Auxiliary voltage tests of circuit breakers

Background

Measurement of the outer limits of the operating mechanism is required by international standards such IEEE C37 and as IEC 62271, when certifying a circuit breaker (CB). Some of those tests are valuable to repeat in field tests, obviously to ensure that the CB fulfil its design specification, but those tests and some additional tests in similar spirit can also disclose potential future problems. The most common is to vary the auxiliary voltage but it could also be other energy resources for example hydraulic and pneumatic pressure. This application note will ***focus of the auxiliary voltage, what the standard requires, sort out the terminology and what tests that are valuable to repeat in field tests***.

Operating conditions

Seen from the auxiliary voltage a CB has a nominal voltage operating condition and then tolerances where the CB should operate within specified limits. Since most of the auxiliary voltage supplies are through stationary battery systems, it is common that the CB operates at other voltages than the nominal voltage. When the battery is fully charged it has a higher voltage than nominal and in case of an outage the batteries will discharge, and the voltage will drop. International standards therefore require under and over voltage tests.

Energy

The coil requires a certain energy to operate and the energy in this case is built from both current and voltage (Figure 1.) which means that the operating time will change with changed voltage. High voltages, in the upper region of the tolerance, will provide high energy and the operating coil will react faster and obviously then with lower voltage, down to the minimum voltage level, provides lower energy and the operating time will be longer. Still both conditions need to be within time specification for the breaker.

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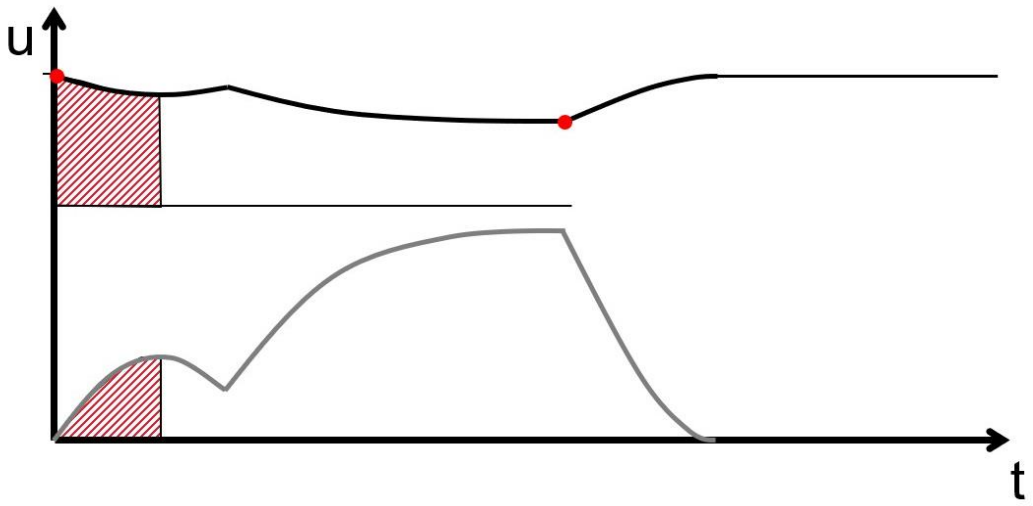

Figure 1 Energy required to release the anchor. It is important to measure both coil current trace and station voltage to analyse the energy needed to operate the coil.

Auxiliary voltage tests

Both current and voltage builds the energy in this case, so it is important to measure both to get the full picture. Coil current analysis is a science on its own and will not be focused on in this application note.

With a reference to the IEC 62271 standard, it is required that the supply voltage is measured during operation when performing tests, that closing coils shall operate correctly between 85% and 110% of the rated supply voltage (AC or DC) and the opening coils shall operate between 70% DC (85% AC) and 110% (AC or DC) of the rated supply voltage. When the CB is in service, voltages close to the upper limit normally doesn't cause any problems so the focus in field test are at the station voltage or nominal and minimum voltage levels.

Nominal voltage or station voltage

Most common is to test the CB operation with the station voltage. The advantage to do that is that it's not just the CB that is analysed but also the supply voltage circuit where significant voltage drops at CB operation will affect the time and therefore should be remedied. The disadvantage is that the voltage is what it is, normally higher than nominal voltage, and cannot be adjusted. A portable power supply can be used instead of the station voltage where the advantage obviously is that one can adjust to exactly match the nominal voltage and of course other desired voltage levels. The disadvantage is that extra weight must be carried, and it is important that the power supply is stiff so there is no voltage dip (Figure 2.) when the coil is energized.

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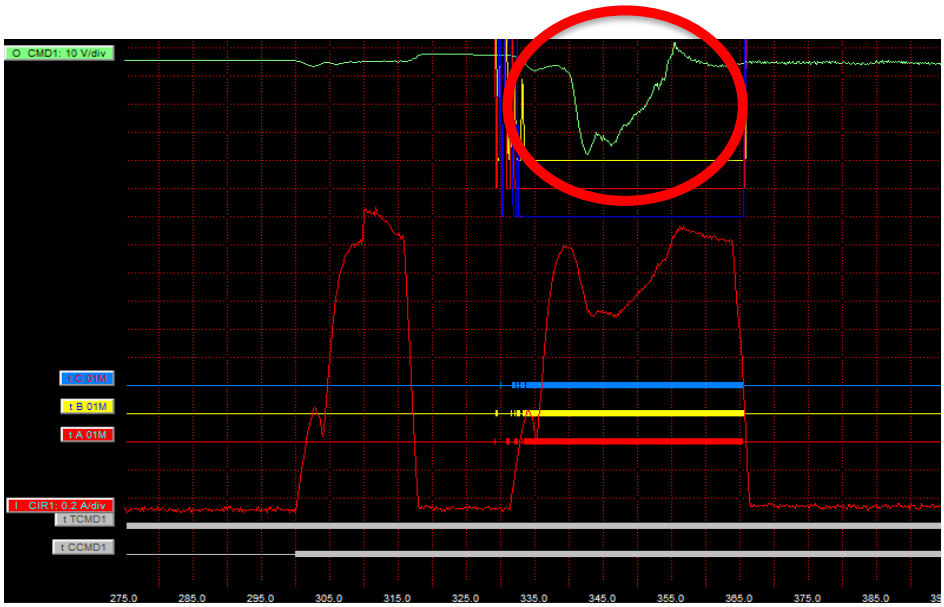

Figure 2 Typical voltage dip from a weak voltage source in a CO operation.

Minimum voltage test

With reference to the standards the minimum voltage test is a test at a certain percentage of the nominal voltage. It obviously requires a power supply so that voltage can be set. This test is to make sure that that the CB operates within the designed time in an undervoltage condition. For DC operated CBs, which are most common, it is different voltage levels for the close and open coils where closing coil is 85% of nominal while the opening coil should operate down to 70% of nominal voltage. The difference comes from that if it is possible to close the CB it should be a safety margin for the CB to open. In other words, the circuit breaker should always be able to break a fault current in a Close-Open operation.

Besides fulfilling tests according to the standard by performing minimum voltage operation, it is also easier to detect problems with slow breakers, i.e. lubrication problems, since the energy applied is lower than in the normal test case.

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Pick-up voltage test

This test is not described in international standards, but it still has some value. The test is performed by applying voltage pulse significantly under the minimum voltage, then increase the voltage for the next pulse and continue like that until the coil operates. The voltage level when the coil operated is the pick-up voltage and this should be significantly under the minimum voltage level.

If the pick-up voltage comes close to the minimum voltage level it means that there is risk that the CB will not operate in an undervoltage situation, so if the CB is found this way, corrective actions should be taken.

Summary

To measure the station voltage is critical to perform an analysis of the coils in the CB operating mechanism. There are advantages to use the station voltage to make sure the supply and wiring as well as the CB is in good condition. International standards made for certifying CBs require tests which has both lower and higher voltage than the nominal voltage. However, in field tests more attention is given to voltages at nominal / station voltage and undervoltage level. Minimum voltage test is defined that the closing coils shall operate correctly between 85% and 110% of the rated supply voltage (AC or DC) and the opening coils shall operate between 70% DC (85% AC) and 110% (AC or DC) of the rated supply voltage. Pick-up voltage test is not required by international standards but still the test gives some value to make sure there is a safety margin between the pick-up voltage and the minimum voltage.

Megger products required to perform these tests are CB analyser EGIL or TM-series and the portable power supply B10E.

Megger circuit breaker analysers

Power supply B10E