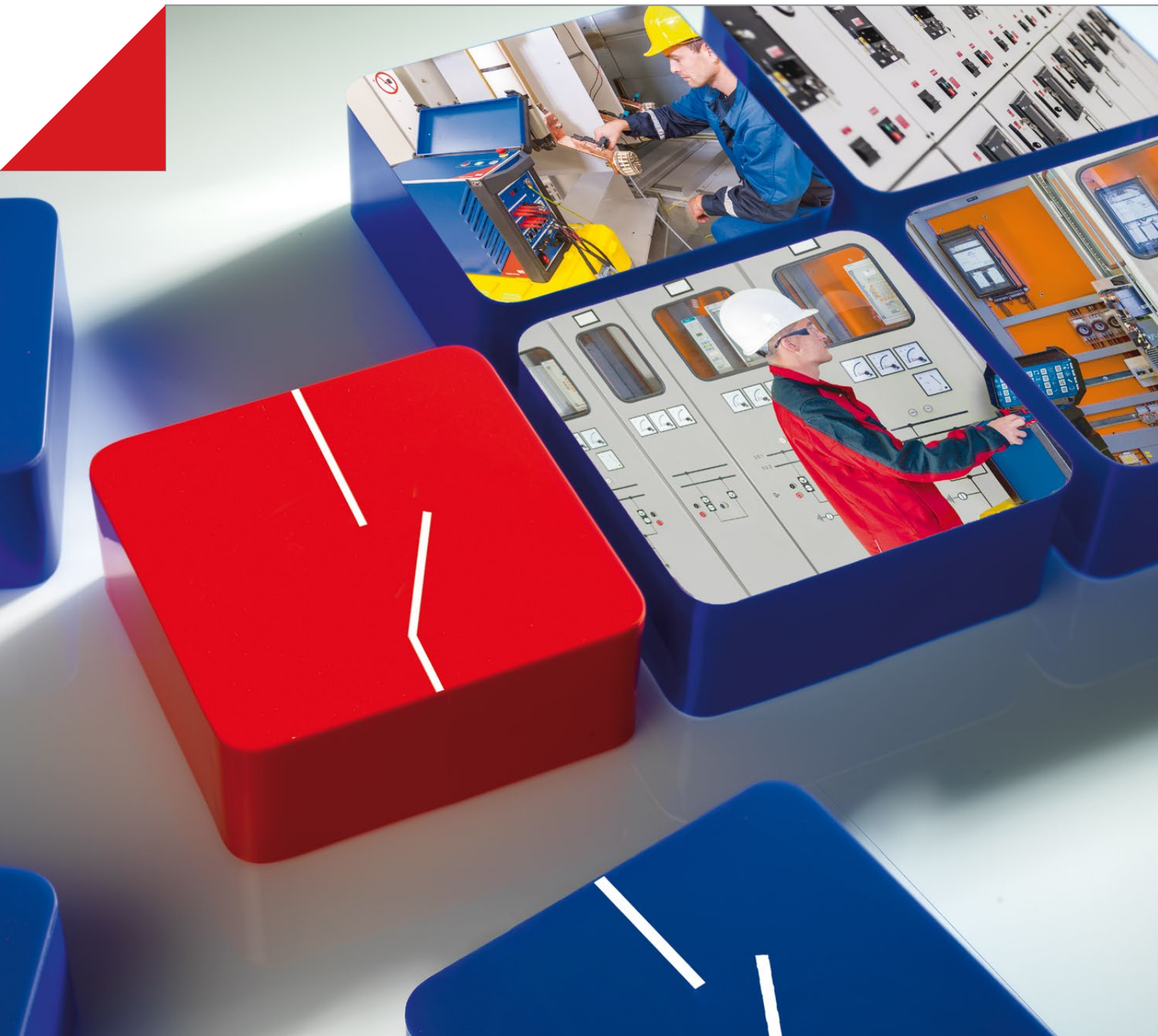
OMICRON

Diagnostic testing on medium-voltage switchgear



Assessing the condition of MV switchgear

Reducing the risk of failure in MV switchgear

The testing of medium-voltage (MV) switchgear is vital for ensuring the reliability, safety, and longevity of electrical equipment and power systems. By identifying potential issues early, testing helps prevent costly downtime, accidents, and regulatory non-compliance.

Failures are often attributed to a combination of factors, including environmental conditions, aging, poor maintenance, and operational issues.

These failures can range from minor disruptions to catastrophic system outages, highlighting the importance of proactive maintenance and preventative measures.

Regular switchgear testing offers numerous benefits, including enhanced safety, improved reliability, compliance with industry standards, and cost savings, by identifying and addressing potential issues early on, testing helps prevent accidents, equipment damage, and costly downtime, ultimately leading to a safer and more efficient power system.

MV switchgear testing

- **Initial testing:** Switchgear should undergo comprehensive testing before being commissioned and put into operation;
- **Periodic testing:** Regular testing should be performed at intervals determined by equipment criticality, age, and operational environment, typically every 2-5 years;
- **After repairs or modifications:** Testing is essential after any repairs or modifications to ensure the switchgear's continued reliability;
- **Following anomalies:** If any unusual behavior or measurement values are observed, testing should be performed to diagnose the issue.

The benefits of testing

- **Safety:**
  Testing helps identify and mitigate potential hazards, reducing the risk of potential of electrical accidents, arc flashes and fires;
- **Reliability:**
  Regular testing ensures the switchgear operates correctly, preventing breakdowns and maintaining an uninterrupted power supply
- **Compliance:**
  Many industry standards and regulations mandate switchgear testing for safety and performance compliance;
- **Cost savings:**
  Early detection and addressing of issues through testing can save significant costs compared to dealing with unexpected failures;
- **Equipment protection:**
  Testing verifies the proper functioning of circuit breakers, relays, and other components, protecting equipment from damage;
- **Optimal performance:**
  Testing ensures the switchgear operates within specific parameters, maximizing efficiency and reducing energy costs.

Negative influences on MV switchgear reliability and life expectancy

- **Environmental factors:**
  Moisture, dust and contaminants, temperature fluctuations, vibration, ice and snow;
- **Aging and deterioration:**
  Aging components, insulation breakdown, corrosion, wear of components;
- **Poor maintenance:**
  Inadequate inspection and testing, lack of cleaning, improper lubrication;
- Operational issues:
  Overloading, voltage fluctuations, faults and arcs, operator errors;
- **Other factors:**
  Manufacturing defects, external damage (animals, accidents), inadequate design.

Normal life
Ensuring reliable operation

End of life
Extending lifetime

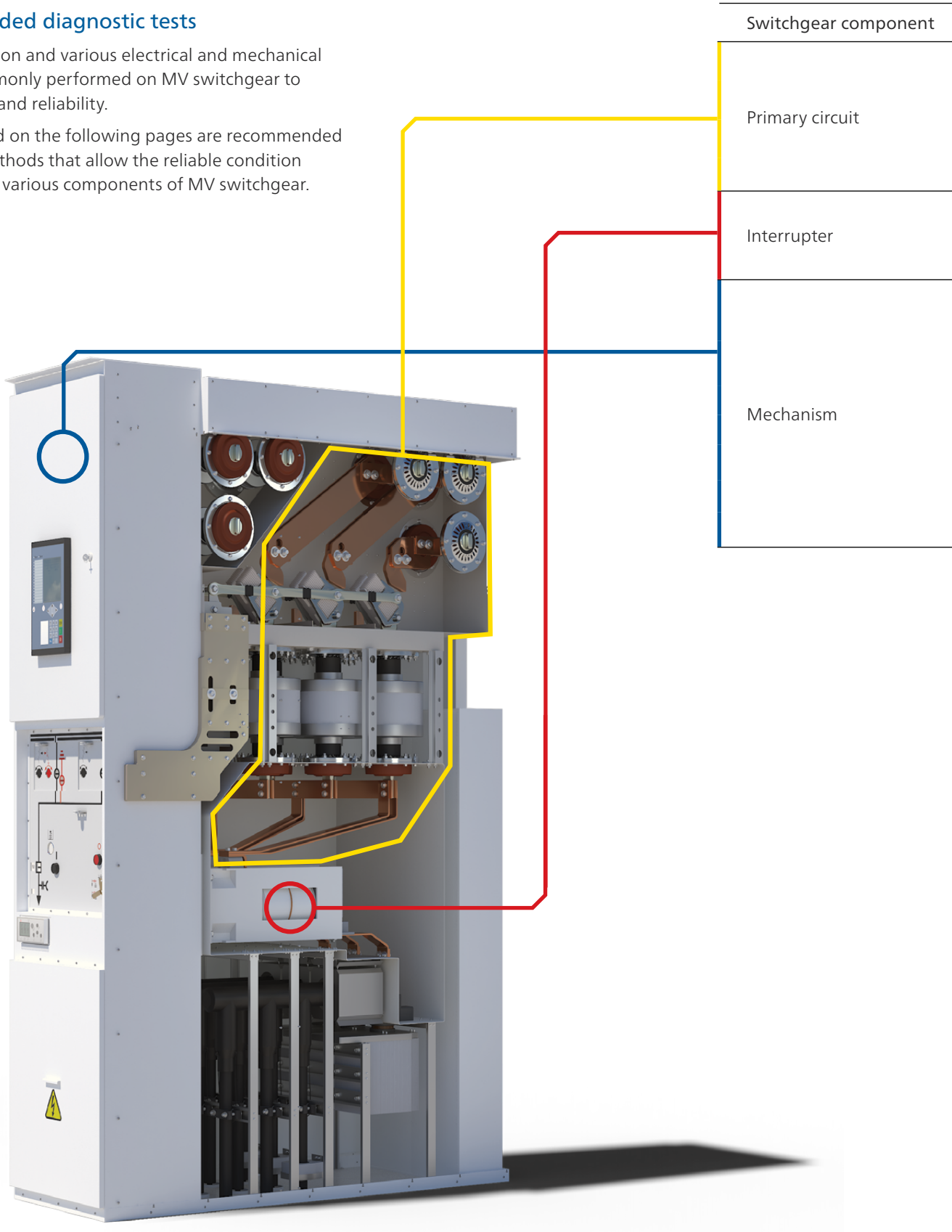
MV switchgear life expectancy

MV switchgear parts and recommended diagnostic tests

Recommended diagnostic tests

Visual inspection and various electrical and mechanical tests are commonly performed on MV switchgear to ensure safety and reliability.

The tests listed on the following pages are recommended diagnostic methods that allow the reliable condition assessment of various components of MV switchgear.



Subcomponent	Failure Mode	Condition indicator	Recommended tests					
			1	2	3	4	5	6
Conductor joint	Loose, overtight connection	Resistance	■					
Insulation medium	Particles, protrusions, or voids	Partial discharge						■
Shielding Electrode	Poor electrical contact	Partial discharge						■
Cable joint, Bushing	Dielectric condition degradation	Partial discharge						■
Main contact	High resistance	Resistance static	■					
	Deformed	Bounces		■				
Mechanical Linkage	Opening / Closing time out of tolerance	Main contact state over time		■				
	Pole synchronism > threshold	Time differences of contacts		■				
	Not open or close on command	Auxiliary contact state over time		■				
		Coil Current profile			■			
Operating rod	Mechanical problem	Main contact state over time		■			■	
Spring, damper	Wear of spring or damping	Contact travel over time					■	
Motor	Not or insufficient charging	Motor current over time				■		

Recommended tests

1 Static contact resistance measurement
Apply high current source across the closed contact and measuring the resulting voltage drop. (Pages 10-11)

2 Timing tests
In-Service and Off-Service methods for determine operating time of switchgear contacts. (Pages 12-15)

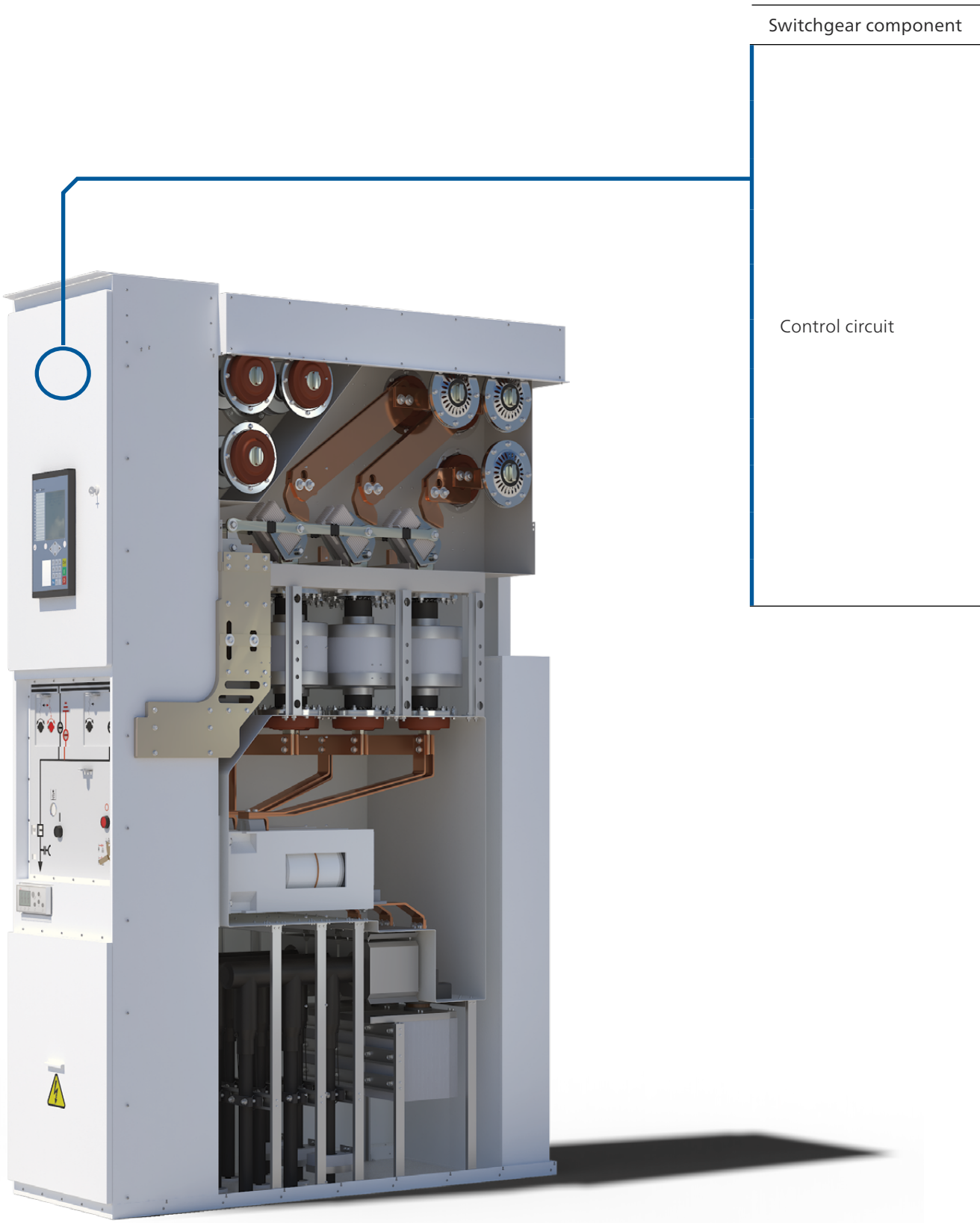
3 Coil current measurement
Measure the current of the trip and close coil over time. Use graphical comparison to evaluate the typical shape of the captured current. (Pages 16-17)

4 Motor current measurement
Measure the current of the spring charging motor and evaluate the duration, the inrush current and the nominal current. (Pages 18-19)

5 Motion measurement
Apply a travel transducer to the mechanical linkage and record the motion during operation. (Pages 20-21)

6 Partial discharge testing
Measure partial discharge to determine deterioration of electrical insulation and detect developing insulation detects. (Pages 30-33)

MV switchgear parts and recommended diagnostic tests



Subcomponent	Failure Mode	Condition indicator	Recommended Tests						
Trip and close coils	Electrical failure, mechanical friction issues	Coil current profile		■					
		Auxiliary contact state over time	■						
	Mechanical friction issues	Release operation voltage			■				
Undervoltage coil	Electrical failure	Supply voltage when tripping				■			
Overcurrent release	Electrical failure	Supply voltage when tripping					■		
Auxiliary contacts	Electrical or mechanical wear	Diff to main contacts	■						
		Bounces	■						
Grounding system	Corrosion	Resistance static							■
Communication	System overload	Message delay time						■	
Power supply	Degrading batteries	Voltage during operation	■						
		Under-voltage condition	■						
			7	8	9	10	11	12	13

Recommended tests

7 Timing tests
In-Service and Off-Service methods for determine operating time of switchgear contacts. (Pages 12-15)

8 Coil current measurement
Measure the current of the trip and close coil over time. Use graphical comparison to evaluate the typical shape of the captured current. (Pages 16-17)

9 Minimum pick-up test
Increase the trip/close coil supply voltage step-by-step until the switchgear operates. (Pages 22-23)

10 Undervoltage release test
Decrease the supply voltage of an undervoltage coil until the switchgear trips. (Pages 24-25)

11 Overcurrent release test
Decrease the supplied current until the switchgear trips. (Pages 26-27)

12 Delay time measurement
Evaluate the performance on intelligent switchgear with IEC 61850 interface according to IEC 62271-3. (Pages 28-29)

13 Static contact resistance measurement
Apply high current source across the closed contact and measuring the resulting voltage drop. (Pages 10-11)

The ideal solution for your MV switchgear testing needs

Recommended diagnostic tools

These solutions allow you to perform a thorough condition assessment of MV switchgear in order to quickly identify potential problems and risk of failure.

	CIBANO 500	CPX 200	COMPANO 100
	Dedicated circuit breaker test device with guided assistance	*Powerful, compact and lightweight primary asset test device*	*Lightweight, battery powered multi-pupose test device*
Diagnostic test			
Guided workflows	■	■	–
Static contact resistance measurement	up to 200 A DC	up to 1000 A DC	up to 100 A DC
Timing tests			
Main Contact Timing	■	■	■
Contact Synchronism	■	■	–
Contact Bounce Analysis	■	■	–
Auxiliary Contact Timing	■	■	■
Integrated Power Supply	up to 2400 VA (300 V)	up to 2500 VA (125 V)	up to 30 VA (220 V)
Pre-Insertion Resistor Timing	■	–	–
Test with Current Clamps (First Trip)	■	–	–
Coil current measurement	■	■	–
Motor current measurement	■	■	■
Motion measurement	■	–	–
Minimum pick-up test	■	–	–
Undervoltage release test	■	–	–
Overcurrent release test	■	–	–
Delay time measurement	–	–	–

Legend: ■ = Performs test; – = Not applicable

CMC 500
Modular, multi-phase protection relay test set and commissioning tool
–
–
■
■
■
■
up to 320 VA (600 V)
■
■
■
■
–
■
■
■
■

MPD 800
Portable universal multichannel PD measuring system

Partial discharge measurement	
According to IEC 60270	■
TEV (Transient Earth Voltage)	■
HFCT (High Frequency Current Transformer)	■
VDS (Voltage Detection System)	■

Legend: ■ = Performs test; – = Not applicable

Static contact resistance measurement

Areas tested

- ✓ Primary circuit
- ✓ Interrupter

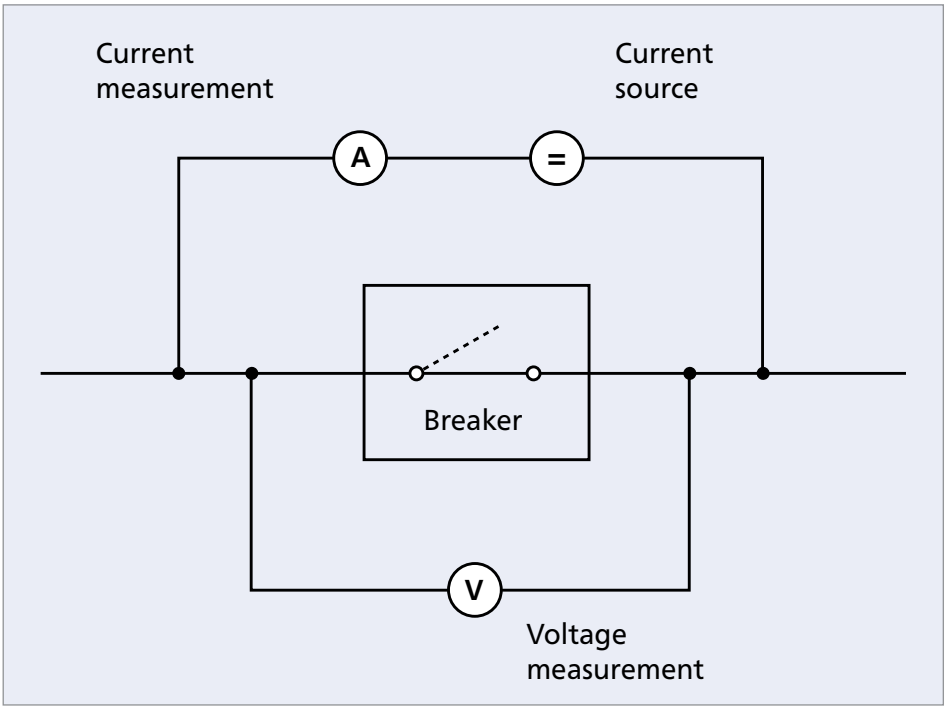
Why measure?

Static Contact Resistance tests serve to confirm if the resistance at the main contacts of a switch or connections in the primary circuit permits current to flow with minimal losses. Measurements of static contact resistance, often referred to as micro-ohm measurements, constitute one of the crucial tests for switchgear circuit breakers.

The test assesses whether the resistance in the contacts conducting current allows the flow of rated current with acceptable losses. Resistance is influenced by the properties of the contact surfaces, which are the connection points on a microscopic scale, along with the contact pressure and surface oxidation. An elevation in temperature beyond specified limits can alter these electrical contact surface characteristics, subsequently increasing the losses. This process can accelerate over time, potentially culminating in a sharp increase towards the end.

How does it work?

Usually a four-wire measuring method is used for static contact resistance measurements. Two wires are used to inject the current, and the voltage drop is measured with the other two wires. This measurement method is suitable for resistance measurements in the micro-ohm range. Typical resistances values are between 10 to 100 µΩ.



Apply Ohm's Law, expressed as R = V/I, to determine the contact resistance using the observed voltage drop and the supplied current. Evaluate the calculated resistance against the permissible limits or norms for the particular switchgear type. Document the measurement outcomes for subsequent reference and evaluation.

Good to know ..

> Insufficient contact pressure can lead to higher resistance.

> Higher injection currents, up to the nominal current, can be beneficial on air insulated switches to overcome the oxidation.

Recommended solutions

CIBANO 500

> **All-important tests:** CIBANO 500 combines a micro-ohmmeter, timing analyzer, and a coil and motor supply. All-important tests on all types of switchgear can be carried out even when a station battery is not available.

> **Powerful integrated supply.** The integrated power supply can output a highly accurate, digitally generated output signal of up to 2.4kW.

> **High measurement accuracy:** Using four measurement ranges, CIBANO 500 can accurately determine contact resistances with an accuracy of better than 1 µΩ.

CPX 200

> **High current output:** Generates up to 1000 A AC/DC combined with the High Current Module, making it more suitable for resistance measurement on contacts that are prone to having a thin layer of byproducts from the arc extinguishing process.

> **High accuracy and reliability:** Utilizes a 4-wire measurement method for highly accurate resistance measurements, even in the micro-ohm range. This accuracy is crucial for detecting even minor deviations.

> **Guided testing and reporting:** Guided workflows, wiring instructions, as well as procedures for automated testing and reporting, save time, reduce the potential for human error and eliminate manual data recording and report writing.

COMPANO 100

> **Basic checks on breakers: C**OMPANO 100 allows to perform micro-ohm measurements, basic timing measurements and motor current measurements.

> **High measurement accuracy:** COMPANO 100 can perform precise timing and micro-ohm measurements with an typical accuracy of better than 1 µΩ at 100 A DC.

> **Battery powered operation:** The integrated battery allows to perform basic checks fast and efficient, even if no mains supply is available.

Timing tests

Areas Tested

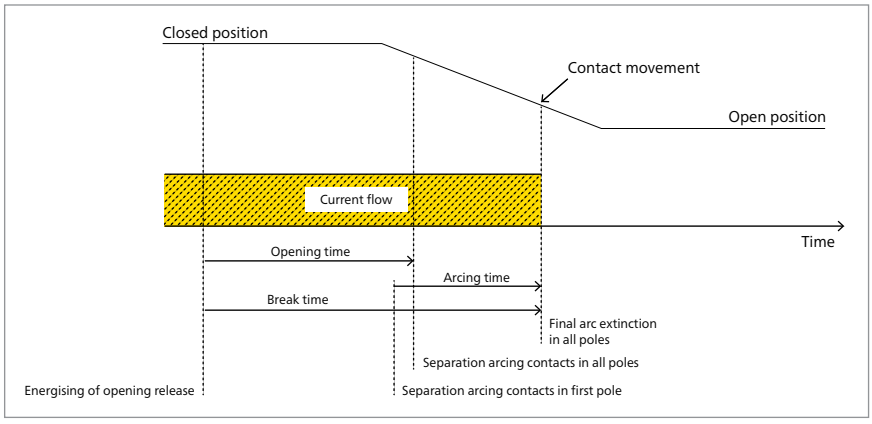
- ✓ Interrupter
- ✓ Mechanism
- ✓ Control circuit

Why measure?

The primary function of every switching device is to control the electrical flow by connecting and disconnecting high voltage lines. For any applied grid protective mechanisms to work properly, it is crucial that these devices operate within specified boundaries. If the devices do not perform within these specified parameters, it could imply a potential issue in one of the areas within the switchgear. To ensure the safety and reliability of the switching device, further testing is usually performed to identify and resolve the root cause of any deviation in performance.

How does it work?

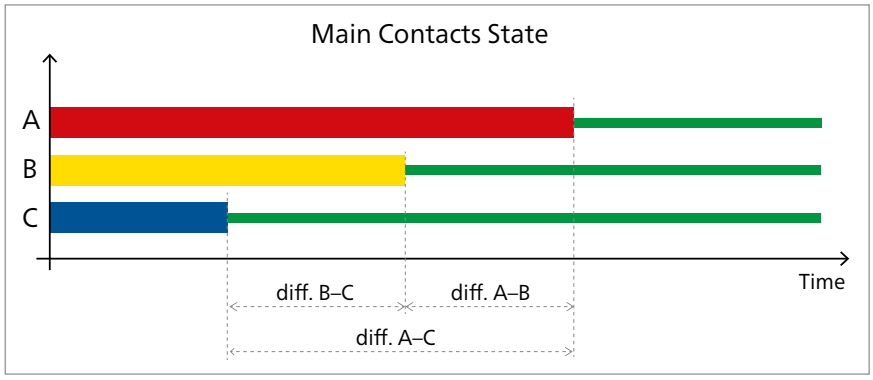
There are a variety of switchgear timing testers that differ from each other by their set of features. The feature set and thus the device that a tester needs depend on their specific area of application and the associated requirements. The following Timing Test feature are available:



Opening time definition according IEC 62271-100

1. Operation Time Main Contact

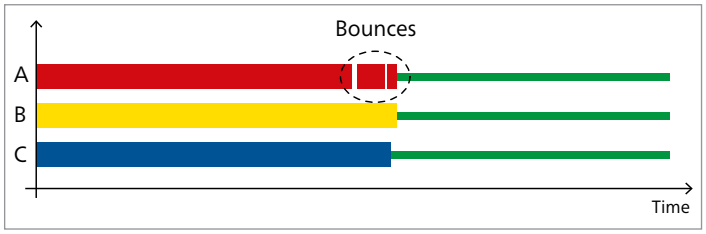
Test devices with this feature measure the operation time of the main contacts of the switchgear according to the IEC 62271-100 standard. Switchgear manufacturers are widely accepting this standard and utilize it to define their product specifications. Therefore, any test device that aims to verify or compare manufacturer specifications with actual measurements taken in the field will follow this standard. This ensures consistency and accuracy in assessing whether the switchgear operates within the designated time constraints.



Time differences between phases

2. Contact synchronism

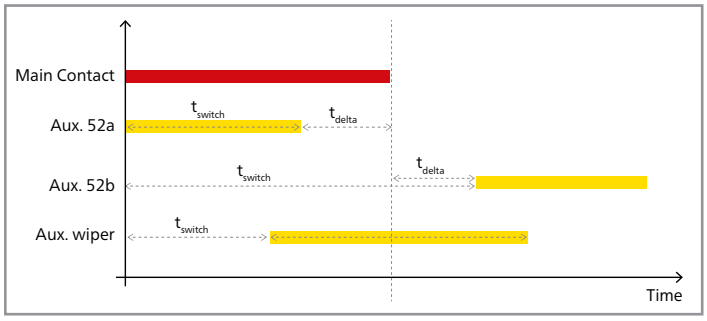
This feature assess the time differences between phases (synchronism). Significant deviations can harm three-phase inductive machines such as generators, power transformers, and motors. According to the IEC 62271-100 standard, there are defined limits for allowable discrepancies.



Graphical representation of contact bounces

3. Bounces

Binary traces serve as graphical representations to evaluate contact bouncing, illustrating the main contact state. The amount of bounces that occur in switching devices is influenced by the contact mechanism and the speed at which they open or close. This undesirable effect generates significant transients that can cause over voltages and damage other components of the electrical network.



Timing relationship of auxiliary contacts 52a, 52b and wiper to main contact

4. Timing of auxiliary contacts

The coordination of timing between main and auxiliary contacts in switchgear control systems is essential. Main contacts are responsible for handling the main circuit flow, whereas auxiliary contacts enable supplementary operations, such as initiating a spring-charging motor, in a sequence aligned with primary actions like circuit closure. Manufacturers supply detailed specifications of these timing relationships, which are crucial for optimal system functionality.

Influence of supply voltage on coil current

5. Timing test with integrated power supply

The built-in power supply enables a complete separation between the switchgear control voltage and the substation station's power source. This improves safety for operators and makes it easier to assess switching times at different voltage levels, including the station's minimum, standard, or maximum defined operation voltage.

Operating times

		Opening time
	Breaker	39,30 ms
+	A	38,40 ms
+	B	39,30 ms
+	C	38,90 ms

Coil characteristics

	Peak current
Trip A	1,28 A

$0{,}7U_n$

Operating times

		Opening time
	Breaker	36,90 ms
+	A	36,00 ms
+	B	36,90 ms
+	C	36,40 ms

Coil characteristics

	Peak current
Trip A	1,85 A

U_n

Operating times

		Opening time
	Breaker	36,60 ms
+	A	36,60 ms
+	B	36,60 ms
+	C	36,20 ms

Coil characteristics

	Peak current
Trip A	2.04 A

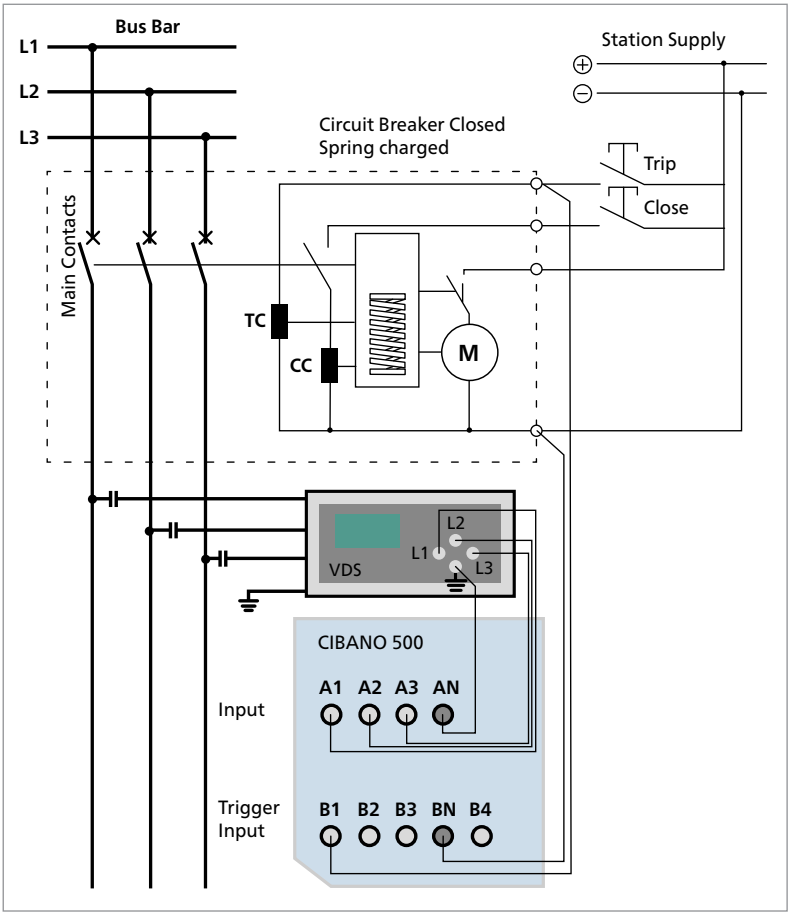
$1{,}1U_n$

Different control voltage results in different timing measurements

Timing tests

6. With VDS (Voltage Detection System)

Metal-clad switchgear frequently includes voltage detection systems (VDS) that alert to hazardous voltages on the primary side. These systems include a capacitive voltage divider that provides a low-voltage signal proportional to the network voltage. By using this signal in conjunction with the coil energizing signal, the Voltage Based Timing (VTM) measurement method can automatically calculate the switchgear's operating times, making it a straightforward method for conducting timing measurements while in service.



In-Service timing test with VDS system

Recommended solutions

CIBANO 500 (Timing tests 1-7)

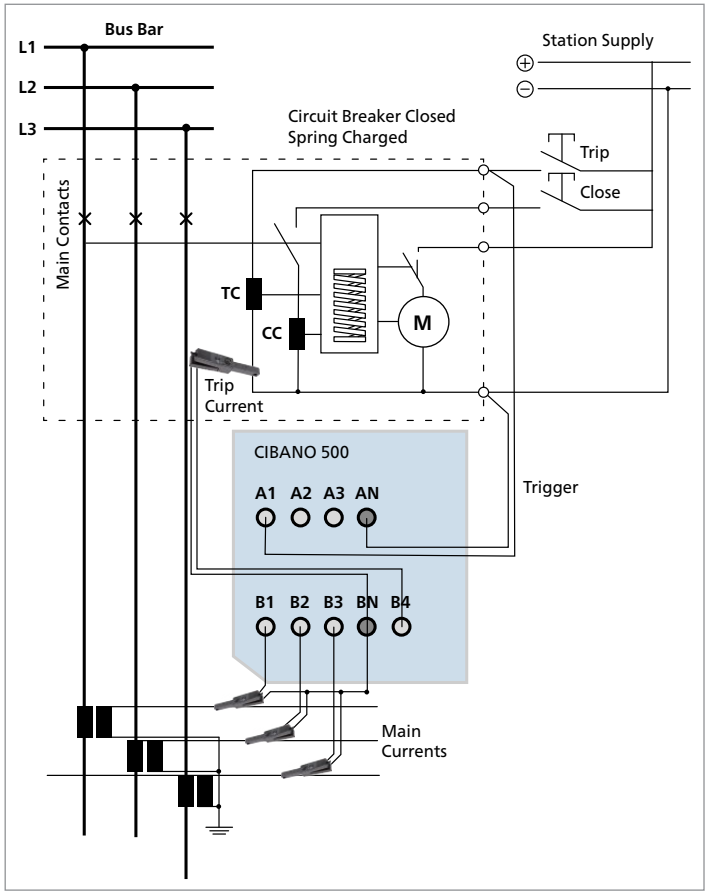
- **All essential breaker tests:** The CIBANO 500 integrates a micro-ohmmeter, a timing analyzer, and a coil and motor power source. It enables all key tests on every type of switchgear, even in the absence of a station battery.
- **Powerful integrated power source:** The built-in power supply delivers a highly precise, digitally generated output signal of up to 2.4 kW.

CPX 200 (Timing tests 1-5)

- **Accurate and reliable timing measurements:** Designed for precision, allowing accurate measurement of timing parameters, ranging from opening and closing times of main and auxiliary contacts according to IEC 62271-100 to graphical evaluation of bounces to measuring the synchronism between phases.
- **Integrated power supply:** The integrated power supply ensures an easy adaption to minimal, nominal and maximal control voltages and even allows a complete disconnection of the circuit breaker from the station power supply.
- **Guided testing and reporting:** Guided workflows, wiring instructions, as well as procedures for automated testing and reporting, save time, simplify the testing process and reduce the learning curve for users.

7. Use current clamps based In-service test methods

The first trip test is designed to measure the operation time of a switching device that has remained closed and in-service for a long period of time. Its purpose is to assess if there is a notable discrepancy when compared to the operation time of a regularly operated switching device. To conduct this test current clamps connected to the secondary side of current transformers are used to measure trip time to ensure the switch must remain connected to the grid until the first trip after a long time in service.



In-service timing test with current clamps

COMPANO 100 (Timing tests 1, 4 & 5)

- **Simple timing checks:** The versatile QUICK and FLEX modules in combination with the flexible timer function allows to perform a large variety of timing checks.
- **Accuracy and reproducibility:** The COMPANO 100 is designed for precise and reproducible measurements.
- **Versatility:** The COMPANO 100 can also be used for many other basic tests like CT/VT ratio, polarity and wiring checks and testing basic protection relays.

CMC 500 (Timing tests 1-7)

- **Simple timing checks:** Several Test Universe modules in combination with the real-time measurement and signal recorder EnerLyzer allows users to perform a large variety of timing checks with graphical visualization.
- **Accuracy:** Measurement accuracy minimizes the risk of incorrect settings or faulty operation of the circuit breaker.
- **Troubleshooting:** The user-friendly software makes troubleshooting easier and faster, which is especially beneficial during commissioning or after a fault.

Coil current measurement

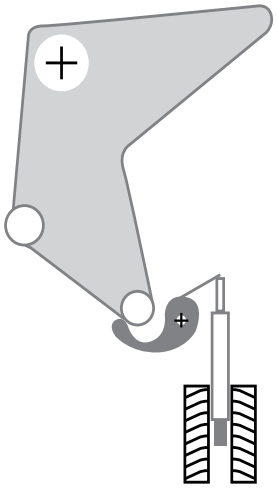
Areas tested
- ✓ Mechanism
- ✓ Control circuit

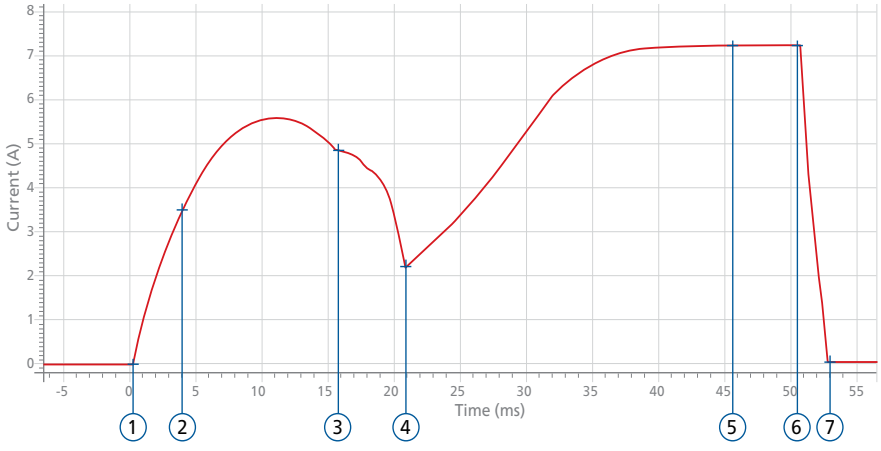
Why measure?

Coil current measurements record the current signature curve of trip and close coils during breaker operation to detect potential mechanical and electrical issues. They help identify problems like lubrication issues, latch operation problems, and the quality of the control voltage supply before they manifest as actual faults. This allows you to identify potential issues before they escalate, preventing costly outages and repairs. It also enables proactive maintenance based on the measured coil current, ensuring the proper functioning of the circuit breaker's operating mechanism and control circuit for reliable and efficient operation and extended lifespan of the MV circuit breaker.

How does it work?

During a coil current analysis, the current flow in the trip or close coil during the closing or opening operation of the switchgear is measured and displayed in a chart over time. Resulting curve deviations from the electrical coil properties that are expected (time constant), the necessary driving force (proportional current), and the correct timing sequence of the auxiliary contacts are indicators for electrical or mechanical problems within the trip and close mechanism of the circuit breaker.





1–2	Coil energized	4–5	Armature comes to stop	6–7	Auxiliary contact interrupts coil supply
2–3	Armature induces back	5	Current overcomes inductance		
3–4	Armature hits trigger releases spring	6	Auxiliary contact opens		

Detection of potential problems in actuating coils – Comparison is the best method of analysis.

Good to know ..

- The ability to do graphical comparison is a very useful feature when comparing test results.
- Using a stable power source guarantees that the measured coil current curves are repeatable as different control voltages will influence the shape of the curves.
- Advanced test devices combine these measurements with the timing test to increase efficiency.

Recommended solutions

CIBANO 500

- **All-important tests on breakers:** CIBANO 500 combines a micro-ohmmeter, timing analyzer, and a coil and motor supply. All-important CB tests on all types of CBs can be carried out even when a station battery is not available.
- **Powerful integrated supply:** The integrated power supply can output a highly accurate, digitally generated output signal of up to 2.4kW.
- **High measurement accuracy:** CIBANO 500 can accurately determine DC currents of up to 55 Amps or AC currents of up to 40 Amps with high accuracy.

CPX 200

- **Accurate and reliable measurements:** The CPX 200 uses digital filtering and a high sampling rate up to 40kHz to provide highly accurate current measurements, even in the presence of interference from the power grid.
- **Guided testing and reporting:** Automated testing procedures and reporting optimize efficiency and streamline the testing process, saving time and reducing the potential for human error and eliminates manual data recording and report writing.
- **Compact and portable:** Designed to be the most compact and lightweight solution in the industry, making it easy to transport and ideal for on-site testing.

CMC 500

- **Basic current measurements:** The CMC 500 allows to measure the coil current using a current clamp or a shunt with the real-time measurement and signal recorder EnerLyzer with graphical visualization.
- **Accuracy:** The CMC 500's precision and reliability ensure accurate measurements, minimizing the risk of incorrect settings or faulty operation of the circuit breaker.
- **Troubleshooting:** The CMC 500's user-friendly software makes troubleshooting easier and faster, which is especially beneficial during commissioning or after a fault.

Motor current measurement

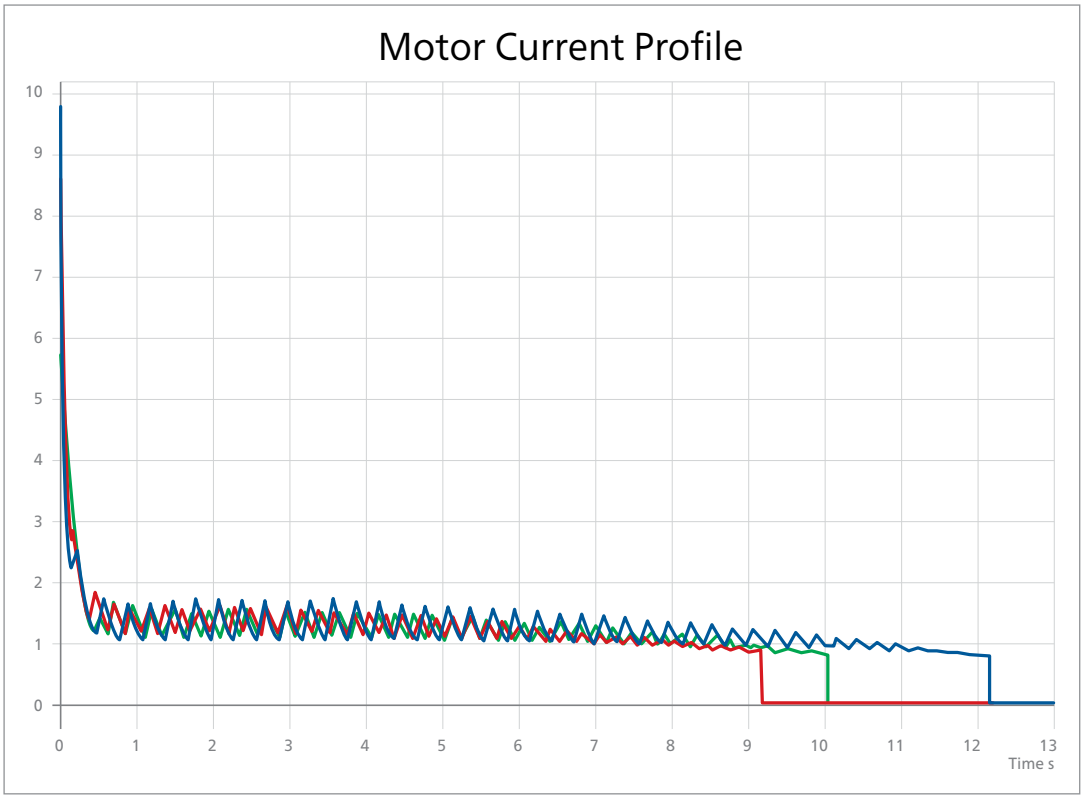
Area tested

✓ Mechanism

Why measure?

Motor Current Signature Analysis is a non-intrusive diagnostic technique that analyzes the current waveform and run-time of a motor to detect variations from the expected waveform. It involves breaking down the current waveform into inrush-currents and continuous currents drawn from the station supply or directly from the test device.

Early detection of potential issues through motor current measurements can optimize maintenance strategies as well as prevent costly breakdowns and outages.



Performance of charging motor – The displayed motor current profiles show the behavior with reduced and increased motor supply voltage.

How does it work?

The test involves measuring the current drawn when the motor is charging the spring of the operating mechanism. Analysing this current helps to verify the adequacy of lubrication in the operating mechanism or any electrical issues of the drives. Besides the manufacturer's specifications, also graphical comparison to a commissioning fingerprint is commonly used for condition assessment.

Good to know ..

- Use a precise and adjustable power supply for accurate motor current fingerprint comparisons for minimum, nominal and maximum supply voltage.
- The spring charging motor starts right after a close operation. Therefore it is useful to combine them with a close timing test.
- It is very handy to use current clamps to avoid any re-wiring.

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- **Guided testing and reporting:** Automated testing procedures and reporting optimize efficiency and streamline the testing process, saving time, reducing the potential for human error and eliminating manual data recording and report writing.

COMPANO 100

- **Basic current measurements:** The COMPANO 100 allows to measure the motor current using a currnt clamp or a shunt. It can record up to 100 results in the FLEX sequencer, allowing to manually trace the current over time.
- **Versatility:** The COMPANO 100 can also be used for many other basic tests like CT/VT ratio, polarity and wiring checks and testing basic protection relays.

CMC 500

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- **Accuracy:** The CMC 500's precision and reliability ensure accurate measurements, minimizing the risk of incorrect settings or faulty operation of the circuit breaker.
- **Troubleshooting:** The CMC 500's user-friendly software makes troubleshooting easier and faster, which is especially beneficial during commissioning or after a fault.

Motion measurement

Area tested

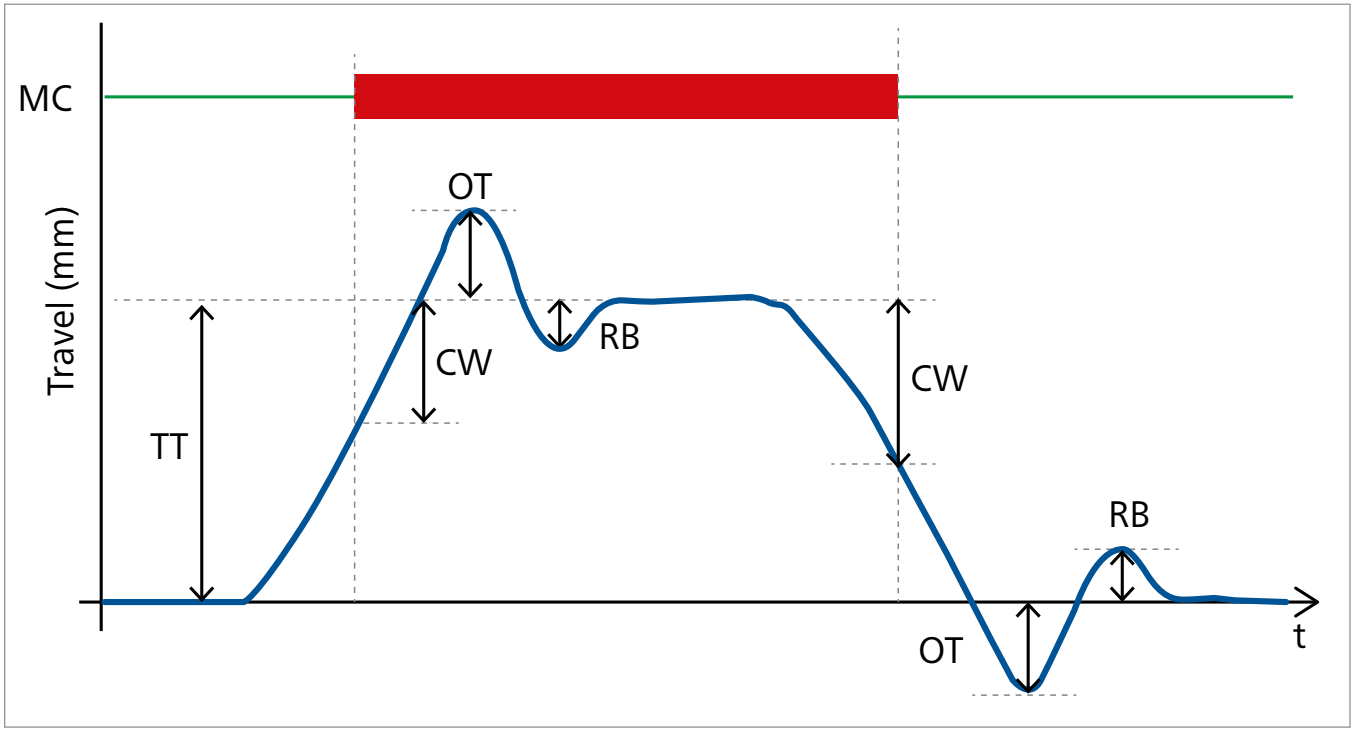
✓ Mechanism

Why measure?

Motion measurements on medium-voltage switchgear, specifically circuit breakers, are vital for assessing their operational condition and ensuring reliable performance. These measurements provide data on the mechanism's performance, including closing and opening times, contact travel, and velocity, ensuring the breaker operates within specified limits. They also help detect early signs of wear and tear, allowing for preventative maintenance to ensure the reliability and longevity of medium-voltage switchgear, minimize the risk of costly outages and optimize the safety of personnel and equipment.

How does it work?

The procedure involves attaching a linear or rotary transducer to the operating mechanism. Ideally, it should be positioned at the same location where the manufacturer places it for factory acceptance tests. If this is not feasible, place it as near as possible to the main contact, ensuring consistent placement for any repeat tests.



Motion measurements check the overall mechanism performance as well as to detect defects of the kinematic chain.

Good to know ..

> The tests are usually done together with timing measurements.

> There is a big selection of motion sensor mounting videos on OMICRON's youtube channel.

Recommended solutions

CIBANO 500

> **High-precision measurements:** The CIBANO 500 offers high accuracy in timing measurements, contact resistance testing, and coil/motor current analysis.

> **Condition Indicators:** It computes various condition indicators for the breaker's motion, including total travel, contact wipe, velocity, and rebound.

> **Combined Measurements:** CIBANO 500 can perform various tests, including timing tests (main and auxiliary contacts, pre-insertion resistors), static and dynamic contact resistance measurements (DRM), coil and motor current analysis, and motion/contact travel analysis.

> **Automated Testing:** The system, combined with the Primary Test Manager (PTM) software, allows for automatic test execution and result evaluation, further boosting efficiency.

Minimum pick-up measurement

Area tested

✓ Control circuit

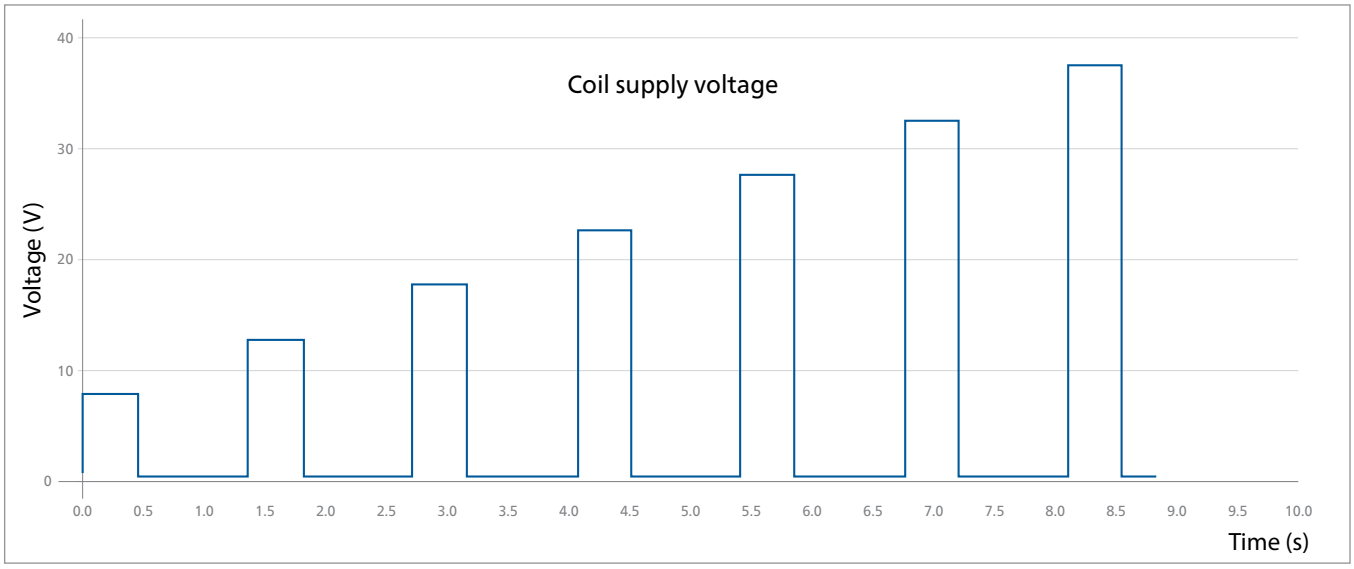
Why measure?

The minimum pick-up voltage test on MV switchgear determines the lowest voltage at which the circuit breaker's trip or close coil reliably activates the latch mechanism and initiates switching. This ensures proper operation even under low voltage conditions and helps prevent equipment damage and safety hazards during faults. By verifying the trip coil's response to minimal voltage, the test confirms the breaker will operate when needed, maintaining system integrity and protecting personnel from arc flash risks. As a preventative measure, it supports the safe and reliable performance of the electrical system.

How does it work?

To perform the test, the supply voltage applied to the circuit breaker coil is gradually increased, while monitoring the current draw. The minimum trip voltage is recorded when the circuit breaker actuates and trips. Repeat the test multiple times to ensure consistency and accuracy of the measured minimum trip voltage.

Keep detailed records of the test results, including the measured minimum trip voltage and any observed discrepancies. For example, a high pick-up voltage can indicate problems with the trip coil, control wiring, or other components, allowing for timely repairs or replacements before a fault occurs.



The coil voltage is consequently ramped up in defined voltage steps. With every further ramp the magnetic field increases until it's enough for the latch to hit the trigger and releases the energy stored in the spring, causing the circuit breaker to open. This procedure is done separately to find out the minimum pick-up voltage required to trip (open) and close the circuit breaker.

Good to know ..

> The test voltage range should be chosen based on the circuit breaker's rated voltage.

> The test procedure may vary slightly depending on the specific standards and regulations applicable to the switchgear.

Recommended solutions

CIBANO 500

> **Efficiency:** By using short, controlled voltage pulses instead of continuous voltage, the CIBANO 500 minimizes the risk of overheating the trip coils during the test, allowing for quicker and more frequent testing without damage.

> **Accuracy:** The CIBANO 500's integrated power supply provides a stable and precise output, ensuring consistent and reliable test results.

> **Comprehensive testing:** The CIBANO 500 allows for a complete assessment of the circuit breaker's performance under various voltage conditions, ensuring reliable operation, even during low DC supply scenarios.

> **Combined test reports:** The CIBANO 500 can combine the results of timing, contact resistance, coil currents, and motion tests into a single, comprehensive report, simplifying analysis and interpretation.

CMC 500

> **Simple minimum pick-up voltage release test:** The Test Universe Ramping module in combination with the real-time measurement and signal recorder EnerLyzer allows to perform minimum pick-up measurements with graphical visualization.

> **Accuracy:** The CMC 500's precision and reliability ensure accurate measurement of the minimum pick-up voltage, reducing the risk of incorrect settings or faulty operation of the circuit breaker.

> **Troubleshooting:** The CMC 500's user-friendly software makes troubleshooting easier and faster, which is especially beneficial during commissioning or after a fault.

Undervoltage release test

Area tested

✓ Control circuit

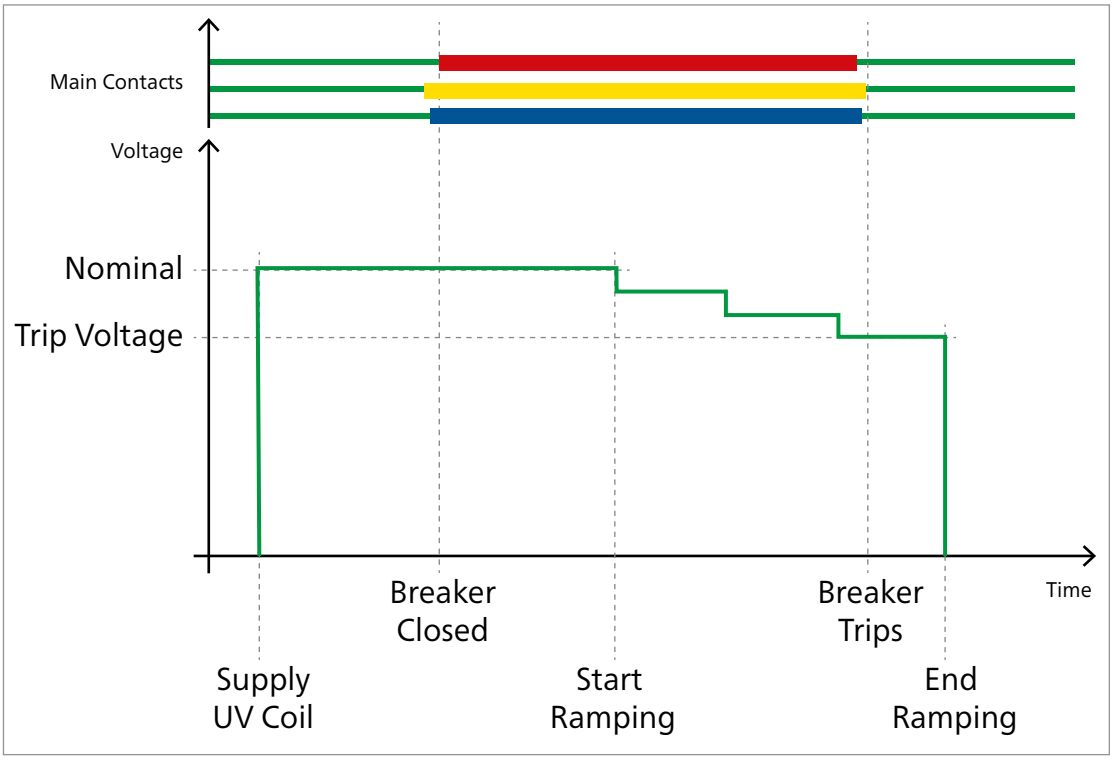
Why measure?

Switchgear that does not have a redundant power supply can be equipped with an undervoltage release system. This system opens the circuit breaker as soon as the supply voltage drops below a defined threshold. The undervoltage release test is performed to determine the voltage level at which the undervoltage coil triggers the circuit breaker to open.

How does it work?

To test the undervoltage coil, a clearly defined sequence of tasks must be performed. Before the test starts, the system must be disconnected from the grid, meaning the switch is de-energized and the contacts are open. Then the test begins by applying the control voltage, closing the switch, and then ramping down the control voltage for the undervoltage coil. This continues until the threshold voltage is reached and the undervoltage coil opens the switch.

Document the trip voltage and any other relevant observations.



Test sequence for UV-Coil testing

Good to know ..

> Due to the complexity of the test process, a guided test is very beneficial. Prevents errors and leads to more efficient test execution.

Recommended solutions

CIBANO 500

> **All-important tests on breakers:** CIBANO 500 combines a micro-ohmmeter, timing analyzer, and a coil and motor supply. All-important CB tests on all types of CBs can be carried out even when a station battery is not available.

> **Powerful integrated supply:** The integrated power supply can output a highly accurate, digitally generated output signal of up to 2.4kW.

CMC 500

> **Simple undervoltage release test:** The Test Universe Ramping module in combination with the real-time measurement and signal recorder EnerLyzer allows to perform undervoltage release tests with graphical visualization.

> **Accuracy:** The CMC 500's precision and reliability ensure accurate undervoltage release tests , minimizing the risk of incorrect settings or faulty operation of the circuit breaker.

> **Troubleshooting:** The CMC 500's user-friendly software makes troubleshooting easier and faster, which is especially beneficial during commissioning or after a fault.

Overcurrent release test

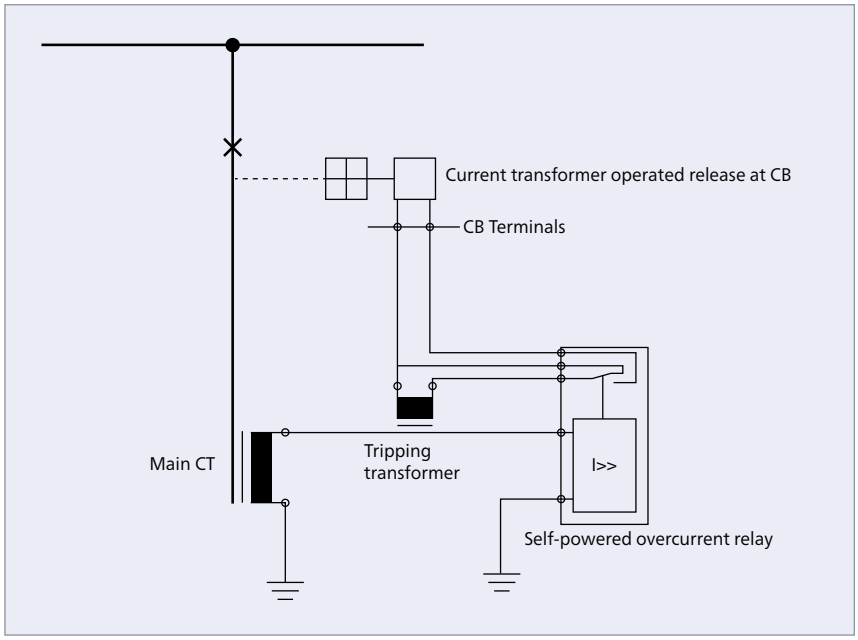
Area tested

✓ Control circuit

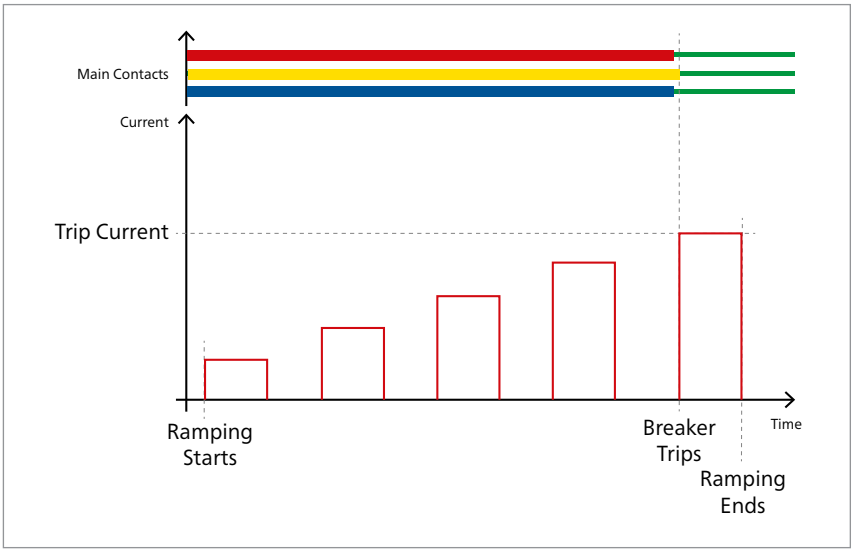
Why measure?

Overcurrent releases are used on breakers in substations where no supply voltage is available. Overcurrent releases are activated by a current coming from the tripping transformer, with a typical nominal value of 0.5, 1.0 or 5 A AC. An overcurrent relay feeds the current flow from the tripping transformer to the breaker. In the event of an overcurrent, the relay switches the current of the tripping transformer to the breaker and thus causes it to open the main contacts and isolate the faulty grid part. Quite often such breakers do not have a close coil.

Some substations do not have a station battery to supply the protection relays or circuit breakers. In such substations, the overcurrent relay and the circuit breaker is supplied via the secondary side of the current transformer. When the current is exceeding a certain current threshold the circuit breaker is tripped by the same CT current.



The purpose of the overcurrent release test is to evaluate at which current level the overcurrent coil releases (trips) the circuit breaker.



How does it work?

The overcurrent release test determines the current level at which a circuit breaker trips. The test provides valuable information about the performance of the overcurrent release of the circuit breaker.

Good to know ..

> The CIBANO 500 Medium Voltage Package includes an guided under-voltage test and an overcurrent release test, during which the test device uses its inbuild supply to output a voltage ramp, or a current pulse ramp, respectively.

Recommended solutions

CIBANO 500

> **All-important tests on breakers:** CIBANO 500 combines a micro-ohmmeter, timing analyzer, and a coil and motor supply. All-important CB tests on all types of CBs can be carried out even when a station battery is not available.

> **Guided workflow:** The user interface Primary Test Manager (PTM) provides a guided workflow for various tests.

> **Testing breakers without a close coil:** For circuit breakers without a close coil and as a result the time calculation according to IEC standard cannot be applied, CIBANO 500 can use the motion/ contact travel as measurement start reference.

CMC 500

> **Simple overcurrent release test:** The Test Universe Ramping module in combination with the real-time measurement and signal recorder EnerLyzer allows to perform overcurrent release tests with graphical visualization.

> **Accuracy:** The CMC 500's precision and reliability ensure accurate measurements and minimizing the risk of incorrect settings or faulty operation of the circuit breaker.

> **Troubleshooting:** The CMC 500's user-friendly software makes troubleshooting easier and faster, which is especially beneficial during commissioning or after a fault.

Delay time measurement

Area tested

✓ Control circuit

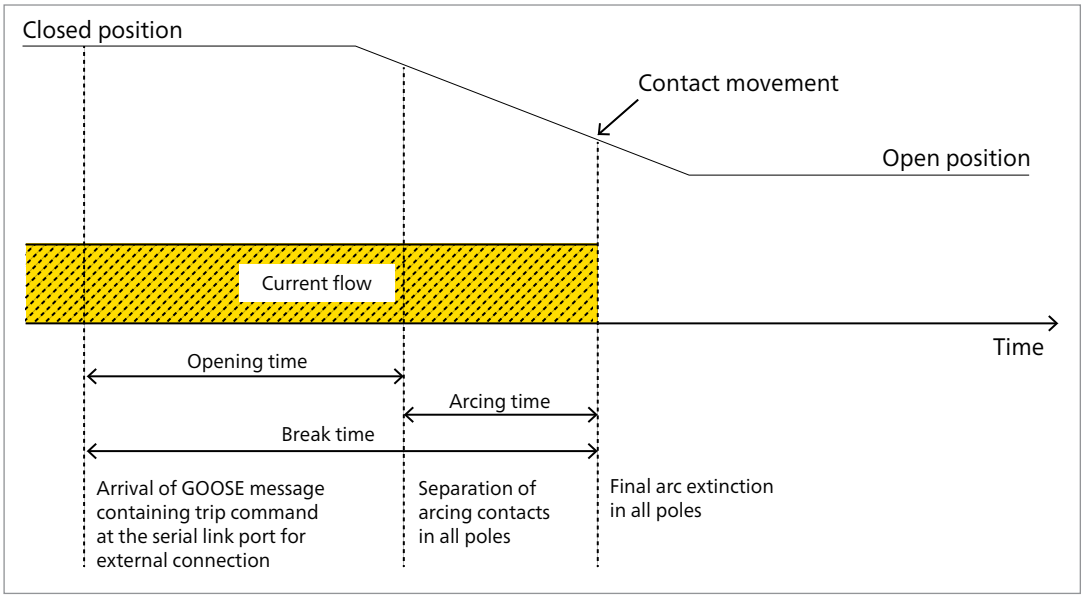
Why measure?

Modern substations use digital communication links between assets. These digital interfaces are used to exchange measurement data and control commands between different devices and with the control center. During commissioning, it is essential to verify the correct configuration and installation.

How does it work?

Delay time evaluations are performed during both the commissioning and troubleshooting phases. The procedure includes activating a breaker using IEC 61850 and recording the duration from activation to separation of the primary circuit.

Evaluate the recorded time delays and compare them with the manufacturer's specifications or the intended coordination plan. Record the measurement outcomes, highlighting any discrepancies from the anticipated values or any identified problems.



Opening operation of an intelligent switchgear, the opening time shall be the time from the reception of the first message containing the trip command via the interface according to the IEC 61850 series (GOOSE message according to 5.2.3), the circuit breaker being in the closed position, to the instant when the arcing contacts have separated in all poles.

Good to know ..

> Consider testing already during the design phase of the smart substation and provide related testing ports on your network switches.

Recommended solutions

CMC 500

> **Delay time measurement:** The IEC 61850 features of the CMC 500 in combination with the real-time measurement and signal recorder EnerLyzer allows to perform syncronized delay time mesurements of analog/binary signals with IEC 61850 GOOSE and Sampled Values with graphical visualization.

> **Accuracy:** The CMC 500's precision and reliability ensure accurate delay time measurements, minimizing the risk of incorrect settings or faulty operation of the circuit breaker.

> **Troubleshooting:** The CMC 500's user-friendly software makes troubleshooting easier and faster, which is especially beneficial during commissioning or after a fault.

Partial discharge measurement

Area tested

✓ Primary circuit

Why measure?

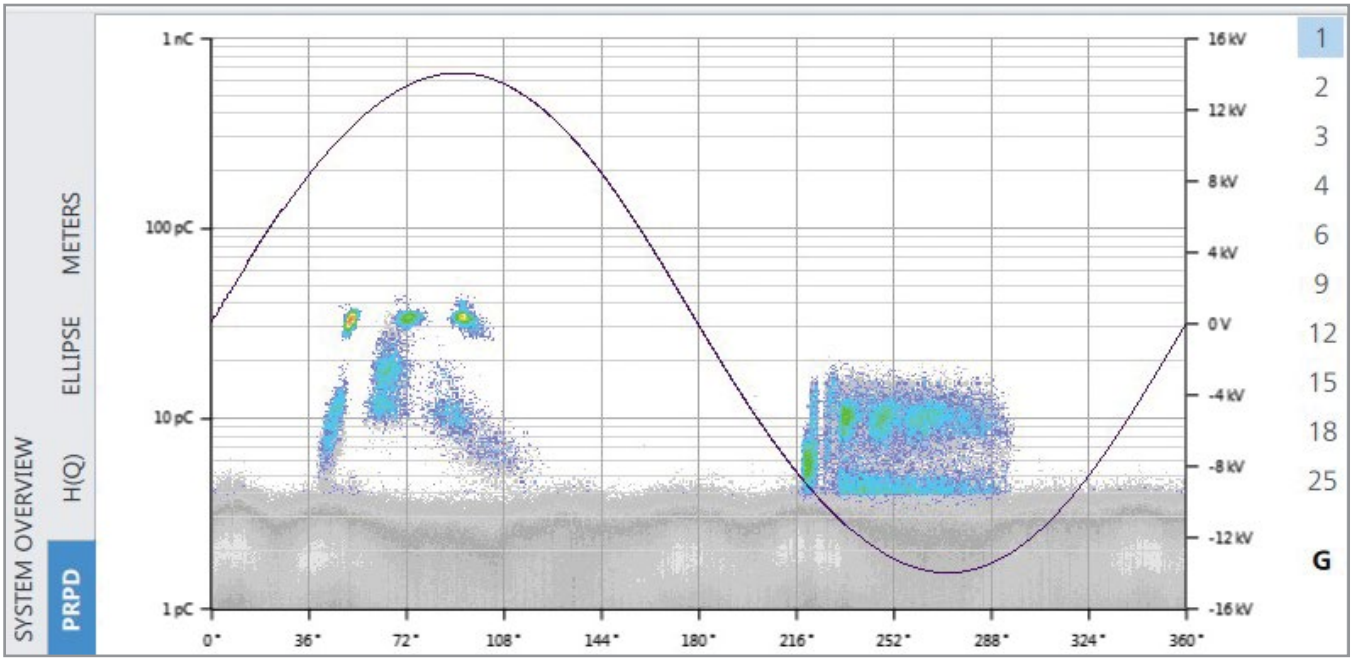
Partial discharge (PD) refers to electrical discharges that occur within an insulation system, often at defects or voids, without completely bridging the gap between conductors. PD measurement on MV switchgear is a crucial diagnostic tool for assessing the condition of insulation systems and identifying potential failures. PD testing helps detect and locate weak spots in the insulation, which can lead to premature equipment failure and costly downtime.

By detecting PD activity, maintenance plans can be adjusted to proactively address potential issues before they escalate and lead to a full breakdown.

How does it work?

PD measurements can be performed both offline and online. Offline PD measurements involve applying a controlled test voltage to the equipment while it's disconnected from the grid and then measuring the resulting PD signals. Online PD measurements do not require the tested asset to be taken out of service and are often performed with permanently installed PD sensors and do not required an additional test voltage source.

PD measurement on switchgear involves detecting and quantifying the electrical discharges occurring within the insulation system of the switchgear using one of the following methods:



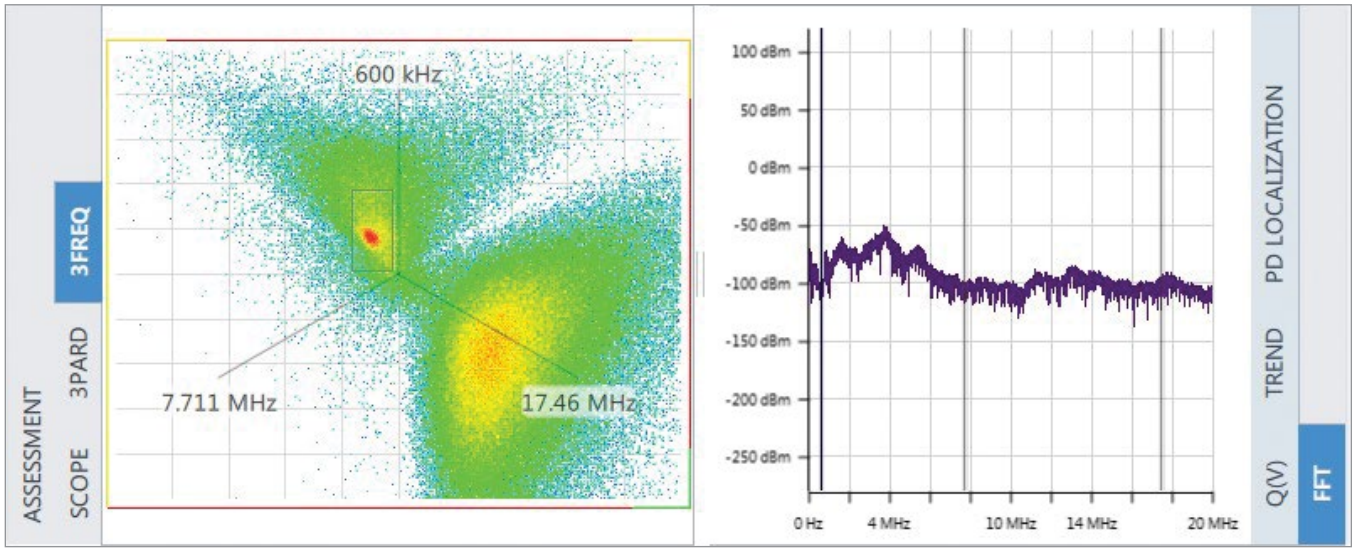
How to suppress noise and separate partial discharge sources – The 3FREQ (3-center frequencies relation diagram) is a one-channel filtering tool using three digital filter frequencies for PD analysis. The PRPD diagram shows filtered out pulses while greying out the residual pulses in the background to improve the testing reliability.

1. **Measurement according to IEC 60270:** To perform a PD measurement in line with IEC 60270 at an MV substation, a typical setup involves using a coupling capacitor. This capacitor is generally connected via a test cable to the substation's cable termination. The measurement is conducted offline, with the test voltage supplied by an external source brought to the site. These measurements are typically carried out during commissioning and are valued for their comparability to factory measurements. However, it's important to consider challenges such as noise and the overall effort required.

2. **Voltage Detection System (VDS) detection:** VDS detection is used often in MV switchgear to verify the absence of voltage and ensure safety. The VDS system is connected to the bushings of a switchgear and form a capacitive divider, which transfer the applied voltage to the connection terminals. These capacitances to grid voltage can be also used often as a rudimentary coupling capacitor and to enable PD detection. The use of VDS in PD measurement provides a non-destructive method to access the system in a time-effective manner which can be done also in online conditions.

3. **Cable termination detection:** HFCTs (High-frequency current transformers) are typically connected to the ground straps or earth connections of MV cables within switchgear. The HFCTs can be clamped around the cable's grounding braid or, when cable ends are inaccessible, around the cable's over-sheath. The HFCT then detects the high-frequency current pulses generated by partial discharges in the cable termination, allowing for PD detection without having to directly access the high-voltage conductors.

High-Frequency Current Transformer (HFCT)



3FREQ characterizes PD sources by their frequency signature. You can easily separate PD events from disturbances. The high resolution FFT (right) shows all disturbances and allows you to place the filters selectively.

Partial discharge measurement

TEV1 sensor

4. **Transient Earth Voltage (TEV) detection:** TEV sensors are typically placed on the outside of the equipment on the metal enclosure. They measure the high-frequency electromagnetic pulses generated by PD which leads to transient earth voltages (TEV) on grounded parts of the switchgear. Even though this method is not as reproducible as or comparable to standard-compliant PD measurements for spotting a potential defect, it is sometimes more efficient to detect potential internal PD with minimal effort while the switchgear is online. It helps to assess whether detailed diagnostic PD measurements are required for further investigation.

The collected data from the sensors or coupling capacitors is analyzed to identify patterns and trends in PD activity. This analysis can help to pinpoint the location and severity of the PD source. Thresholds are set to trigger alarms when PD activity exceeds acceptable levels. The data can also be used to observe the overall health of the GIS equipment and predict potential failures.

The results are compared with established standards and historical data to determine if PD levels are within acceptable limits. Any detected PD activity is evaluated to determine if it indicates potential insulation issues or defects. If PD levels are excessive, further investigation is needed to identify the cause and take corrective action, which may include repairs, replacements, or improved maintenance practices.

By detecting PD activity, maintenance plans can be adjusted to proactively address potential issues before they escalate and lead to a full breakdown.

Good to know ..

- While less common, PD measurement can also be used in MV switchgear to assess insulation quality and identify potential issues.
- Expert knowledge and specialized equipment are often required for accurate and reliable PD measurements.

Recommended solutions

MPD 800

- **High sensitivity:** The MPD 800 is designed for highly sensitive PD measurements, which is crucial because PD signals can be weak and easily masked by noise.
- **Industry standard compliance:** The MPD 800 adheres to the IEC 60270 standard for PD measurement, ensuring reliable detection of PD activity in MV switchgear.
- **Noise filtering:** It offers a broad adjustable PD frequency range and adjustable measurement bandwidths, allowing for effective noise filtering in environments with high interference.
- **Accurate detection and localization:** The system accurately detects and locates insulation defects in switchgear, enabling users to assess the risk of failure and plan maintenance based on the condition of the insulation.
- **Advanced analysis tools:** It provides advanced graphical tools, such as 3PARD (3-Phase Amplitude Relation Diagram), to differentiate between multiple PD sources for more precise fault detection.

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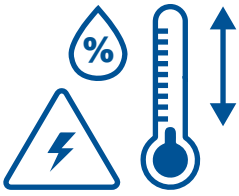

100%

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... a product portfolio tailored to my needs

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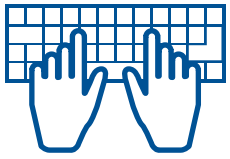

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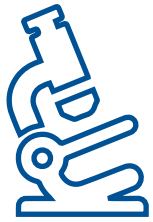

Save up to

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testing time through templates and automation

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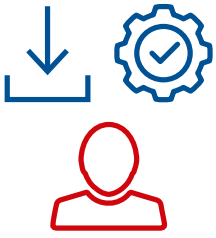
Professional technical support at any time



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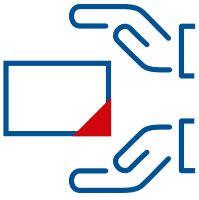

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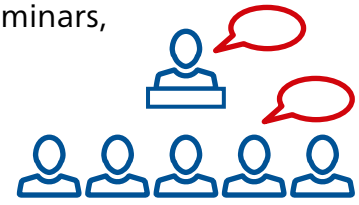
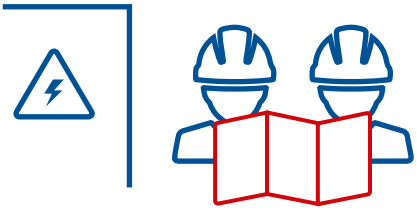


to thousands of technical papers and application notes



Extensive expertise in consulting, testing and diagnostics

OMICRON is an international company that works passionately on ideas for making electric power systems safe, secure, and reliable. Our pioneering solutions are designed to meet our industry's current and future challenges. We always go the extra mile to empower our customers: we react to their needs, provide extraordinary local support, and share our expertise.

Within the OMICRON group, we research and develop innovative technologies for all fields in electric power systems. Customers worldwide rely on the accuracy, speed, and quality of our reliable, user-friendly solutions for electrical testing of medium- and high-voltage equipment, protection systems, digital substations, and cybersecurity.

Founded in 1984, OMICRON draws on their decades of profound expertise in the field of electric power engineering. A dedicated team of more than 1,300 employees provides solutions with 24/7 support at 23 locations worldwide and serves customers in more than 170 countries.

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