New methods for Switchgear testing and analysis

The demands being placed on switchgear testing are increasing constantly. At the same time less and less personnel are available to carry out test tasks in the various sectors of electrical power supply systems. As a consequence, individual testers often do not have the expert knowledge required to assess recorded measurement data and results with sufficient accuracy. The growing challenge for test technology today is therefore to provide testers with tools to automate test execution and analysis.

High-voltage switchgear equipment is located at the nodes of electrical power supply systems. For this reason they are required to be extremely reliable. Switchgear devices are constantly subjected to external influences such as dirt, humidity and temperature fluctuations. They are frequently not operated for years at a time but under fault conditions they must still switch reliably within the shortest possible time up to as many as 20 times or more in the case of a malfunction connected with a thunder storm, for example.

It is essential that the relevant device parameters are measured and checked regularly independently of the maintenance cycles defined in the revision plan, to ensure that preventative action can be taken at an early stage if changes in switching behaviour are detected. Various mechanical and electrical parameters must be I investigated for a full assessment of switchgear performance. These parameters include main contact velocity, main contact travel and the operating times of all switching contacts. Deviations from the rated values are an indication of defects in the drive or switching chamber. In addition to mechanical parameters, electrical parameters are also important indicators of faults in the making. For instance, the amplitudes, shape and timing of the operating currents of trip coils provide important clues as to the state they are in: changes in the operating forces caused by mechanical wear, for example, usually have a direct and perceptible effect on the amplitude and shape of the coil current. For this reason, modern switchgear test systems should be able to provide synchronous measurements of coil operating currents, the operating currents of spring-tensioning or pump motors, valve pressures, valve travel and mechanical main contact travel, in addition to capturing main and auxiliary contact state. Only then is it possible to determine all the parameters with a decisive effect on switchgear performance and assess conditions inside a switchgear device without even having to open the drive, let alone the arcing chambers.

Fig 1. *"ACTAS C16" Stationary test system for testing vacuum MV breakers*

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Specialized hardware requirements: dynamic timing

The number of analogue and binary signals to be measured varies depending on the class and design of the switchgear. Testing a medium-voltage circuit breaker with just one interrupter assembly per pole and a three-pole spring drive is therefore much less demanding than testing a high-voltage circuit breaker with four interrupter assemblies and a single-pole hydraulic drive. The test sets of the ACTAS range (ACTAS - Advanced Circuit Breaker Test and Analysing System) manufactured by KoCoS Messtechnik AG in Korbach, Germany [1] (fig.1) can be adapted to perform any type of test task thanks to their modular construction and flexible test software. If specialist hardware is necessary for a specific test, these hardware requirements can be met by the ACTAS modular system. "Dynamic timing" as provided by the ACTAS P16DYN test set (fig.2) is a good example of this.

Fig 2. *"ACTAS P16DYN" allows dynamic timing tests*

The "dynamic timing" method can be used for high-voltage circuit breakers with graphite contacts for which traditional comparator measurement methods fail. The problem with this type of contact is that due to the different contact materials a clear, digital characteristic of contact resistance is not available for analysis in the case of close operations. Indeed random bounce in conjunction with pronounced analogue behaviour of the resistance characteristic often occur. A simple on/off differentiation with fixed operating points does not work here. The test method employed by ACTAS involves the analogue measurement of contact resistances being carried out via six separate Kelvin measurement circuits simultaneously (four-wire method) with a d.c. measurement current of 10 A in each case. The evaluation software then correlates the recorded measurement values with an idealized resistance characteristic using an algorithm homologated by Siemens [2] to obtain the significant switching points. "ACTAS P16DYN" was the first test system in the world to offer the option of carrying out a dynamic time measurement on up to six arcing chambers simultaneously. This test method has an important spin-off from a safety point of view: switchgear can remain earthed on both sides during a test.

Integral Testing

The concept of "integral switchgear testing" comprises two basic requirements:

- Firstly, the test technology employed should provide comprehensive coverage across the entire lifespan of a switchgear device "from the cradle to the grave", while affording access to reference measurements at all times. For this purpose, all tests must be carried out according to the same method, starting from initial experiments in the development phase and continuing on throughlife-time tests, type, routine and commissioning tests right on up to the very last revision test. This applies to test specifications and methods, test hardware and data formats. KoCoS provides a whole range of ACTAS test sets with hardware which is specially designed for each specific application. All the test sets are configured and operated using the same software. Records from test instruments made by other manufacturers can be imported via various software interfaces. Similarly, the data captured by ACTAS can of course be exported in various formats for further processing and analysis.
- Secondly, it should be possible to determine all the measurement values and parameters necessary for assessing switchgear performance in a single test run. It follows that the test set must be able to accommodate the connection and measurement of all signals at the same time. The test instrument must therefore have an appropriate number of analogue in- and outputs as well as sufficient data storage capacity. The significance of this point is seen in the proper light when it is considered that, depending on the drive type, a typical switching operation including all related processes (spring tensioning, readjustment of the drive pressure, etc.) can take up to 60 seconds and requires a resolution of up to 0.1 millisecond. Similarly, on the evaluation side it is not enough to look at individual parameters in isolation as various parameters can influence each other. For instance, if the contact wipe (overlap) of the main contacts is too small, a shorter closing time can be the consequence.

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Automated evaluation : reference characteristics

Like most modern test systems, ACTAS carries out a comprehensive evaluation of recorded measurements using downstream software with expert functionality. The job of the software is to assess the recorded data fully automatically, reliably and informatively. Generally the assessment of individual parameters is carried out using limit values saved in the software, most of which are dependent on constructional principles. However, this method does not always work as a number of parameters are also mutually dependent upon one another. In such cases the aim is to find a balance of all influenced parameters. A comparison of the measured signal characteristics with reference characteristics is the obvious solution. The idea is that when none of the measured signal characteristics extend beyond a defined tolerance band surrounding the reference characteristic, then all the parameters of decisive importance will also be within the defined limits. IEC 62271-100:2003-05 [3] requires this method for the assessment of the mechanical behaviour of high-voltage circuit breakers. The reference

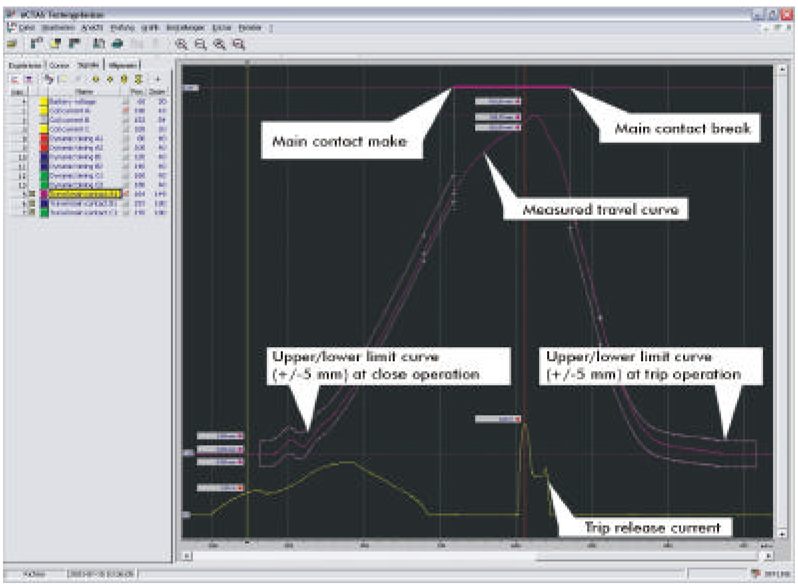

Fig 3. *Measured signal characteristics can be evaluated automatically by the software*

example. The reference characteristics can be defined and analysed purely digitally: the high-speed and

light-spot recorders commonly used in the past have long been replaced by digital, real-time test systems and the dynamic recording of mechanical travel via analogue or incremental potentiometers is now standard practice.
As all the necessary information is available digitally, the evaluation of measured signal characteristics can be carried out automatically by the software (fig.3). This involves a check being made in accordance with the standard as to whether the measured travel characteristics lie outside the limit curves defined by the reference characteristic and the configured tolerances at any point in time. The limit curves are defined by simple tolerance vectors in relation to the reference characteristic, such as ±2 mm absolute or ±5 % of static contact travel, for example. As a rule, reference characteristics and measured signals are synchronised on the time axis using the switching times of the main contacts.
The latest version of the ACTAS evaluation software fully supports the generation and application of reference characteristics as stipulated in IEC 62271-100:2003-05 [3]. The scope of the standard has been extended to the effect that not only travel-time curves, but also any other signals such as coil currents or valve pressures (in the case of circuit breakers with pneumatic drives) may be assessed by reference characteristics. This allows signals which can only be inadequately characterised using individual parameters such as amplitude or duration to be subjected to precise and accurate assessment for the first time.
As reference characteristics may originate from external systems or exist in the form of idealized curves, ACTAS supports the import of characteristics via a universal ASCII interface. This means that idealized characteristics can be constructed in MS-Excel® using only a small number of interpolation points before being imported to ACTAS. In addition, any signals measured previously using ACTAS may of course be defined as reference characteristics. This is particularly useful as ACTAS provides a comprehensive switchgear test solution from development, through final factory tests and continuing on up to on-site check tests: measurements recorded during development can be saved as reference characteristics by the manufacturer in the test plans for subsequent tests. Leading switchgear manufacturers such as ABB [4], Alstom [5] and Siemens rely on ACTAS in all the areas mentioned above.

Literature

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