The InterNational Electrical Testing Association Journal

NETA WORLD™

FALL 2017

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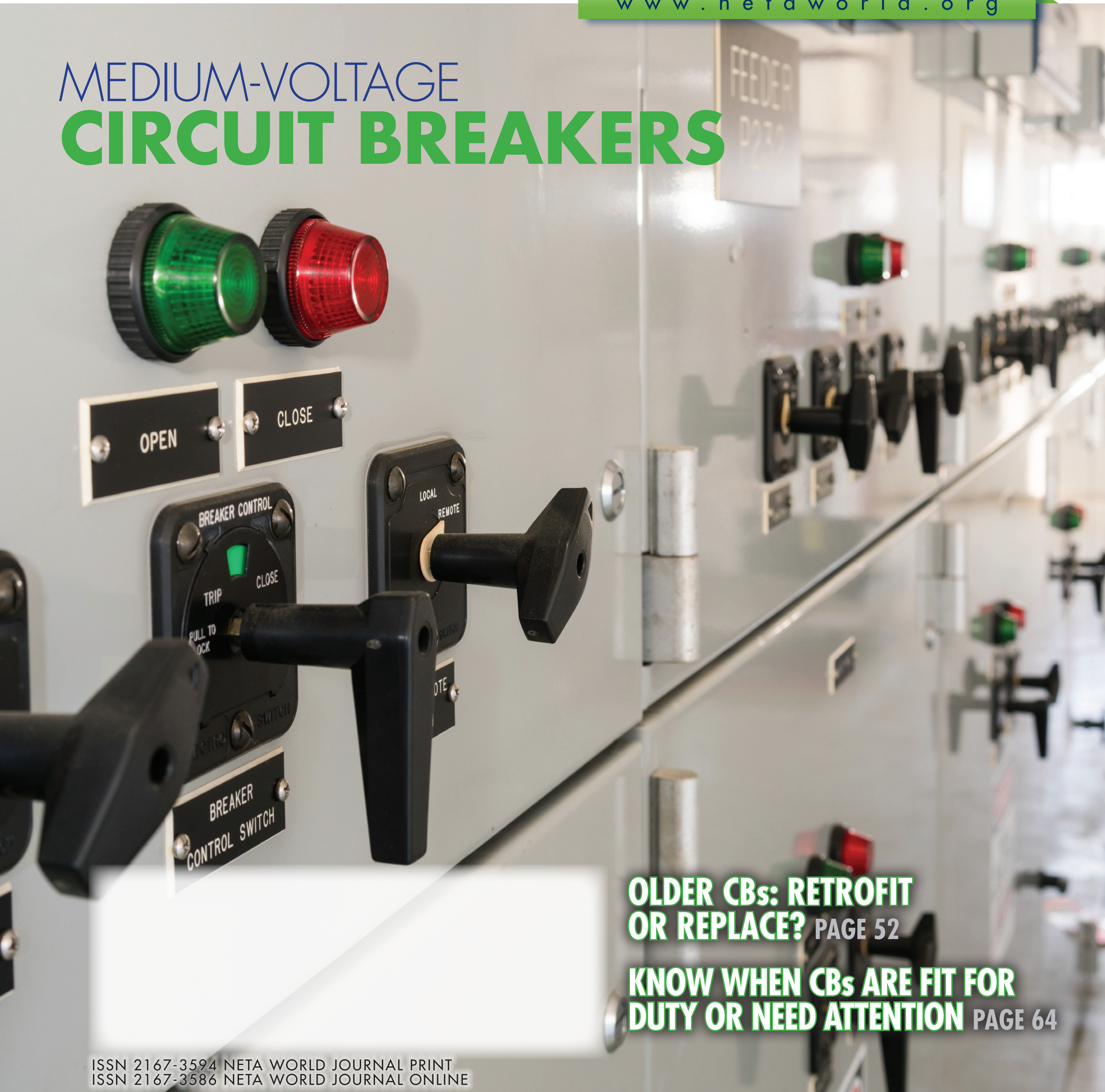
MEDIUM-VOLTAGE CIRCUIT BREAKERS



OLDER CBs: RETROFIT OR REPLACE? PAGE 52

KNOW WHEN CBs ARE FIT FOR DUTY OR NEED ATTENTION PAGE 64

ISSN 2167-3594 NETA WORLD JOURNAL PRINT
ISSN 2167-3586 NETA WORLD JOURNAL ONLINE

TESTING SWITCHGEAR: CONVENTIONAL vs. BOTH-SIDES-GROUNDED METHODS

BY GUY WASFY, *KoCoS America LLC,* and CHRISTIAN STUDEN, *KoCoS Messtecknik AG*

In the Summer 2017 *NETA World Journal*, "Requirements for Testing Switchgear Quickly and Economically" outlined some of the modern techniques and technologies now available for testing switchgear. The article showed how new technology drastically reduces testing time while increasing useable information for diagnosing the condition of switchgear. This article expands on that information and illustrates practical examples of how testing switchgear with both sides grounded yields the same results as the conventional method.

OVERVIEW

International Standard IEC EN 50110-1 states that any part of a high-voltage installation being tested shall be grounded. As such, it is highly recommended that users find equipment suitable to perform the test(s) in accordance with the standard.

Testing switchgear with grounding on both sides should be performed to decrease potential dangers caused by capacitively coupled voltages from neighboring components. When using the conventional method to test switchgear equipment, a ground must be removed from at least one side. In contrast, the alternative method allows for the same tests to be conducted with grounding maintained on both sides. Not only does this make testing much safer, it makes it simpler and quicker as the steps to remove the ground lead are no longer required.

One of the main requirements of testing switchgear with a new methodology is that the results correlate to historical practices. The both-sides-grounded method and the conventional method yield the same results as long as they are performed in identical test conditions. Further, the both-sides-grounded method is faster, safer, and provides more diagnostic information.

CONVENTIONAL METHOD

When conducting a test on switchgear using the conventional method, the steps are as follows:

1. Open the switchgear.
2. Ground both sides of the switchgear.
3. Connect the coil operating currents in series with the test system.
4. Connect the transducer to measure motion.
5. Connect the main contact leads.
6. Remove ground from one side of the switchgear.
7. Test the switchgear.
8. Reattach ground on open side of the switchgear.
9. Remove all breaker timing cables.
10. Connect main contacts to micro-ohmmeter for resistance measurements.
11. Perform resistance test on phase A, interrupter unit 1.
12. Perform resistance test on phase A, interrupter unit 2 (if applicable).
13. Perform resistance test on phase B, interrupter unit 1.
14. Perform resistance test on phase B, interrupter unit 2 (if applicable).
15. Perform resistance test on phase C, interrupter unit 1.
16. Perform resistance test on phase C, interrupter unit 2 (if applicable).
17. Perform procedure for safe breaker.

BOTH-SIDES-GROUNDED METHOD

When using the both-sides-grounded method, the procedure is more efficient in three major ways. In both methods, the controls for the coils and transducers are connected in the same manner, but instead of connecting the main contact leads in step 5, the connection for main contacts uses the connections of a portable micro-ohmmeter. The main contact times are measured via the cables of the micro-ohmmeter.

Additionally, it is unnecessary to remove the ground on one side of the switchgear (step 6). The micro-ohmmeter is able to perform these measurements with both sides grounded; therefore, steps 8 – 16 are eliminated. The resistance measurements are included in the main test, and all three phases are measured at the same time.

Without the time-consuming connection and disconnection procedures, testing with both sides grounded turns a 17-step process into an eight-step process. The benefits of this method are as follows:

1. Safer environment for employees and contractors
2. Saves time as all tests can be completed with one cable configuration
3. Significantly more efficient, and with less connections, less probability of a mistake

Figure 1 illustrates the both-sides-grounded method connection on a live-tank breaker. The connection on a dead-tank breaker is the same but with one less main contact.

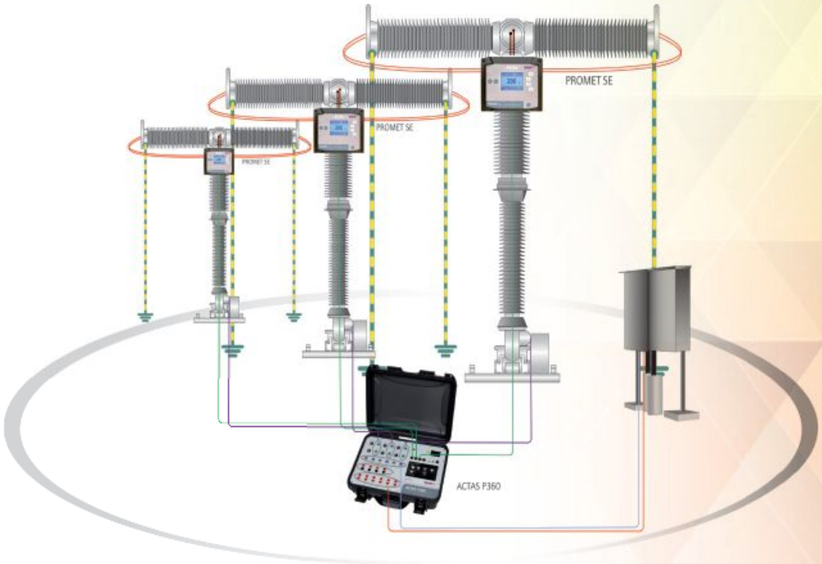


Figure 1: *Measuring a Live-Tank Switchgear with Both Sides Grounded*

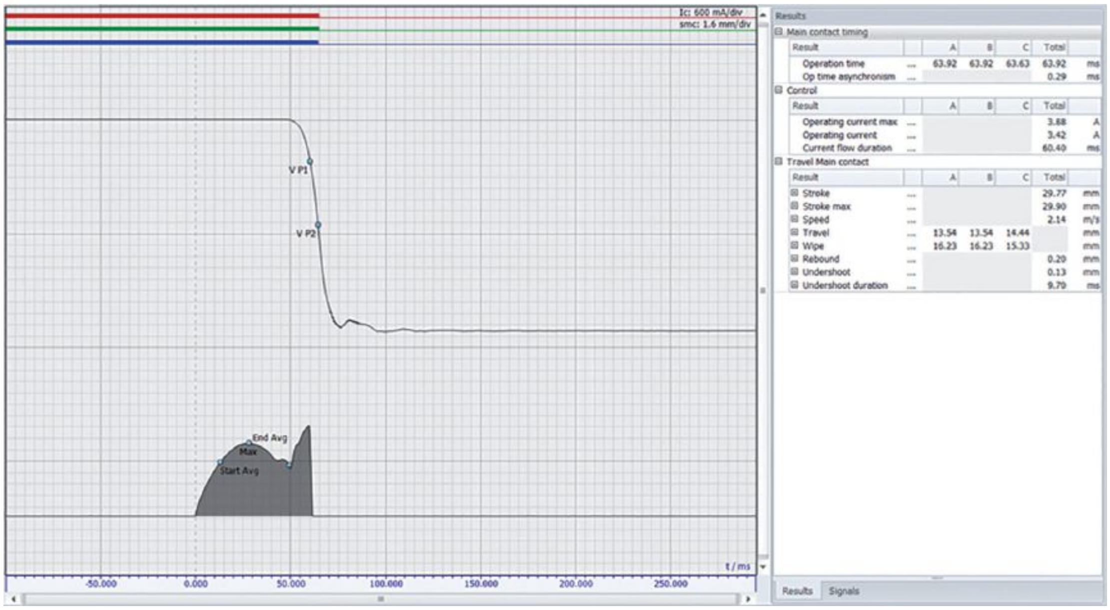


Figure 2: *Open Operation, Conventional Method*

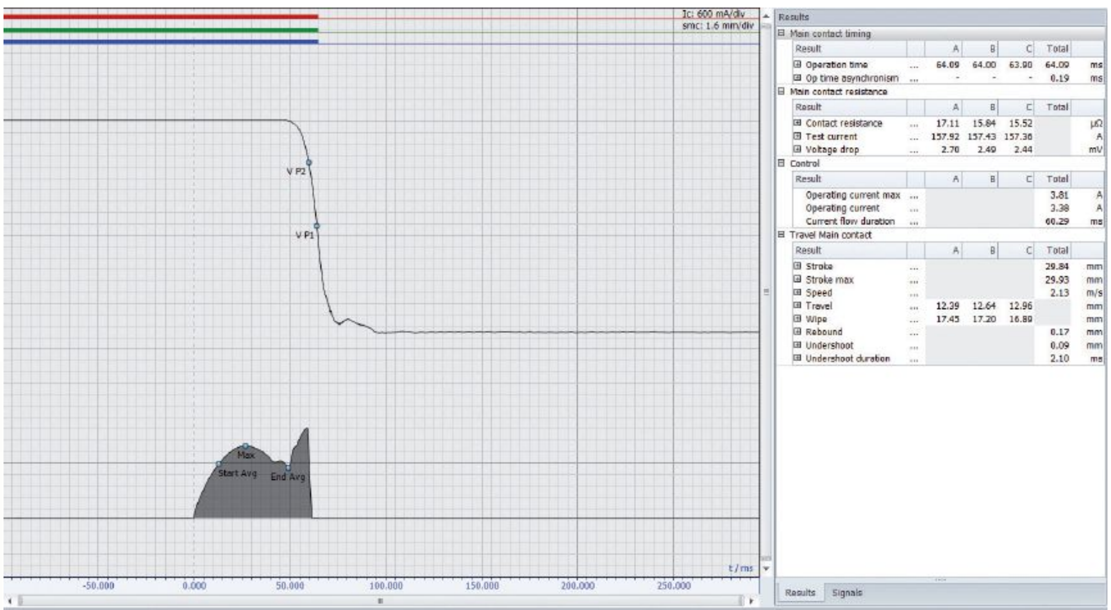


Figure 3: *Open Operation, Both-Sides-Grounded Method*

COMPARING TEST RESULTS — OPEN OPERATION

Figure 2 and Figure 3 show open operations. Figure 2 illustrates tests with the conventional method, and Figure 3 shows tests with the both-sides-grounded method. The results show that the main contact timing was approximately 64 ms for both methods. The parameters were set to be measured from the start of the coil current to the breaker opening. All other parameters were measured in the same manner.

The both-sides-grounded method measures and provides contact resistance results in the same test, measuring them before the breaker opens. This makes the additional test steps needed for measuring contact resistance in the conventional method unnecessary.

COMPARING TEST RESULTS — CLOSE OPERATION

Figure 4 and Figure 5 show close operations. Figure 4 illustrates tests with the conventional method, and Figure 5 shows tests with the both-

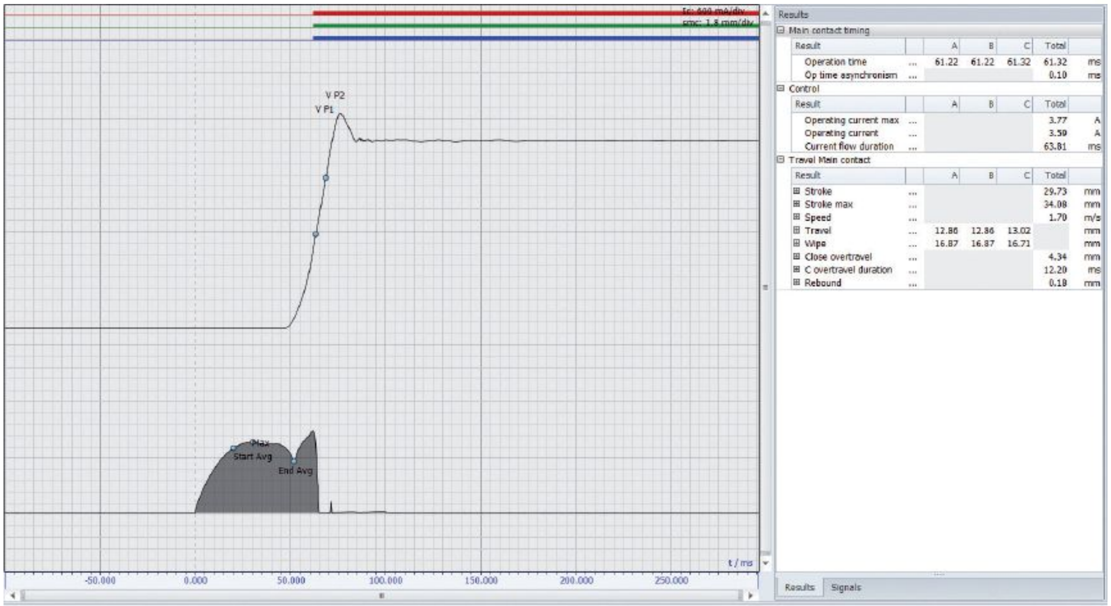


Figure 4: *Close Operation, Conventional Method*

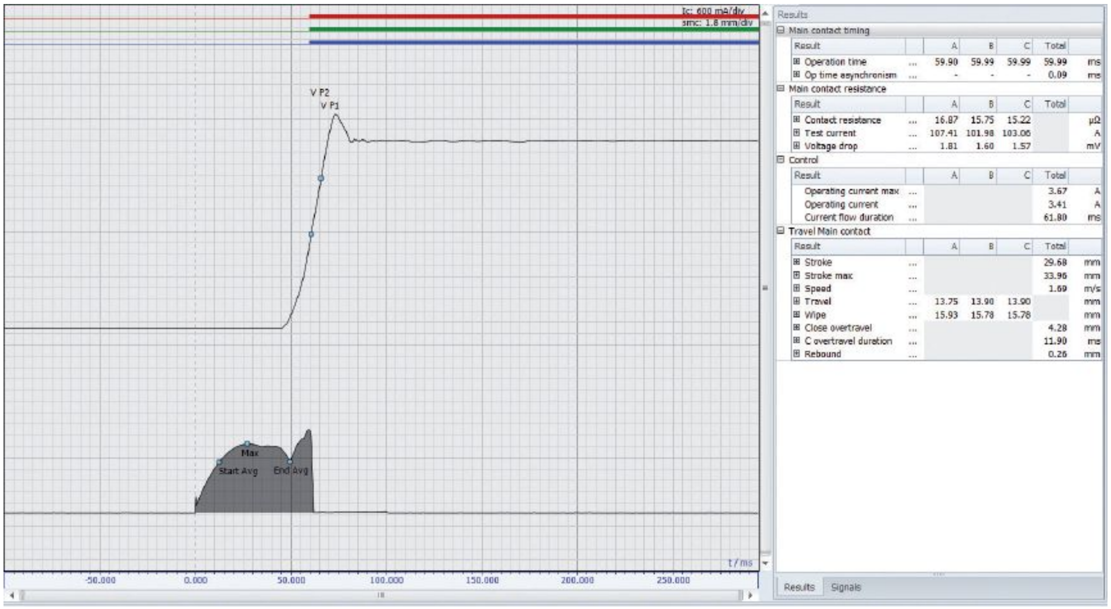


Figure 5: *Close Operation, Both-Sides-Grounded Method*

sides-grounded method. The results show that the main contact timing was approximately 60 ms for both methods. All other parameters were measured in the same manner. Again, when testing using the both-sides-grounded method, the main contact resistance can be measured within the test operation.

WORKINGS OF AN INTERRUPTER UNIT ON A LIVE-TANK CIRCUIT BREAKER

In electrical energy transmission and distribution systems, switchgear devices are the connection to further parts of an installation. Throughout their operational lives, switchgear devices must constantly connect, interrupt, or disconnect operating parts. In the open status, they are a puncture-proof disconnection point; in the closed status, they carry and control short-circuit currents.

Switchgear devices must endure mechanical and thermal stresses during operation without damage; friction and abrasion influence the performance of the mechanical parts. The contact systems in the current-carrying circuits

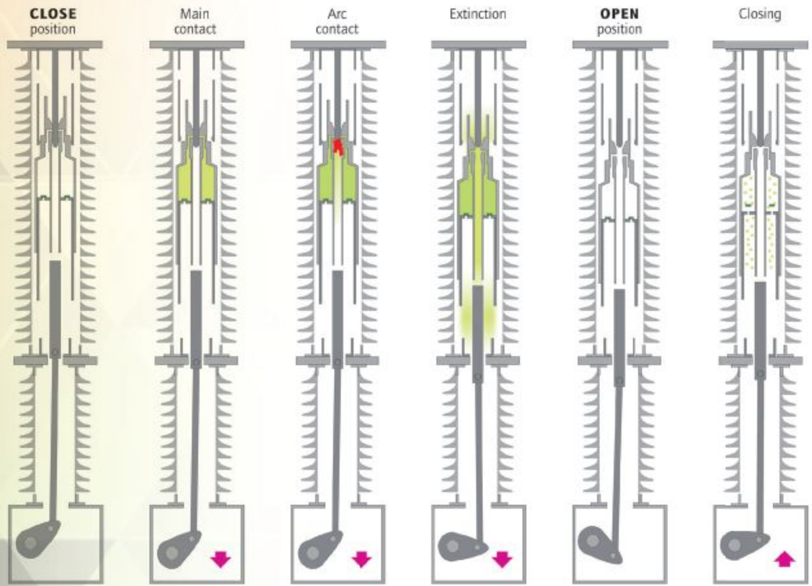


Figure 6: *Workings of a Live-Tank Circuit Breaker*

can deteriorate and thus increase development of excessive heat.

Figure 6 illustrates the workings of a live-tank circuit breaker.

1. Close position: Current flows via main contacts
2. Start of Open operation: Movement and disconnection of the main contacts; current is transferred to the arc contacts
3. Disconnection of the arc contacts; arc occurs between the contacts
4. Arc extinguished
5. Contacts opened
6. Close operation: Preparation for the next operation

These different positions can be seen in the results in Figure 7.

ASSESSING THE INTERRUPTER UNIT BY ANALYZING CONTACT RESISTANCE

Regular measurements of the static and dynamic contact resistance allow an accurate assessment of the condition of the entire contact system. This ensures that maintenance requirements can be identified at an early stage and downtimes kept to a minimum.

High contact resistance within a switchgear device leads to high power loss, and coupled with thermal stress, can potentially cause serious damage to the switchgear device. Problems such as high transfer resistance resulting from poor connections can be identified by measuring static contact resistance.

For the static resistance measurement, the contact resistance is determined when the interrupter

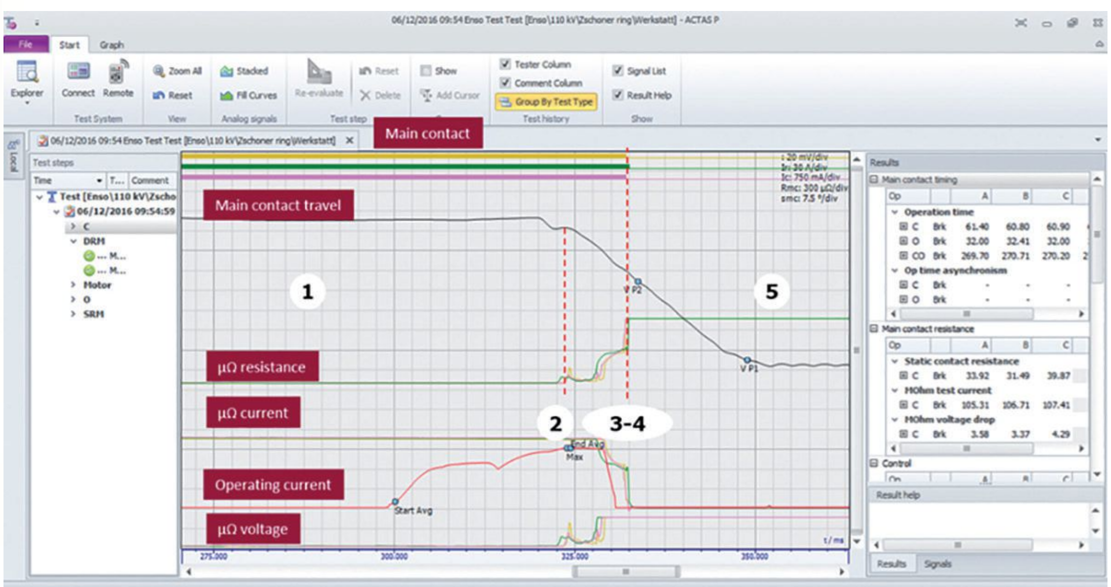


Figure 7: *Measurement Curve for Live-Tank Circuit Breaker*

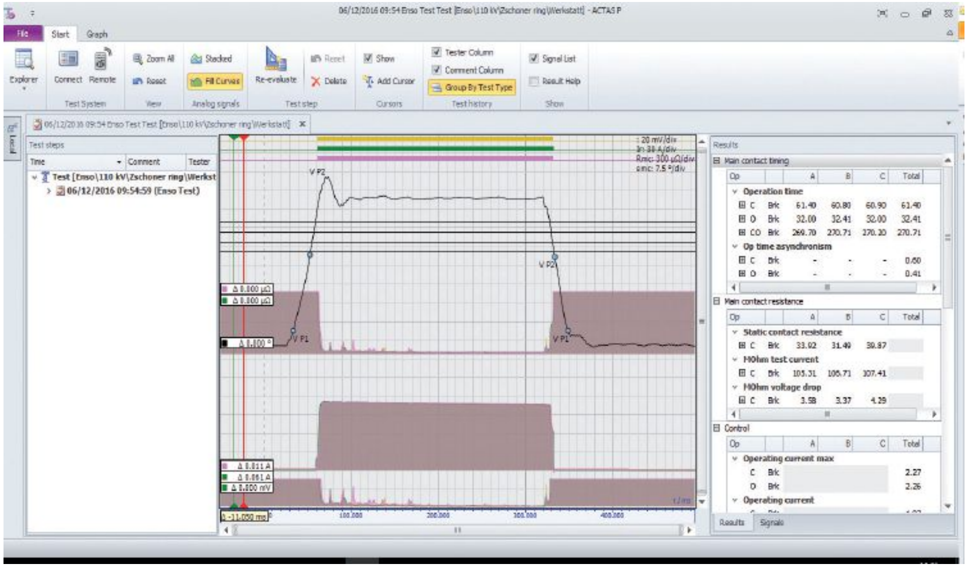


Figure 8: *Close-Open DRM on a Live-Tank Circuit Breaker*

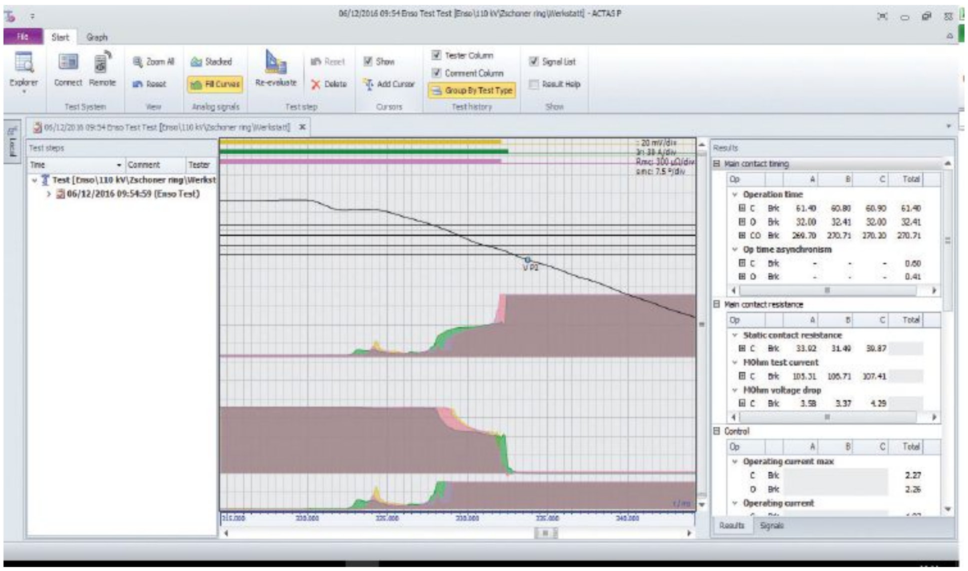


Figure 9: *Curve Used to Determine Health of Arcing Contacts*

unit is closed. However, this measurement does not give an indication of the internal state, especially of the arc contacts. An assessment can be made by an internal inspection of the contact, but this is labor intensive and time consuming.

To simplify switchgear analysis, the dynamic resistance measurement was introduced. Dynamic contact resistance measurements can be used to determine the resistance characteristic during a freely definable switching operation. The contact resistance is dynamically measured via a close-open operation. The contact characteristic and the arc contact can be reliably determined via the measurement results. During this switching operation, a high test current is applied and the voltage drop is measured. The measurement of the complete switching operation shows the resistance characteristic of the entire contact travel. The information given by the dynamic resistance measurement provides an overview of the entire contact status, particularly of the arc contact, and indicates any contact erosion. The condition of the arcing contacts cannot be determined by static resistance measurement.

Figure 8 and Figure 9 show the characteristics of the dynamic resistance measurement, illustrating the movement of the contacts.

Measuring Setup in the Field

The transition to the arc contact is clearly visible. If the travel is measured, the length of the arc can also be determined. The display of the resistance characteristic and the length of the arc contact provide an insight into the internal status of the contact without opening it.

CONCLUSION

Testing switchgear with the both-sides-grounded method saves a substantial amount of time, increases safety, and provides more diagnostic information than the conventional method. The effort involved in connecting and disconnecting cables on site is greatly reduced as all required tests are completed using one test setup. There is no need to change the cabling. Ensuring both sides of the switchgear are grounded significantly increases safety during tests. When using micro-ohmmeters for main contact cables, more information about the main and arcing contacts becomes available. The main contact diagnostics are measured by performing static resistance measurement, while arcing contact diagnostics are measured through performing dynamic resistance measurement. With this method, tests can be performed according to standards.

Guy Wasfy *is the Director of North American Operations at KoCoS America LLC in Westerly, Rhode Island. After graduating from the University of Rhode Island's Electrical Engineering program in 1990, he went directly into the utility industry. After years of working around the world, Guy started KoCoS America in 2001, establishing and growing the sales, service, and application departments of KoCoS in North America.*

Christian Studen *is Product Manager for Circuit Breaker Test Systems at KoCoS Messtechnik AG in Korbach, Germany. He provides product and application support to distributors and customers throughout the world. Christian joined KoCoS in May 2013 and spent the first two years on the Service & Support team acquiring knowledge and practical experience in electrical power engineering. After completing an apprenticeship as a power electronics installer with Viessmann in Allendorf, Germany, Christian earned a BS in Electrical Engineering at the University of Applied Sciences in Lemgo, Germany. While working toward his MS in Mechatronic Systems, he was employed as a research assistant in the power electronics laboratory.*