Introduction

Today plant managers are faced with increasing demands for various performance indicators and equipment health records. In other words, the expectations of the maintenance managers are growing because of the increasing sophistication of maintenance technology:

- First generation method: Fix it when it’s broken (otherwise known as run to failure).
- Second generation method: Time-based maintenance to achieve higher plant availability.
- Third generation method: A mix of preventive and predictive maintenance to achieve greater safety and higher plant availability (minimize equipment downtime).
- Forth generation method: Reliability-centered maintenance to maximize employee and equipment safety and operating equipment efficiency (OEE).

In North America and Europe much of the electrical substation equipment is reaching the end of its useful life. These substations were designed and commissioned with standards, specifications, and technology available at that time. For example, 30 to 40 years ago circuit breaker interrupting mediums were air and oil. Protective and control schemes utilized discrete electromechanical devices for protection, metering, and control. Electromechanical relays performed protection, analog devices performed metering, and auxiliary relays and human interaction exercised substation control.

Modern research and development has made it possible to increase the efficiency and benefits of electrical distribution equipment. Today, we have the latest technology of vacuum or SF$_6$ gas breakers, multifunction digital protective relays, and arc resistant switchgear. When equipment is commissioned, a one-line diagram may be posted in the control room to facilitate future operation and maintenance of the equipment. As a facility ages, a maintenance and modernization plan is the key to achieving reliable equipment operation. Plant managers give top priority to preparing a master equipment maintenance plan similar in scope to the one-line diagram. Aging plants require a modernization plan to pinpoint which equipment needs upgrading and modern standards that need to be implemented. Such a plan improves the plant’s bottom line.

Today’s equipment is loaded with features that enable the plant engineer to easily gather diagnostics. Experience has shown that by using the latest technology to modernize existing equipment, its performance is improved and its useful life is extended. Traditionally, in most substations electrical distribution assets are maintained in one of two modes. The first mode is fix it when it breaks and the second mode is time-based maintenance.

The MP4 plan helps plant managers by evaluating the current performance of the equipment and measuring actual against required business performance levels. It also determines the causes of deterioration and recommends ways to improve performance. This MP4 plan will identify possible modifications and evaluate equipment modernization, operation, and maintenance techniques. Failure is now defined as the point when equipment fails to perform according to its intended function, rather than simply determining whether the equipment is working. Today, maintenance procedures are included in the asset maintenance program. This includes condition-based tasks to check for potential failure, i.e., visual inspection or predictive technologies such as breaker operation analysis, temperature monitoring, and other methods. New services application software such as “IB Suite” analyzes the electrical distribution asset’s
performance and provides recommendations for improving the availability to meet business needs.

**MP4 plan architecture**

This system will collect a wide variety of electrical distribution equipment data during on-site inspection such as history of maintenance records and diagnostics, and then it will process the data to identify equipment health. Collected data is analyzed to understand strengths and weaknesses of the installation and equipment, major risks according to process/business needs, and solutions to manage the risks and optimize performances. Priorities are clearly identified within a framework based on four plans:

- Maintenance plan: Keeps the installation running.
- Modernization plan: Manages equipment obsolescence and performance improvement.
- Monitoring plan: Monitors risk in terms of availability, power quality, and energy costs.
- Management plan: Ensures the safety of people and optimization of costs.

The program architecture and functions make it the best solution for evaluating electrical distribution asset performance. An effective system must contain:

- Stress level analysis — detects the operational conditions, environment, and aging
- Reliability analysis — detects the critical equipment regarding the architecture
- Criticality index — analyzes the health of electrical distribution assets by combining required reliability and operational stress of equipment.
- Solutions — to manage the risks and to optimize performances and financial risk evaluation

The consultative offer assesses the performance of electrical installation and provides recommendations for improvements to meet business energy needs. The MP4 methodology is based on four steps:

**Step 1: Specification of electrical energy needs**

The electrical energy requirements of a business are specified following a process analysis. The MP4 consultant, with the help of plant personnel inputs, creates a model of plant operation. This will identify the critical process points from the electrical energy supply point of view and also characterize events that need to be prevented such as blackouts, voltage dips, and harmonics and pinpoint the devices on the installation’s single-line diagram that are potentially able to trigger the high-risk unwanted events, locate the main energy consumption points, and define their load.

The cost of the unwanted events (production downtime, machine start-up costs, production, quality problems, etc.) are evaluated based on the data provided by customers. This cost helps plant management to understand the economic advantages of the conclusions and recommended actions.

**Step 2: Assessment of stress level to which the electrical equipment is subjected**

The second step consists of identifying the key devices with respect to the required performance. For each piece of equipment, a stress indicator quantifies both the environmental characteristics and the operating conditions. In addition to this, a qualitative assessment of the equipment state is performed by an MP4 equipment consultant and is backed up by software.

**Step 3: Electrical network performance analysis**

A reliability analysis quantifies the level of risk in relation to the network architecture and its operating modes. This analysis determines the contribution of each device/equipment to the unwanted event’s probability. The first step of a reliability study is positioning of the unexpected events. Unexpected event (UE) is a typical terminology used in the reliability domain to identify the critical failure that will lead to catastrophic damages (human, financial, ecological, etc.). In the application to electrical networks domain, one UE refers to one busbar: the UE represent the interruption of power supply to this busbar; therefore, we define as UEs only those busbars which are really vital for the facility.

**Step 4: Solutions to manage the risks**

Combining the stress level with the reliability calculation results in a criticality index and a corresponding service policy defined for each device/equipment. The criticality index is calculated by the software which uses the reliability algorithm. The criticality calculation gives an index for each electrical device. The index represents the device’s level of criticality to the correct functioning of the electrical network and the continuous power supply of the essential loads. MP4 report focuses on the organizational aspects of operating and maintenance activities. It also backs up and completes
the technical recommendations implemented through the maintenance, monitoring, and modernization plans, giving an economic control over these technical recommendations.

**Investment guide**

To improve the performance level of the electrical power supply system, and to reach a higher value of its availability, it will be necessary to modify the architecture of the electrical network and to reduce the repair time of electrical devices through a spare parts policy to meet energy needs. The modernization and management plans show some improvement opportunities and the magnitude of their impact on power supply availability. The MP4 approach aims to draw up a reliability-centered maintenance plan that matches the maintenance to be carried out with the device criticality index, while the retrofit schedule aims to optimize the reliability of critical devices. The customized maintenance plan ensures that the expenditure on maintenance is optimal, and that the most critical devices receive the most suitable maintenance to continue their correct functioning. At the same time, it will reduce the corrective maintenance cost by preventing device failures and reducing the failure rates of the electrical devices. Furthermore, implementing a monitoring system will give the opportunity to survey energy consumption and then identify opportunity for energy savings.

**Conclusion**

The MP4 consultative offer is designed to assist plant and maintenance managers by evaluating the current performance of their equipment and measuring the actual performance against required business performance levels. It further proceeds to determine the causes of deterioration and lack of equipment reliability and recommends ways to improve performance. Recommendations may include possible modifications, equipment modernization methods, and operation and maintenance techniques. The objective of this consultative offer is to develop and propose a plan that strikes an optimal balance between investment and cost savings. Other key benefits realized by the MP4 offer include decreased breakdown costs resulting from a reduced number of breakdowns and downtime, optimized energy savings resulting from increased electrical network performance, and increased safety.

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