(Better) predictive maintenance of medium-voltage networks

Using in-house specifications to improve cable diagnostics.

Knowledge about the cable condition is essential for achieving target-oriented and cost-effective maintenance and replacement of medium-voltage cables. Cable diagnostics helps provide reliable information about the status of medium-voltage cables and accessories. So that network operators are able to perform diagnostics more quickly and in accordance with their own specifications, Baur GmbH developed the Baur Software 4. With the current release, the operator can define individual standards for the measurements and tests, specify evaluation criteria, and generate consistent reports. This ensures maximum comparability of the results.

If a company employs a variety of measurement technologies and these are used by different individuals, it is difficult to ensure that identical working methods are used for cable testing and cable diagnostics. Due to differences in the specified measuring times, voltage steps or thresholds, the diagnostic results that are important for the condition-based maintenance of cable routes could turn out to be so different that any comparison with older measurements or with the measured values of similar cables is pointless.

However, comparability is helpful for making reliable, budget-friendly decisions. Comparisons make it easier for asset managers to determine which cable routes require a subsequent measurement in the near future, where early repairs or replacement are required, or which routes currently do not require action.

Individual standards for testing and diagnostics

So that distribution network operators are able to refine and extend the standard-compliant testing and diagnostics of their cable routes according to their own specifications and ensure comparable results, Baur GmbH has developed the Baur Software 4 (Figure 1). This software supports the implementation of a company-specific diagnostics philosophy and combines standard-compliant specifications with company- or project-specific features to create an efficient workflow.

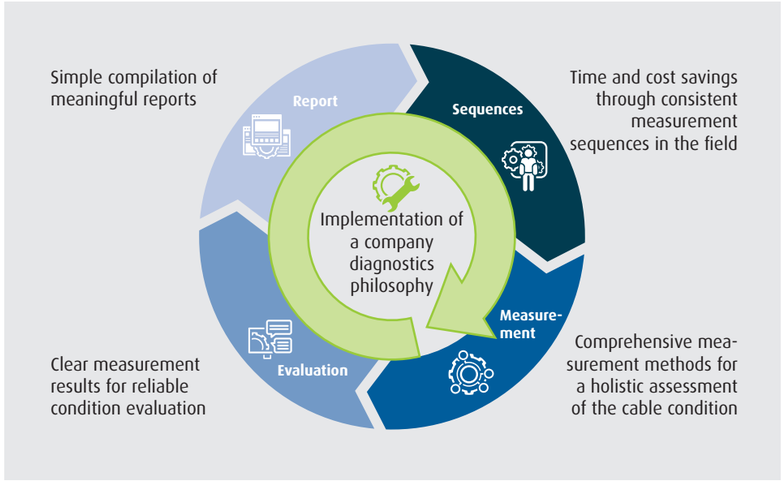

Figure 1: By implementing a company diagnostics philosophy, it is possible to define customised measurement and reporting standards. This has benefits during the assessment of the cable condition and when performing contract measurements

The software runs on Windows PCs and can therefore be used in the test van or on the notebooks of portable Baur testers and measuring devices, e.g. viola and frida, as well as in the office. It supports all of the processes relevant for the diagnostics and testing of medium-voltage cable systems: from measurement and report generation to data transfer and the storing and evaluation required for asset management.

With the Baur Software 4, network operators can define their own diagnostics sequences (Figure 2 and 3) and save them on all Baur measurement systems. The following application examples illustrate the real benefits of defining customised sequences.

New or partially replaced cable routes
In the case of new or partially replaced cable routes, cable testing is standard. However, in order to verify that the joint has been mounted according to the standard and to a high level of quality, for example, it is worth performing a partial discharge measurement. If the company performing the tests wants to document the quality of the work on handover, or if a network operator wants to protect themselves against any faults resulting from the installation, they are now able to combine testing and partial discharge measurement for new cable routes in a single diagnostics sequence. The measurement engineer in the field will then select the "New cable route" sequence and perform the specified measurements. This provides clarity and uniformity for sequences in the field, and ensures comparable measurement results for asset management.

Older cable routes
In the case of older cable routes, dissipation factor measurement provides important additional information about the condition of the insulation, which a partial discharge measurement is not capable of producing. It is worth combining both processes and this can – e.g. in combination with the test – be used as a sequence for existing systems that are over ten years old. In the case of new cables, dissipation factor measurement is not meaningful because it is only able to provide meaningful information after the outgassing of the plasticisers contained in the insulation. This measurement is a relevant part of the data basis used to evaluate the entire ageing process.

Diagnostics based on cable type
Various measurement sequences and evaluation criteria can be stored for plastic-insulated cables, paper-insulated mass-impregnated cables, and mixed routes, so that diagnostics based on the cable type can be performed according to company-specific, standard-compliant specifications.

Testing as a service
Those performing tests and measurements on behalf of third parties, e.g. to investigate the cabling in a wind farm prior to commissioning, are able to specify identical sequences for all team members involved in the project. This is a means of fulfilling all of the special requests of the customer – e.g. taking a measurement with a different duration or at different voltage steps. The tolerance limits relevant for the evaluation or the reports for the customer can also be adjusted in order to provide the client with consistent reports for all measurements or tests.

Faster and easier with greater process reliability

Defining in-house diagnostics sequences not only leads to standardised sequences and reports, it also provides optimal support during daily operations. The standardised sequences enable efficient and fast procedures. The software uses these procedures to automatically evaluate the measured values in the background, providing a target-oriented analysis. The measurement engineer is able to go into the overall analysis in greater detail and call up the assessment for each measured value. This makes crit-

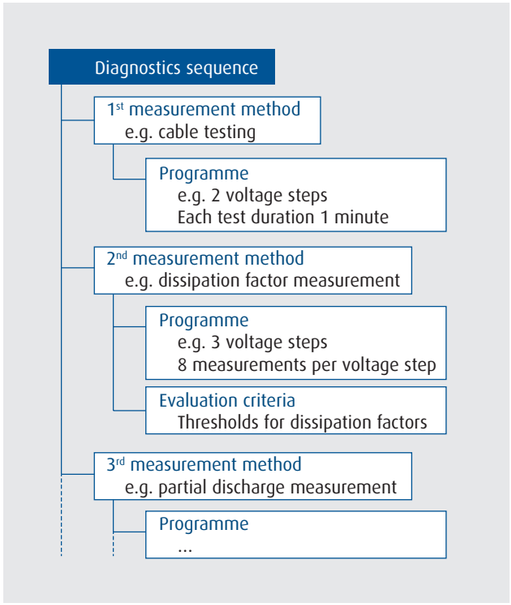

Figure 2: Defining in-house diagnostics sequences makes it possible to incorporate the company's own experience into the measurements and implement individual measurement standards for good comparability.

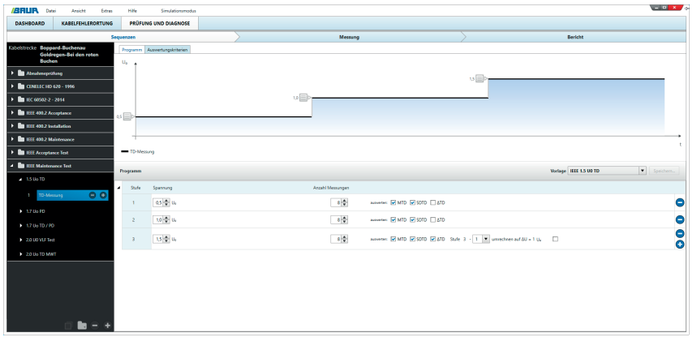

Figure 3: Configuration of a dissipation factor measurement within a sequence

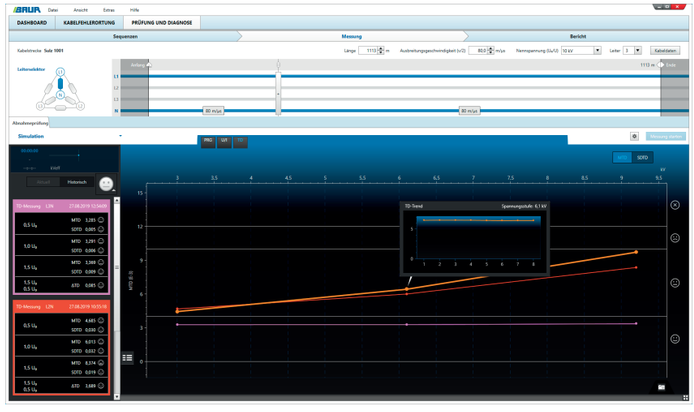

Figure 4: Symbols (area on the left) make it possible to quickly determine the condition of the cable – even in individual phases.

Figure 5: An example of the display during partial discharge measurement

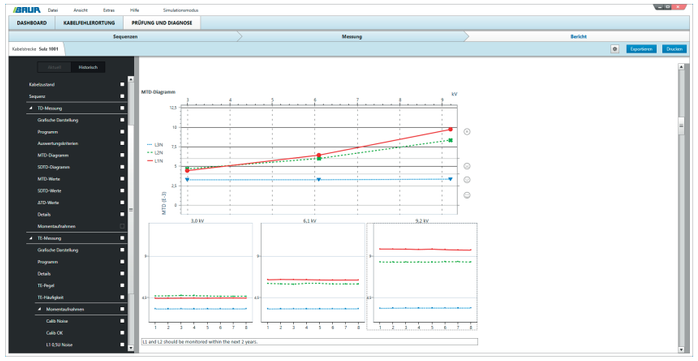

Figure 6: An example of a report comparing the measured values of the dissipation factor measurements in three measured phases

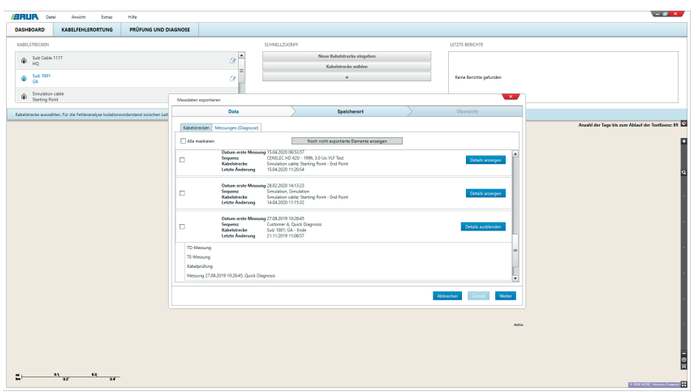

Figure 7: An example of the dialog when exporting measurement data

ical conditions transparent (**Figure 4** and **Figure 5**) and the software will stop the sequence automatically if necessary. This prevents corrupt tests or aborts a diagnostic measurement that could overload the cable, so that the route can remain in operation until a repair is performed.

Time-saving: parallel testing and measurement

Where permissible, cable testing can also be shortened if the diagnostic results have already provided evidence of good condition. This and the parallel measurement and testing sequences provide time and cost benefits. For example, in modern Baur systems, the dissipation factor and partial discharge measurements can be combined. This makes it easy to integrate diagnostic measurements into daily sequences, and compared to tests performed sequentially, significantly less time is required to perform the condition evaluation that is essential for asset management.

Flexible data exchange and simple further processing

In order for customised diagnostics sequences to be used company-wide, centrally created specifications can be rolled out on all relevant systems – irrespective of the hardware and the existing measurement methods. The exchange of reports and measurement results is just as easy. The reports provide a summary of the key results, while also presenting all of the measurements and measured values in detail (Figure 6). Furthermore, employees are able to generate screenshots of relevant traces or conditions during measurement and include these in the reports.

The results data can be exported to a spreadsheet or the statex® analysis software for further evaluation (Figure 7) (see ew 11-12/2019). statex® from Baur evaluates the data of the dissipation factor measurement and calculates the statistical remaining life time of cables. It uses a patented algorithm that delivers prognoses that are more accurate than an evaluation performed according to IEEE 400.2, for example.

Summary

The innovations in the Baur Software 4 allow distribution network operators to implement their maintenance and replacement strategies on the basis of objective, qualified, and reproducible condition evaluations – while taking into consideration company procedures and the in-house knowledge that is incorporated within these procedures. The consistent application of a company diagnostics philosophy leads to the accumulation of experience and knowledge, which can trickle down into greater network availability, as well as lower maintenance costs and investments in replacements.

The simplification of the measurement and test sequences associated with the definition of in-house sequences minimises the risk of incorrectly performed or divergent measurements, and speeds up the work performed in the field, as measurements can be started quickly and efficiently. This allows the measurement engineers to concentrate on the essentials, and the diagnostics essential for asset management can run without involving considerable additional time. Service providers that measure and test third-party cable routes can implement customer requirements more easily (and more quickly) using self-defined sequences. Lastly, they can offer their clients a greater degree of transparency thanks to standardised reports.

Michael Klee,
Software Product Manager,
Baur GmbH in Sulz/Austria

>> michael.klee@baur.at

>> www.baur.eu/de/bsw4

Info box

Cable diagnostics procedures

Dissipation factor measurement (tan δ or TD measurement) is a non-destructive and integral procedure that serves to evaluate the condition of a cable route. It provides clear information on the condition of the cable insulation and its ageing condition. With the Baur Software 4, dissipation factor measurement can be used to carry out a fast and differentiated assessment of the cable insulation within a few minutes and the following weak points can be detected:

- Areas in the insulation of XLPE cables that are damaged by water (water trees)
- Faults in the insulation of paper-insulated mass-impregnated cables due to drying
- Insufficient insulation of paper-insulated mass-impregnated cables due to moisture
- Moisture in joints/terminations
- Possible partial discharge

The recording and clear visualisation of all relevant dissipation factor parameters allows distinctions to be made between different ageing effects on the cable.

In many cases, partial discharges (PD) are the preliminary stage for a breakdown, whereby their occurrence is a key criterion for evaluating the quality of the insulation. **Partial discharge measurement** is performed after laying a new cable, making repairs, and to verify the operational reliability of aged cables, as it is capable of identifying the following faults:

- Faults in new and old cable accessories (e.g. incorrectly mounted joints)
- Faults in the insulation of plastic-insulated cables (e.g. electrical trees)
- Insufficient mass-impregnated paper insulation due to drying
- Mechanical damage to the cable sheath

The phasing of partial discharges can be determined through state-of-the-art evaluation methods from Baur. The type of fault can be identified, and subsequent measurements and repairs can be performed in a targeted manner, thus saving time and money.