Introduction of condition-based maintenance at Wienstrom using the knowledge-based expert system MABI

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The deregulation of the electric power market in Austria and thus the resulting reorganization at WIENSTROM have entailed fundamental changes of the framework conditions for the maintenance of the switchgear and controlgear. While in the past funds were invested primarily in power network expansion and power network renewal, the increasing cost pressure brought about by the ongoing deregulation of the electric power market has led to a great reticence in the investing behavior. As a consequence, there have been significant changes in the age structure of the various switchgear units. And it is the increasing age of the existing devices in particular that calls for an analysis and the optimization of the maintenance to be carried out. Accordingly, an efficient maintenance needs to utilize the available resources as suited to the needs and cost-effectiveness. Its aim is to obtain the best possible value added to the existing switchgear potential. Scope and contents of measures must be archived well, evaluated, and questioned. WIENSTROM accomplished this aim by introducing MABI, a modular plant evaluation and maintenance package.

Keywords: condition based maintenance; reliability based maintenance; gas isolated switchgear

Einführung einer zustandsbezogenen Instandhaltung bei WIENSTROM mittels eines Expertensystems (elektronischer Datenbank) MABI.


Schlüsselwörter: zustandsorientierte Instandhaltung; zuverlässigkeits- oder risikoorientierte Instandhaltung; GIS-Anlage; gasisolierte Schaltanlage

1. Activities of the department

The authors of this report work for WIENSTROM’s NT4 Department (“Erection and Operation of Substations, Switching and Traction Substations”). The name of this department already shows that the tasks of this department focus primarily on substation-related matters – from the installation to the operation of high- and medium-voltage switchgear. More specifically, the switchgear can be subdivided into three 400/110 kV, 39 110/20 kV, and 97 d.c. systems used for the supply of Vienna’s subways and trams as well as into four hydroelectric power plants. It must be noted that the area supplied by WIENSTROM comprises not only the conurbation of a city having a total population of 1.8 million, but also its surrounding regions.

2. Previous maintenance strategies

The foremost goal of the previous maintenance strategy was to achieve a high degree of reliability of the switchgear, the cost not being of primary relevance.

2.1 No risk-oriented strategies

The aim of past maintenance measures was to prevent any faults and disturbances as much as possible and to refrain from
using risk as a control parameter when planning maintenance measures. Yet, in spite of the objective of achieving the highest possible reliability, it was not possible to fully prevent errors and resulting outages.

2.2 Time-based maintenance
As is customary in power engineering, in the past the company has serviced its switchgear according to the “round robin” principle. Depending on the type of switchgear, it resp. certain elements of it were serviced according to a sequential pattern, the time since the last maintenance job serving being the basis for the planning of further maintenance measures.

2.3 System type and technology determined the maintenance intervals
Especially in the case of high-voltage switchgear, the maintenance intervals were specified by the manufacturer and mostly adopted by the power network operator.

Typically, the same maintenance measures and cycles were applied to the entire switchgear and its devices, even though the devices involved were of a different importance, in different technical conditions, and at different stages of wear etc.

The biggest downside of this method was that not only elements in need of maintenance but also elements that were still reliable and fully functional were subjected to maintenance. An example of this is a 110-kV switchgear with line feeders, transformer feeders, and a shunt reactor feeder. The power network operation results in a staggered sequence of circuit breaker switching cycles of these feeders. Thus, a shunt reactor is operated daily, a transformer several times a month, but a line feeder almost never. This demonstrates that, due to the number of switching operations and the load to be switched in this process, the circuit breaker of a shunt reactor needs to be inspected and serviced more frequently than that of a transformer or a line feeder.

2.4 Equipment data
In the various specific segments (high-voltage technology, secondary technology, etc.) separate small decentral databases have emerged. There were no competencies for a higher-level concept of maintenance-relevant equipment databases. In the past, for lack of necessity, data were not centralized and no appropriate computer environment was created. Engineering knowledge was not integrated when the data contents were created, the data remaining limited to “index card” character. Therefore, the creation of useful parameters for modern maintenance strategies was hardly possible.

2.5 Maintenance-oriented investments
"Maintenance begins with the procurement!". This sentence is increasingly gaining importance. Maintenance-relevant aspects in the procurement of new technical systems or investments in replacements only become important in full-fledged state-of-the-art maintenance strategies and have so far hardly ever been taken into account. Technical quality used to be regarded as much more important than pure cost-efficiency considerations.

In order to make optimum use of financial and human resources, WIENSTROM now aims at incorporating such considerations into its maintenance concept and basing its measure planning, inner organization, and distribution of competencies thereon.

3. Future maintenance strategies
3.1 Prioritization of switchgear segments
For a new, more intelligent maintenance tool, it is necessary to also contemplate the desired scope of maintenance. It must be evaluated which devices need to be considered, and with which data depth such consideration should take place. In addition, switchgear components are to be prioritized, based on their type of use and importance (Balzer, Schmitt, Halfmann, 2001). It is also useful to take individual switchgear segments and incorporate them step by step into a maintenance system, thereby gathering experience from easy-to-survey detailed segments and also collecting aspects specific to power supply companies. Such a procedure makes sense in particular in the event of complex data contents which can be found where a commercial & strategic maintenance tool is used.

3.2 Condition-based instead of time-based maintenance
When managing a large number of switchgear units, a simple time schedule is all it takes to schedule these jobs and the costs incurred in connection therewith for several years in advance. In this case, the devices involved will undergo maintenance at certain predefined time intervals.

However, to obtain the same quality of switchgear condition and the same reliability of the various switchgear units with fewer resources, the technical condition of the devices is acquired and action intervals adapted accordingly are defined. So far, the best possible safety has been the uppermost priority in maintenance cycle scheduling. In most cases, it can be expected that in a condition-oriented maintenance regime the intervals for maintenance measures will become longer and that, consequently, the costs incurred can be reduced.

The best-case objective would be to service the devices only shortly before they break down. However, to do so, maintenance managers would also have to be "psychics". The more intelligent the maintenance tool, the closer one can get to achieving this goal.

3.3 Strategic evaluation of devices
Apart from the purely technical acquisition of the condition of devices, a modern maintenance planning tool should also factor in commercial and strategic targets defined by the enterprise and permit suitable action planning and expense budgeting. For such "strategic evaluation" of the devices, wear, significance, as well as economic efficiency are the decisive factors. Each of these variables is determined by several relevant subparameters as shown in Table 1.

3.4 Risk-oriented maintenance
As capital costs (investments and replacement investments) can only be reduced on a long-term basis, the cost pressure power network operators are faced with will in the future mainly affect variable costs. Risk-oriented considerations also need to be integrated into the strategic evaluation of devices (Schreiner et al., 2002).

The cost-saving adaptation of maintenance measures will in most cases reduce reliability and system availability only to such an extent where it is still acceptable for customers.

The shift from a technology-oriented to a customer-oriented strategy of the company in maintenance is reflected by the introduction of risk management for switchgear systems. For successful risk management it is necessary to determine the reliability and thus the probability that a fault or an error will occur in devices. This calls for a full-fledged fault management and fault statistics tool. Faults must be detected, and fault analyses and the interpretation of the error type – performed by experts – constitute the basis for ascertaining the reliability of devices.