an optimum cost. Without maintenance, industries suffer emergency shutdown situations (reactive maintenance). Such urgency can cause both spare parts and labor to be purchased at a premium, in addition to process shutdown costs (OpEx).

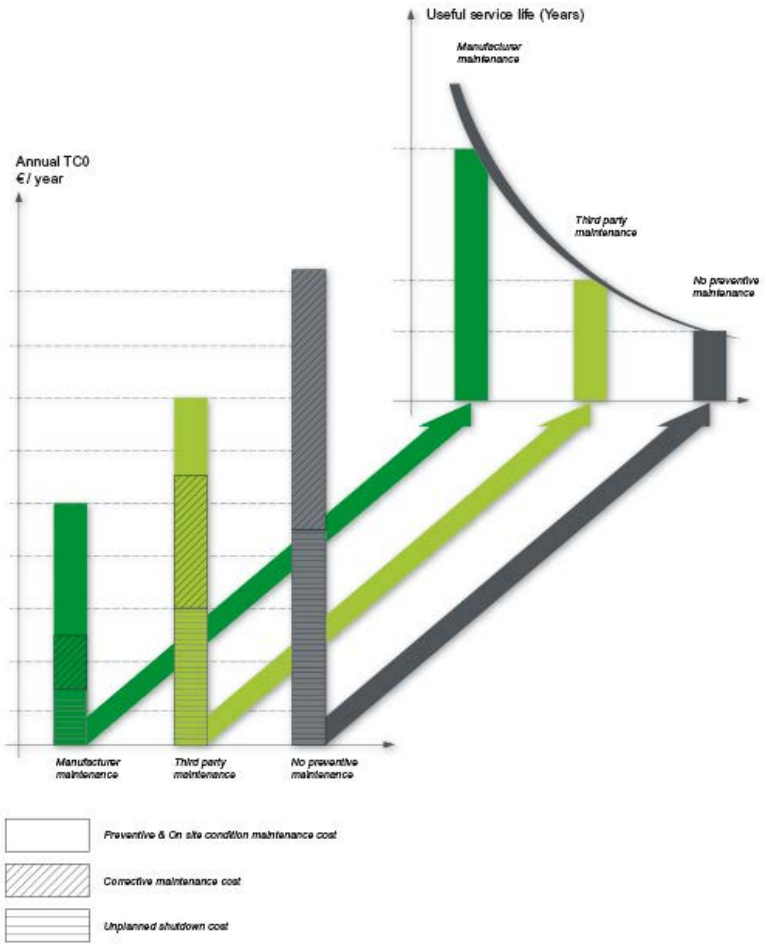
Modern and up-to-date maintenance techniques become a key competitive advantage thanks to early detection—identifying problems before they become a major repair. Knowing when scheduled shutdowns will occur allows managers to staff accordingly.

Carrying out maintenance is a unique opportunity to reduce TCO (CaPex + OpEx) and create more value for a business. It must be professionally executed by highly qualified and skilled technical operators.

What is the impact of a maintenance strategy on the TCO of electrical equipment?

Figure 1

Example of complete annual costs for an MV switch protection cubicle



Hence, for manufacturer maintenance:

- Annual TCO is lower because the useful service life of equipment is longer
- Predictive (with remote monitoring technologies) and on-site condition (with regular on-site diagnosis) maintenance reduces reactive maintenance and unplanned shutdown costs that result from equipment failure by improving reliability and maximizing service continuity

Maintenance types

Reactive maintenance

This type of maintenance is basically a misnomer, and would be better referred to as “repair.” It’s defined as equipment intervention that restores the required function of a faulty item.

The result can be:

- Palliative or temporary, to allow a faulty item to perform its required function for a limited interval and until a repair is carried out
- Curative, to allow a faulty item to perform its required function as per original performance

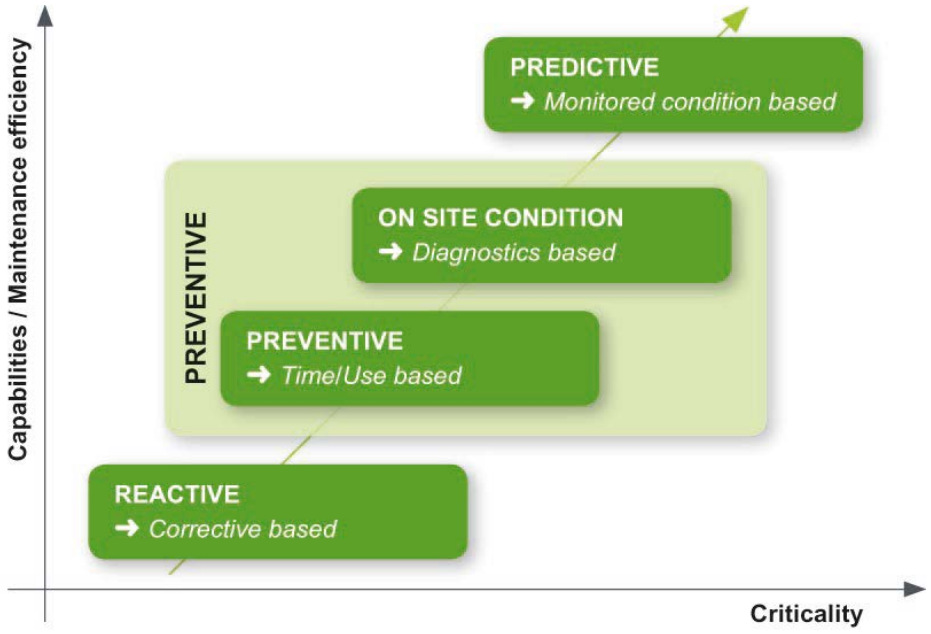
Often, a deep diagnosis of equipment is required for fault recognition, localization, cause identification, and the appropriate solution. A final function check-out is conducted to verify that the item is able to perform the function as required.

Electrical distribution equipment manufacturers’ service offers and their diagnostic solutions are often the best and most cost-efficient corrective solutions thanks to:

- Expertise in manufacturer equipment for the optimal condition, thereby extending equipment lifetime
- Know-how in particular techniques, procedures, test equipment technologies, equipment assembly, and manufacturing processes that may affect equipment performance after intervention
- Direct access to the supply of genuine spare parts for both active and discontinued MV and LV equipment

Figure 2

Maintenance maturity curve



Preventive maintenance

This is the combination of activities consisting of regular inspections, work on mechanisms, and part replacement in electrical distribution equipment. Its goal is to avoid any possible failure (to the best possible extent) and its costly corrective intervention (palliative or curative).

Preventive maintenance can be categorized in three levels according to its complexity:

Exclusive maintenance activities

Conducted by equipment manufacturer services as it impacts electrical distribution equipment performance:

- Cleaning/checking/greasing of the operating mechanism
- Cleaning/checking/greasing of the closing and opening springs

Advanced maintenance activities

Conducted by equipment manufacturer services or certified partners with demonstrated qualifications:

- Cleaning/checking/greasing of moving and withdrawable parts
- Busbar inspection (tightening, chalking, cracking, signs of heating)

Basic maintenance activities

Conducted by personnel trained on manufacturer's preventive maintenance guides:

- General state: Visual examination, cleanliness, insulator condition, oxidation, no corrosion of supporting structure
- Inspection of state of the auxiliaries contact (on/off, rack in, rack off, etc.)

Preventive maintenance is usually conducted during a scheduled shutdown to minimize its impact on business operations, and to respect the principle of periodic maintenance. That is, when interventions are scheduled and conducted based on time intervals and/or the number of units in use, but without any previous equipment condition investigation.

Onsite condition maintenance

The next level of maintenance maturity is the completion of preventive maintenance with onsite diagnosis interventions when available. The goal is to identify the symptoms of an undetected malfunction or equipment degradation before the fault occurs. It can be considered as the entry level of condition-based maintenance.

This helps keep the equipment as close to its optimum condition as possible (excluding the need to repair the device and eliminating all failures) and schedule, during the most convenient time, a complete corrective intervention plan to restore its original performance level, if necessary.

Its applications involve the more critical assets where failure significantly impacts uptime, asset longevity, safety, product quality, or involves major reactive intervention costs. This level of maintenance is an easy-to-implement and cost-efficient solution.

Electrical distribution equipment manufacturers' diagnostic solutions are best positioned to deliver unique performance because of the following:

- Inspection, testing, and analysis are conducted with customized test kits and software, securing efficient and reliable data management
- Availability of a technical database cataloging historical equipment operation to diagnose whether the equipment maintains its original performance level
- Field service representatives' equipment expertise to secure the best recommendations and instructions for electrical distribution performance and optimal condition, thereby extending equipment life
- Experience from an extensive electrical distribution equipment installed base under the most extreme operating conditions
- Information about obsolescence dates of manufacturer equipment and genuine spare parts availability in order to anticipate future evolutions such as extensions, upgrades, and retrofits

The next step is to integrate smart monitoring systems for real-time tracking of an electrical distribution installation, the performance of its critical devices, and degradable parts condition data.

When also following the principles of predictive maintenance, the plant manager gains a complete picture of equipment condition, a comprehensive risk assessment, and greater peace-of-mind when making critical decisions.

Predictive maintenance

Predictive Maintenance is the utmost in maintenance management to minimize unscheduled downtimes to reduce the overall cost of maintenance and peace-of-mind over an electrical distribution infrastructure.

Maintenance cost reductions can be achieved by the better management of resources and spare parts, by using equipment integrity and process reliability studies, by optimizing equipment obsolescence management, and by predicting when a failure is likely to occur and support maintenance work order decisions by plant or facility managers.

Maintenance interventions are forecasted and launched when programmed alarms (online monitoring of selected parameters of equipment's core items) indicate that a predefined wear threshold has been reached. Sensors therefore need to be installed in devices, switchboards, and installations.

This is supported by a maintenance information system (Enterprise Asset Management), sometimes integrated with plant ERP, for planning the most convenient intervention time and derived actions, such as spare parts management, field services, etc.

Predictive maintenance is about equipment condition monitoring using advanced sensor and instrumentation technologies, and its repetitive analysis. It represents the application of the Just-In-Time principle to the preventive maintenance function. It is a way to reduce (but not eliminate) periodic maintenance activities that require shutdowns to a strict minimum.

To predict when equipment is about to fail requires adapted condition monitoring, meaning deep knowledge of how the equipment fulfills its function, and of the relevant, measurable data that need to be used to provide the right information regarding how the asset can continue to operate at optimum conditions.

For this purpose, digital IoT (Internet of Things) solutions for equipment condition monitoring, along with big data and advanced IT platforms (with embedded algorithms emulating equipment behavior and automatically adapting the alarm threshold as per each device's operating conditions based on the current operating range), can provide early warning and diagnosis of equipment health problems in order to predict when the next field maintenance should be performed. This defines the new paradigm to enhance equipment health status in order to get the most of your electrical distribution infrastructure.

Frequency of intervention

Electrical distribution equipment manufacturers recommend a schedule for maintenance activities to extend electrical distribution equipment performance over time. Frequencies under normal, healthy operation (minor equipment criticality and optimal environmental conditions) can be generally defined as follows:

Table 2

Frequency schedule by maintenance activity type and by whom it's conducted

Maintenance activity type	Minimum frequency (1)	Conducted by		
		Manufacturer	Service partner	End User
Exclusive	4 years	√		
Advanced	2 years	√	√	
Basic	1 year	√	√	√

(1) Recommended under normal operating conditions (minor equipment criticality and optimal environmental conditions). However, this recommended frequency should increase according to the level of criticality (low, major, critical) and the severity of environment conditions (i.e., corrosive, naval, offshore) following recommendations of the manufacturer's services

Nonetheless, it is strongly recommended to increase the frequency of interventions when operating under severe, abnormal or unhealthy conditions such as the situations listed below (alone or combined).

Harsh environments

Environments with extreme temperatures, significant temperature changes, high humidity levels, and high dust concentration speed electrical distribution equipment aging individually and even more so in combination.

This leads to a higher risk of equipment malfunction. The more regularly inspections are conducted, the better the chance of mitigating this risk.

Table 3

Normal vs. severe environmental conditions

Risk factor	Normal environmental conditions	Severe environmental conditions
Temperature	Average annual temperature < 25°C outside the switchboard (TA)	Average annual temperature between 35°C -45°C around the switchboard (see IEC 60439-1)
Percent load	< 80% of In 24/24 hours	> 80% of In 8/24 hours or 24/24 hours
Relative humidity	< 70%	> 80%
Corrosive atmosphere (IEC 60721-3-3)	Device installed in environment category 3C1 or 3C2	Device installed in environment category 3C3 or 3C4 without any particular protection
Salt environment	No salt mist	Installation <10 km from seaside and device without any particular protection
Dust	Low level - device protected in switchboard equipped with filters or ventilated IP54 enclosure	High level - device not protected
Vibration	Permanent vibration < 0.2g	Continuous vibration between 0.2g and 0.5g

Intensive exploitation conditions

Exploitation conditions are the working operating conditions to which equipment is subjected within the electrical distribution installation. This includes, for example, frequency of shunting or no shunting, charging and load rate, power and supply quality, and factors that define overall equipment stress levels.

Electrical distribution equipment manufacturers warranty electrical and mechanical endurance for a number of accumulated operations depending on exploitation and environmental operating conditions. When equipment exceeds the operating limits defined by the manufacturer, an accurate and regular diagnostic is recommended.

Spare parts

Every piece of equipment has an associated risk of failure. While one can minimize risk by choosing high-quality electrical distribution equipment and performing regular maintenance, that risk can never be entirely eliminated. By having access to genuine spare parts according to the equipment manufacturer's recommendations, plant or facility managers can ensure equipment is returned to service in the shortest possible time, avoiding lost revenue and safeguarding assets and business.

Equipment obsolescence and unavailability of spare parts

The only solution to extend the electrical distribution equipment life cycle when at the end of its discontinued phase is to carry out intense maintenance while planning for modernization.

Conclusion

Plant managers should strategically schedule and employ a variety of approaches to maintain electrical distribution equipment in order to deliver six key benefits: Personnel safety, equipment and goods protection, service continuity, energy efficiency, efficient spare parts management, and optimized total cost of ownership.

About the author

David Morte is a Senior Marketing Manager in the Schneider Electric Field Services Electrical Distribution Business Unit. He holds a bachelor's degree in electrical engineering and over the last 10 years has assumed numerous engineering and marketing positions within a variety of business units and operational divisions. He's always contributed to building or enhancing customer-centric business models with a distinctive and sustainable customer and brand experience. An expert in strategic and operational marketing, he has recently developed a worldwide, on-site maintenance services offer portfolio.

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