

Testing and assessing the motors and release coils of switchgear

Dipl.-Ing. Jürgen Dreier, Product Manager, KoCoS Messtechnik AG, Korbach

Switchgear devices are situated at the key points of electrical energy transmission and distribution systems. Their reliability has a decisive influence on the availability, safety and economic efficiency of electrical supply networks.

Only regular, on-site tests can ensure that switchgear devices function perfectly throughout their operational life.



Fig. 1: Substation

Switchgear testing is becoming more and more demanding. At the same time, the number of personnel available for carrying out testing tasks in the various different areas of electricity supply systems is on the decrease. As a result, individuals often do not have enough time to assess the recorded measurement data and results adequately. This increases the pressure on test technology to provide tools for the automatic execution and evaluation of tests. ACTAS test instruments for circuit breaker testing, PROMET ohm meters and the EPOS CV / EPOS MC voltage sources are the solutions offered by KoCoS Messtechnik AG for the automatic execution and evaluation of every conceivable test on a switchgear device.

Assessing the reliability of switchgear

The demands placed on the operational reliability of switchgear devices are extremely high. Switchgear devices are constantly exposed to external factors, such as dirt, moisture and temperature fluctuations, which can have negative effects. Often they are not operated for years at a time, but should there be a disturbance due to a thunderstorm, for example, they must still operate reliably up to 20 times within a very short period of time under fault conditions.

In order to be able to take preventive measures at an early stage in reaction to changes in breaker performance, regular acquisition and verification of all the relevant device parameters are essential and should not be limited to the maintenance cycles laid down in the revision plan. In order to make a full assessment of the reliability of a switchgear device, various mechanical and electrical parameters must be determined, including the main contact velocity, its stroke and the operating time of the breaker. Deviations from the rated values point to defects in the drive or in the main contact chamber. Electrical parameters as well as mechanical parameters are important indicators for impending faults. The amplitudes and time-dependent characteristics of the operating currents of release coils, for example, give a good indication of what state they are in: changes in the operating forces which can occur as a result of mechanical wear and tear, for example, usually show up directly in the amplitude and curve shape.

Because of this, as well as measuring main and auxiliary contact status, modern test systems should also be capable of measuring coil currents, the operating currents of spring-charging or pump motors, valve pressures and travel and mechanical main contact travel. Only then is it possible to investigate all the parameters which determine the reliability of a switchgear device and to assess the conditions inside the switchgear device without having to open the drive or even the main contact chamber.

SWITCHGEAR TESTING

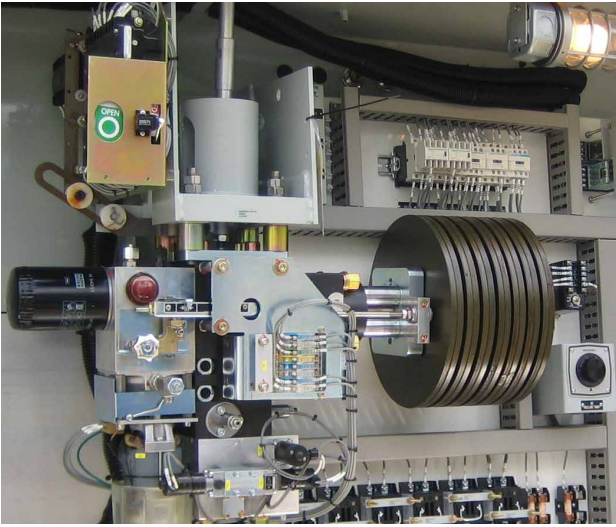


Figure 2: Control and drive cabinet

Drives and releases

The drive of a switchgear device consists of the energy storage mechanism, the control unit with releases and the transmission unit (Figure 2). The switching energy required to move the contacts is provided by various different types of storage units, such as compressed air drives, hydraulic drives or spring energy stores (Table 1). The energy storage mechanism must be suitably dimensioned for automatic reclosing (OCO). Activation of the switching action is performed by means of release coils or valves. For reasons of safety, the release coils of the opening circuit are usually doubled up.

Spring energy store	Spring as energy storage mechanism. The spring is charged by means of an electric motor. Magnetic releases are used for control.
Compressed air drive	Compressed air chamber as energy storage mechanism. Magnetic valves are used for operation. Recharging is carried out by means of a compressor.
Hydraulic drive	Nitrogen accumulator as energy storage mechanism. Recharging is carried out by means of a motor-driven hydraulic pump.
Hydraulic stored energy spring mechanism	Combination of hydraulic drive and stored-energy spring mechanism. Spring as energy storage mechanism which is charged hydraulically.

Table 1: Drives and releases

Characteristic properties of the motor

Figure 3 shows the motor current characteristic during charging of an energy storage mechanism. The current characteristic provides information on the electrical properties of the motor and the mechanical load.

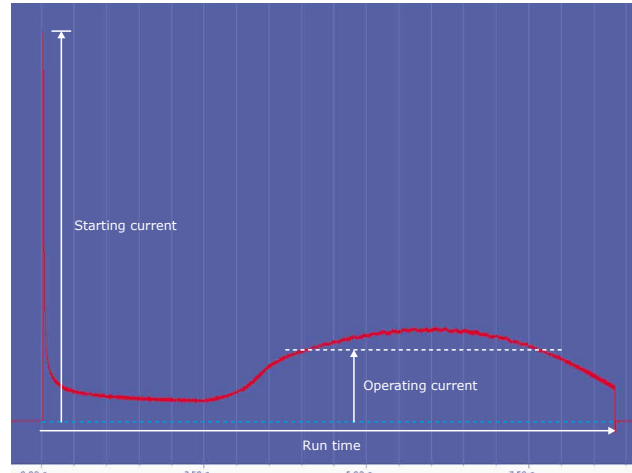


Figure 3: Motor current characteristic

The characteristic values of the motor current are:

- Starting current of the motor:
In general the starting current is equal to the maximum current measured during a test
- Operating current:
Mean value of the motor current calculated over the defined evaluation period
- Motor run time:
Duration of motor operation during a test

Faults on drives can be defective electric motors. Sluggishness can also be identified by means of the motor current as the value of the motor current corresponds to the torque.

Characteristic properties of the release coil

Figure 4 shows the current characteristic of a release coil during operation of a tripping latch. The release coil consists of the excitation winding and a movable coil armature. If voltage is applied, the electric current and the magnetic flux rise. A force acts upon the coil armature. The movement of the armature induces a counter-voltage.

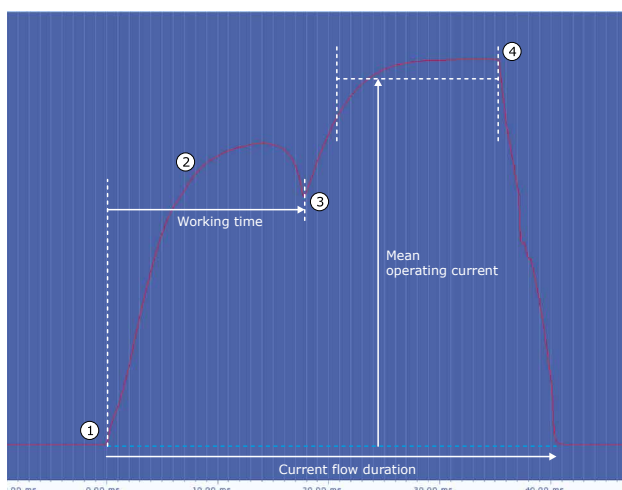


Figure 4: Coil current characteristic

- 1) Voltage is applied to the coil.
- 2-3) The coil armature moves and releases the latch.
- 3) The coil armature reaches its final position.
- 4) The auxiliary contact opens and switches off the coil voltage.

The characteristic values of the coil current are:

- Mean operating current:
Mean value of the coil current within the evaluation period
- Current flow duration:
Duration of the current flow through the coil during a switching operation
- Working time:
Time interval between the trigger time and the end of the movement of the coil armature.

A fault on release coils can be a sluggish coil armature. The operation of valve or latch takes place at a reduced speed. If the worst comes to the worst, the breaker can no longer operate. If the movement of the coil armature is slowed, this has an effect on the characteristic of the coil current and leads to an increase in the working time.

Another important characteristic quantity for releases is the d.c. resistance of the coil which allows an assessment of the electrical state of the coil and can, for example, point to a fault between turns. In order to

assess the functioning and reliability of circuit breakers, an analysis of the motor and coil current signature is required. Evaluation can point to faulty motors and coils, sluggishness or defective mechanisms.

Motor and coil tests

The fixed station voltage imposes significant limitations on motor and coil tests. A voltage source which can be adjusted and controlled is needed in order to test releases with minimum voltage, the resistance and also the minimum operating voltage.

For some circuit breakers a separate and independent voltage output is required to supply the control independently (Figure 5).

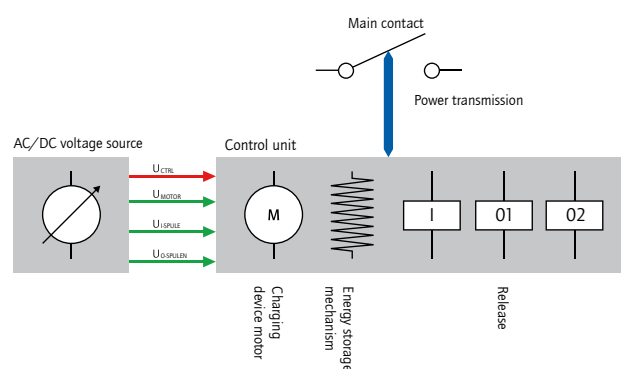


Figure 5: Simplified diagram of a switchgear device

The following functions should be available for the analysis of switchgear analysis:

- Analysis of motor and coil operation
- Determination of the coil resistance
- Determination of the minimum operating voltage
- Tests for undervoltage releases

The evaluation of results is carried out quickly and easily; the state of the coils and the motor is immediately identifiable. During recording of the motor current signature, the significant quantities such as the starting current and run time are calculated from the curve characteristic (Figure 3).

SWITCHGEAR TESTING

There are a number of different options for testing release coils in order to obtain results pertaining to their behaviour. The standard stipulates that a test voltage of 70 or 85% of the rated voltage be applied to the breaker. The object of this is to identify whether the breaker works at the lowest specified station voltage and complies with the required limit values (Figure 4).

The minimum operating voltage should be determined for release coils independently of this. The operating times of the circuit breaker are not taken into consideration. The results obtained allow an assessment of the mechanical properties to be made, i.e. how much force must be applied in order to move the coil armature.

For the determination of the minimum operating voltage, the ramp is started with a test voltage which lies below the operating point of the coil and is increased in steps with appropriate pauses. After each increase, a switching pulse is applied to the release coil and the reaction of the breaker is evaluated (Figure 6). The voltage value at which the switchgear device operates is the result obtained.

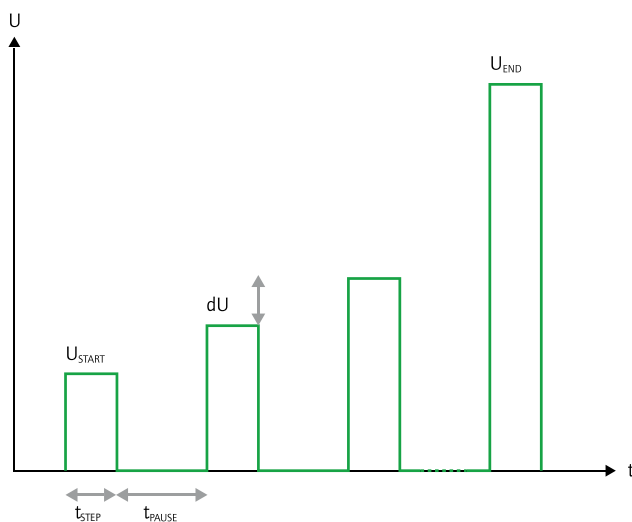


Figure 6: Minimum operating voltage ramp

The determination of the coil resistance allows an assessment to be made of the electrical state of the coil. During determination of the d.c. resistance, a low voltage is applied to the coil so that it does not operate.

Conclusions

Only regular, on-site tests can ensure that switchgear devices function perfectly throughout their operational life. In addition to main and auxiliary contact status, mechanical main contact travel, valve pressures and valve travel, the acquisition of the operating currents of release coils and the operating currents of spring-charging or pump motors is also of great relevance.

Analysing the curve signatures of the operating currents of release coils and spring-charging or pump motors as well as the resulting characteristic quantities provides accurate information on the performance of motors and coils, making it possible to draw conclusions as to their electrical and mechanical state.

In addition to its powerful AC/DC sources, a motor and coil test system should provide the following measurement functions:

- Analysis of motor and coil operation
- Determination of the coil resistance
- Determination of the minimum operating voltage
- Tests for undervoltage releases

Thanks to easy integration in automated circuit breaker tests, this also offers real savings in time and money compared with conventional systems and also keeps switchgear maintenance to a minimum.

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