CIGRE JWG A3.43 progress report "Tools for lifecycle management of T&D switchgear based on data from condition monitoring systems"

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SUMMARY

The joint working group A3.43 "Tools for lifecycle management of T&D switchgear based on data from condition monitoring systems" started in March 2019 and it takes the relay from WG A3.32, which described non-intrusive condition monitoring of switchgear in the Cigre technical brochure 737. Different measurement methods are shown.

The condition indicators listed there will be further processed by the present WG. The different sources of data are presented as well as a procedure to calculate a health index. Several examples are presented in detail.

The digitisation of substation equipment is an ongoing process, which will affect also asset management. The impact of IEC 61850 will be presented. By interviewing engineers at different utilities, we collect experience from the users.

KEYWORDS

Asset management, condition monitoring, switchgear, health index.

INTRODUCTION

In March 2019, the joint working group A3.43 "Tools for lifecycle management of T&D switchgear based on data from condition monitoring systems" started its activities with the goal to provide within three years a guide on how to use the data from monitoring activities of switchgear.

The working group counts presently 27 members from 14 different countries. It has met already physically four times and online four times. The main work is the technical brochure (TB), whose structure is as follows:

1. Executive summary
2. Introduction
3. Literature review
4. Condition indicators of T&D switchgear
5. Tools and criteria for lifecycle management and switchgear health index
6. Compliance with digital substation for data management
7. User's experiences of end-of-life of T&D switchgear: survey, case studies and interviews
8. Future needs and trends

The term switchgear comprises here transmission and distribution circuit breakers, reclosers, and fault interrupters, based on different technologies (i.e. gas, vacuum, oil etc.). Other devices as disconnectors and load switches are also included. However, HVDC breakers are out of scope in this working group.

A literature review offers a glimpse into the state of the art with tools and techniques for lifecycle management and the equipment used. A very steep increase of publications on this matter is observed in the last years with implications in other aspects beyond lifecycle management. The technical brochures from other WGs on substation level in the B3 study committees are presented. A fundamental decision has been made to follow health index concepts as defined in the working group B3.48 concentrating on providing valuable inputs specifically for switchgear. The condition indicators determined in the TB737 from A3.32 are used also in this work.[1] Other useful sources are TB 725 about ageing of breakers, TB 167 about monitoring of breakers, TB 510 about the last survey of reliability of breakers and TB 462 from study committee B3 about condition monitoring in substations.[2], [3], [4], [5]

CONDITION INDICATORS

The main part of the work concentrates on the tools and techniques once their framework is established. A large chapter is dedicated to condition indicators. The main point is to link measured physical parameters to condition indicators, which are calculated. They are connected to a degradation mechanism and a possible failure. There is a table for each subsystem with those links, as well as several examples of measured processes. Figure 1 display the dynamic resistance and the coil current during opening, whereas Figures 2 shows the current need to charge the spring. There are more is condition indicators like gas pressure.

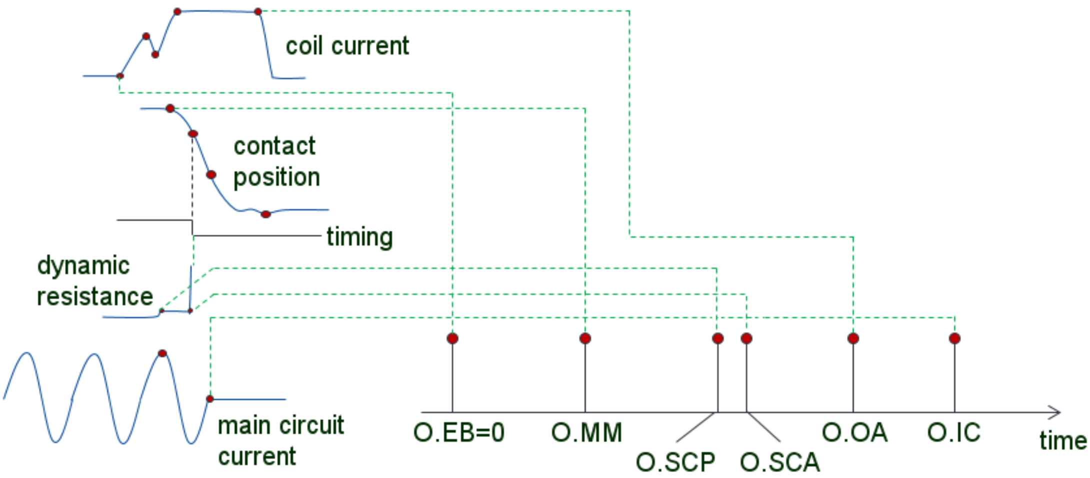

Figure 1: Elements of a sequence of event on opening based on different physical measurements: coil current, load current and dynamic resistance with contact travel.

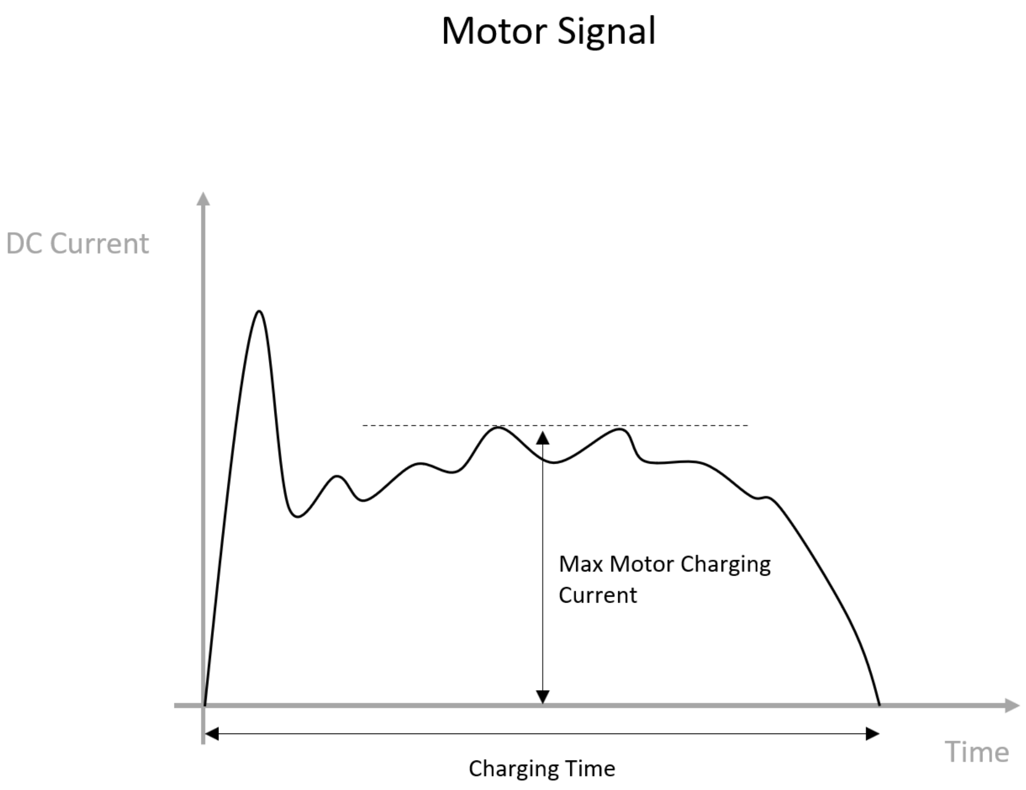

Figure 2: Current to the motor that charges the spring in the breakers with two measured parameters.

TOOLS AND CRITERIA FOR LIFECYCLE MANAGEMENT

An asset lifecycle is the series of stages involved in the management of an asset. It starts with the planning stages when the need for an asset is identified and continues all the way through its useful life and eventual disposal.

The asset lifecycle can be tracked in different ways and is generally monitored in some way at every company, even if it is not always a formalized process. The importance of any given asset lifecycle is determined by a number of factors, including how costly is the asset to replace, how crucial it is to the business or company, and the overall reliability of the asset in question.

The basic objective of asset lifecycle management is to extend your assets' usability as far as you can, while maintaining its safe operation and without losing any functionality. Proper planning and management are essential to this process, which rests on four stepping stones:

- initial and ongoing assessments,
- data collection,
- creation of plans for the assets, and
- integration across all assets.

The purpose of this chapter is to build up on the notions defined in previous chapters, mainly on the condition indicators, and define a set of tools that, in combination with other economical and safety descriptors, can be used to analyse the asset lifecycle for making better-informed decisions.
As the topic of our working group is focused on switchgear, from here on in when we talk about assets we are actually referring to high voltage circuit breakers.

We have to acknowledge that different utilities and companies may be at different stages of implementation of an integrated asset management system as described by ISO 55000 and ISO 55001, or may not even contemplate any implementation in this direction. For this reason, we will analyse the possibility of defining a minimum set of condition indicators that will still allow a basic lifecycle management implementation and will discuss the optimal set of condition indicators for a comprehensive approach towards lifecycle management.

Following the identification of these sets of condition indicators for lifecycle management, we will focus on the data needed in this process. We have identified the main categories of data that will be relevant for the process as follows:

- data provided by equipment manufacturer(s)
- measured values – data yielded by maintenance process and/or online monitoring systems
- observed values – data gathered during periodic visual inspections, operational tests, etc.
- reference data – values found in international standards (IEC, IEEE, etc.), best international practice recommendations (CIGRE, etc.), local knowledge (expert engineers), etc.

Having now defined the data needed, the next phase is identify how to use the data linked with the condition indicators to assess different functions of the switchgear. We will present workflows and relevant examples of how the system should be implemented. The procedure is as follows:

- measurements (what, and how is defined in Chapter 4 "Condition indicators"),
- a criterion that converts the measurement into a condition assessment,
- a tool that applies the criterion, and
- the health coefficient, the output to be entered in the health index function.

The condition assessment can be described by a number from 1 to 4:

1. the condition indicator is out of range, from more than p=15% of both of its threshold,
2. the condition indicator is out of range, from less than p=15% of one of its thresholds,
3. the condition indicator is within range, but close to one of its thresholds by less than p=15%, and
4. the condition indicator is within range, and far from both of its thresholds by more than p=15%.

The discretisation is a more detailed one than a binary variable. Real-life examples will be provided for most of the condition indicators and their influence in the overall asset health as well as an example of an asset health calculation for a circuit breaker.

DIGITALISATION OF SUBSTATIONS

The digitisation of substation equipment is an ongoing process, which is radically changing how assets will be controlled in the substation. IEC 61850 is today the followed standard on which this automation revolution is based for operation and protection. Four members from study committee B5 are part of the group specifically to identify the potential benefit of a technology, which has not been driven by monitoring.

EXPERIENCES FROM THE USERS

User experiences are under evaluation based on interviews. They have shown mixed opinions between use and necessity. Further collection of experience from the utilities will take place. Finally, the future trends identified so far are discussed. The role of condition monitoring systems as enablers for future developments in the networks is discussed.

AN OUTLOOK INTO THE FUTURE

This chapter focuses on the identified trends, needs, and matters of interest to the electrical power community. The chapter focuses on three main areas: the experts, the tools, and the roles.

Concerning the experts, the main interest is the shift that is being observed in the industry, where new generations are focusing on the fields of computer science asymmetrically much more than in power engineering. One of the main factors and challenges identified nowadays is the changing in the working force not only in their approach to work but also in the areas of need. Currently, three generations are driving the change from an almost fully analog electrical power system concept to a much more integrated and digitized version of it. The possible pitfalls and challenges to overcome are discussed. Granted access is given to CIGRE internal records, statistics on the topic will be presented.

In the tools area, the focus is on the emerging technologies of big data, artificial intelligence, and machine learning applied in the electrical power industry. The advancement of tools (sensors and actuators, computer programs, etc.) has accelerated in the last year thanks to new miniaturization and nanotechnologies breakthroughs. The amount and novelty of the data generated has procured also a new understanding of the criteria that can be used to evaluate the different functional aspects of switchgear that in summation presents the complete state of the apparatus. A general common concern on the use and practical applicability of AI/ML concepts and their ethical and safety implication is discussed in deep.

The roles of the manufacturers, the utilities, policymakers, and the research organizations are finally discussed. Idealistic initiatives such as a global repository of information where key aspects of monitoring and analysis are shared among all interested parties with the only aim of sharing knowledge and best practices. A general need for increased transparency seems to be the common denominator across all players.

The chapter closes with the gaps that have been identified in the WG during its life. These topics are not covered by the WG scope and can/must be investigated in future WGs.

CONCLUSION

From the arrival of a replacement or new asset, asset lifecycles affect every part of the business. When properly maintained throughout their lives, assets can bring an even greater return on investment than they do otherwise. When poorly maintained, they can negatively affect company resources and employees.

In addition, if companies are truly interested in implementing an overarching maintenance solution, an understanding of asset lifecycles is going to be an integral part of a preventive maintenance strategy.

Finally, asset lifecycles, when properly managed, can be a wonderful tool to increase the operational safety, return on investment, total productivity, worker satisfaction, and more.

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