



Circuit Breaker Testing Guide



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About This Guide

Circuit breaker testing confirms that a breaker opens and closes on command, fast enough, with its poles together. An analyser times each pole from the coil command to the contact change, records contact travel and coil current, and repeats the operations at reduced control voltage. This guide covers what to measure, how to connect safely and how to judge the result.

What the Test Is

A set of timed operations on a de-energised breaker: open, close, close-open and reclose, with contact travel, coil current and supply voltage recorded on every operation. The instrument is a circuit breaker analyser.

When It Is Used

At the factory and at commissioning to set the baseline, at routine maintenance, after work on the mechanism, and after a slow operation or heavy fault duty.

Why It Matters

In the Cigré survey summarised by Megger, the operating mechanism and the control and auxiliary circuits caused 74% of major breaker failures (2004 to 2005). Those are the parts a timing test examines. A contact resistance test does not.

Guide at a Glance

Measures

Opening, closing and reclose times, pole spread, contact travel and velocity, coil and motor current.

Method

One timing channel per pole, coil commands from the analyser, a travel transducer on the mechanism.

Operations

O, C, CO and O-CO, at rated and at reduced control voltage.

Standard Limit

Pole spread 1/6 cycle opening, 1/4 cycle closing (AS/NZS 62271.100:2026, 6.101).

Judged Against

Manufacturer's values, the factory routine record and the breaker's own history.



Need the test done, or the analyser to do it? Megavar tests circuit breakers across Australia and hires every analyser in this guide.

Why Measure Circuit Breaker Timing?

Circuit Breaker Testing in Four Numbers

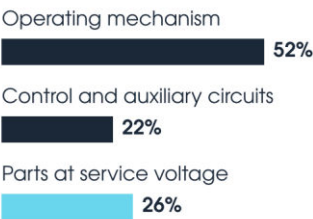
1/6 cycle Maximum pole spread on opening, 3.3 ms at 50 Hz (AS/NZS 62271.100, 6.101)	1/4 cycle Maximum pole spread on closing, 5 ms at 50 Hz (AS/NZS 62271.100, 6.101)	70% Lowest DC supply at which a shunt opening release operates (AS 62271.1, 6.9.3)	±5% Travel envelope about the reference curve, of stroke (AS/NZS 62271.100, Annex G)
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Why Timing Matters

- One Chance to Operate**
A breaker may sit closed for months, then has to clear a fault in a few tens of milliseconds. The protection settings assume it will.
- Most Failures Are Mechanical**
Dried grease, worn latches, tired springs and failing coils slow a breaker long before it fails to operate. Timing and travel show the slowdown.
- Poles Must Move Together**
AS/NZS 62271.100:2026, 6.101, limits the spread between poles to 1/6 cycle on opening and 1/4 cycle on closing.

Where Failures Start

Major failures by originating component



Navy: the parts a timing test examines
Source: Cigré survey 2004 to 2005, as summarised by Megger, 2012

The operating mechanism and the control circuits caused about three quarters of major failures.

When to Test



Where Is It Used?

Breakers Tested

Breaker	What timing and travel find	Points to note
Live-tank SF6 (HV)	Slow mechanism, pole spread, spread between units in one pole	Time each interrupter unit; 1/8 cycle within a pole on opening (6.101)
Dead-tank SF6 (HV)	Slow mechanism, worn damper, pre-insertion resistor timing	Linear transducer is usual (Megger)
Vacuum (MV switchboards)	Slow mechanism, contact bounce on closing	The maker defines the travel check (Annex G)
Bulk and minimum oil	Dashpot wear, friction in the linkage	Travel and coil current are key (Megger)
Independent pole operated	Pole discrepancy, one slow pole mechanism	Coil current on each pole; check pole discrepancy
Reclosers	Reclose sequence and dead times	Covered by IEC 62271-111, not AS/NZS 62271.100

Choosing the Tests

AS/NZS 62271.100:2026

At commissioning, time each pole on O, C and the O and C within a CO, record pole spread, test every trip coil and record the supply voltage (11.3.102.2.5.1).

IEEE C37.09-2018

Five closes and five opens at minimum and at maximum control voltage (5.11). Opening times shall be recorded for all breakers (5.12). Clause 7 lists timing and travel tests after erection.

AS 62271.1:2019

Closing releases operate from 85% to 110% of rated supply, opening releases from 70% (DC) or 85% (AC) to 110% (6.9.2, 6.9.3).

Our Recommendation

Time O, C, CO and the nameplate operating sequence at rated supply, then repeat O and C at the minimum release voltage. The maker's programme governs.

Which Operations to Time

O and C

Opening and closing time of every pole, and the spread between poles.

CO (Close-Open)

Close then trip at once: CO timing. Verify trip-free and anti-pumping separately to the maker's sequence (6.4).

O-CO (Reclose)

First reclose of the rated sequence O - t - CO - t' - CO, with t = 0.3 s for rapid auto-reclosing (5.104).

Good to Know

Record the control voltage at the coil on every operation. Timing changes with supply voltage, so results at different voltages cannot be compared.

How Does It Work?

How a Timing Test Works

The Clock

The analyser energises the trip or close coil and starts its clock. Each main contact channel stops at the instant its contact parts or touches.

What Counts

Opening time runs to separation of the arcing contacts in all poles; closing time to contact touch in all poles (AS/NZS 62271.100, 3.7.131, 3.7.134).

Beyond the Clock

The same operation records coil current, auxiliary contacts and, with a transducer, travel and velocity.

Connection Rules

One Channel per Contact

Each pole, or each interrupter unit, gets its own channel so the spread can be read.

Coils From the Analyser

Open the station supply links first, then land the trip, close and common leads (OMICRON).

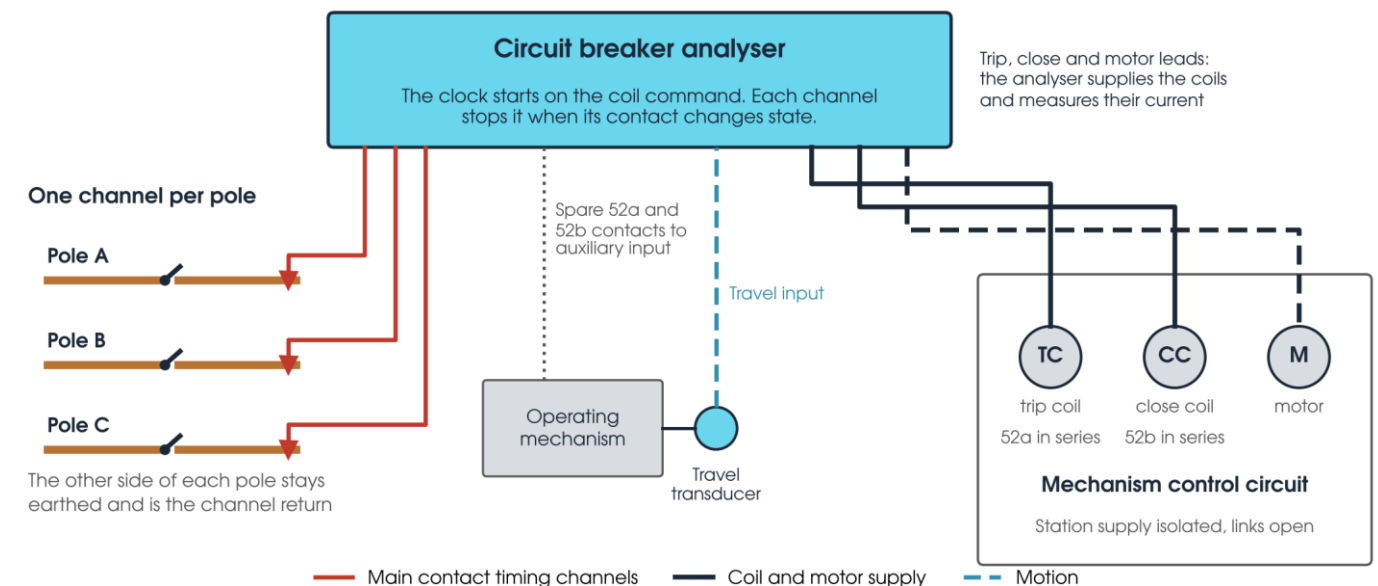
Transducer on the Maker's Point

Mount it where the factory test did, or as near the moving contact as possible, and in the same place every time.

Good to Know

Static contact resistance is a separate test, covered in Megavar's ductor testing guide.

Connection Arrangement



One timing channel per pole, the coils driven from the analyser, and a travel transducer on the mechanism.

How Do I Set Up Safely?

Permits, Isolation and Earthing

1 Access Permit

Confirm the permit covers the test, including any operation of the breaker and any temporary removal of earths by the person the asset owner authorises.

2 Isolated, Proved Dead, Earthed

Confirm it at the plant with the permit issuer before connecting anything.

3 Barricades and Signage

The breaker will operate during the test. Keep everyone clear of the poles, linkages and mechanism.

4 Earth the Test Set First

Connect the analyser to the station earth before any other lead, and remove it last.

Who Should Test

Competent, authorised testing personnel under the asset owner's safety rules.

Induced Voltage and Stored Energy

One Side Earthed

The open breaker leaves one side unearthed, where coupled current from nearby live plant can reach harmful levels (Megger). Keep the earth on the side with the greatest induction risk (Doble).

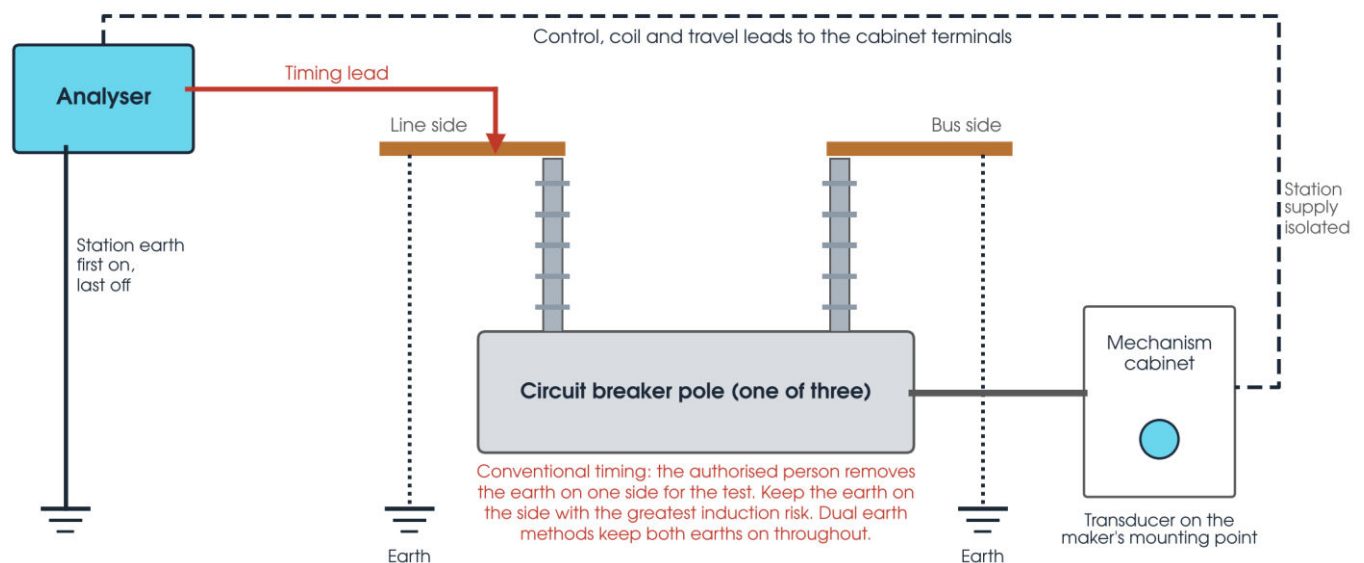
Both Sides Earthed

Dual earth timing methods keep both earths on, such as Megger DualGround, Doble's dual ground option and OMICRON's CIBANO 500 with CB MC2 modules.

Stored Energy and Live Control Panels

The mechanism is charged and can operate without warning. First trip tests are wired to a live control panel on an in-service breaker (USBR FIST 3-16).

Set-Up on an Outdoor Breaker



Analysers earthed first, timing lead on the pole terminal, control and travel leads in the mechanism cabinet with the station supply isolated.

Important

This guide describes general practice for competent HV testing personnel. It is not a work procedure. Work under the asset owner's safety rules, the access permit and a site-specific safe work method statement. Manufacturer and asset owner criteria take precedence over the general guidance here.

How Do I Make the Measurement?

Seven Steps



Steps 1 to 4

1 Plan and Record Data

Nameplate, rated control voltage, the maker's timing and travel limits, and the last results.

2 Isolate Control Supply

Open the trip, close and motor supply links before landing any lead (OMICRON).

3 Connect Channels

One timing channel per pole or unit, the coil leads, a spare auxiliary contact, and supply voltage monitoring.

4 Mount the Transducer

On the maker's mounting point, with the conversion factor from the maker.

Steps 5 to 7

5 Time O, C, CO and O-CO

Record the first operation as found, before any exercising, then the full set at rated supply.

6 Minimum Voltage Tests

Repeat O and C at the minimum release voltage, then find the pick-up voltage of each coil.

7 Restore

Leave the breaker in the state the permit requires, remove the leads, close the supply links, test set earth last.

Good to Know

Use a test supply that delivers full coil current without sagging (EPRI).

Common Mistakes

Exercising Before the First Test

The slow first operation is lost (USBR FIST 3-16).

Supply Voltage Not Recorded

Timing and coil current cannot be compared with the next test.

Loose Clamps

Vibration lifts a clamp and shows false bounces (Megger).

Transducer Moved

Travel and velocity no longer compare with earlier records.

More Common Mistakes

Low Sampling Rate

Bounce is missed. Megger recommends at least 10 kHz for timing.

Coil Held On Too Long

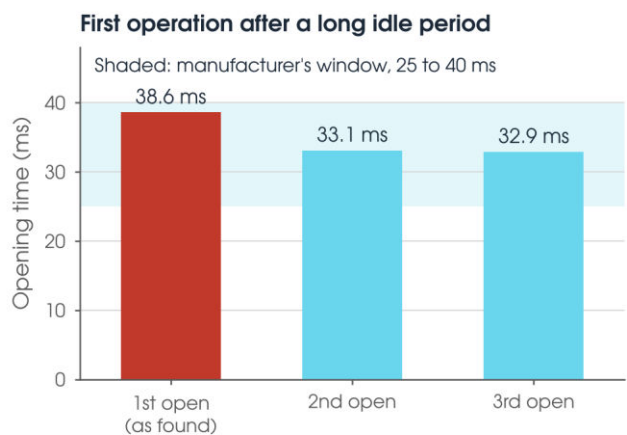
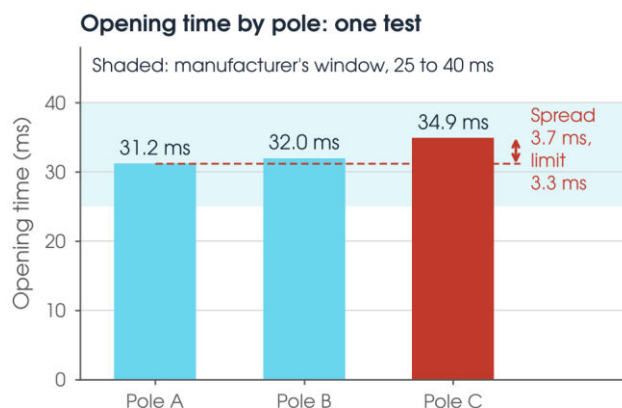
Long pulses overheat coils during pick-up tests (OMICRON).

Bypassing Control Devices

The control scheme is not tested as it works in service (OMICRON).

How Do I Read the Result?

Pole Spread, and the First Operation



Every pole is inside the maker's window, but the spread fails 6.101. The first operation after a long idle period is slow but inside the window. Both warrant action.

Comparing the Result

Manufacturer's Limits

Times, velocity and travel come from the maker (6.105), and the factory routine test records them on every breaker (8.101). IEEE C37.09 gives no timing limits.

Pole Spread

1/6 cycle opening, 1/4 cycle closing (6.101). USBR FIST 3-16 uses 2 ms between phases for most breakers.

Travel Curve

Use the maker's travel criteria. The Annex G envelope ($\pm 5\%$ of stroke, ± 2 mm to 40 mm) is the production check; vacuum breakers use the maker's method.

Trend

Where the maker gives no limit, trend it. There should be very little change over time (USBR FIST 3-16).

What a Bad Result Looks Like

Slow Opening and Closing

Friction through the whole mechanism, such as corrosion in the linkage (Megger).

Closing Slow, Opening Normal

Closing system or latch binding (Megger).

First Operation Slow, Then Normal

Dried or stiff lubricant (USBR FIST 3-16).

One Pole Late

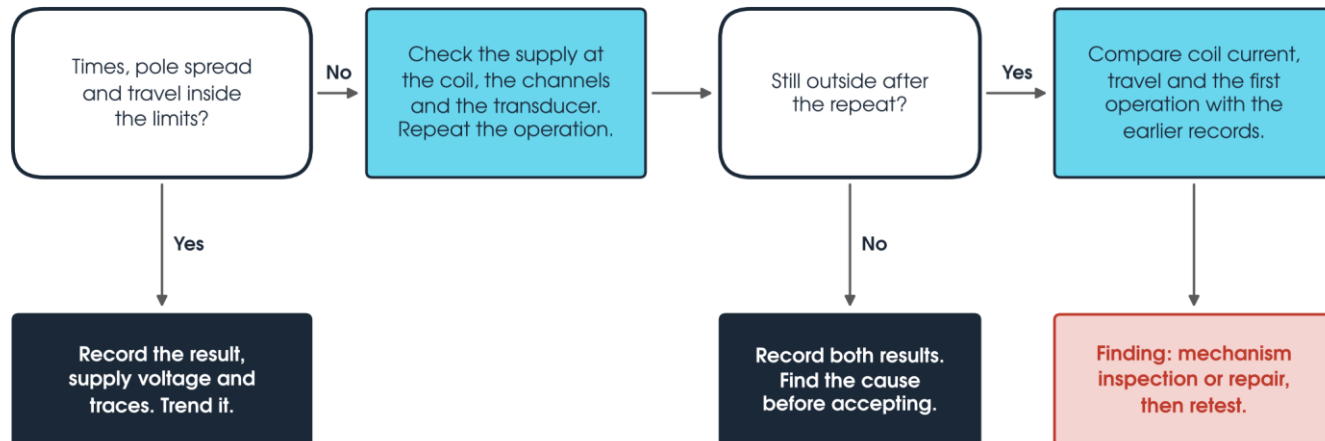
Independent pole: that pole's mechanism. Ganged: the linkage to that pole.

Bounce or Large Rebound

Damper wear; rebound brings a risk of restrike (USBR FIST 3-16).

Is My Result OK?

Decision Path



Pole Spread Limit

AS/NZS 62271.100:2026, 6.101, states the limit as a fraction of a cycle at rated frequency:

$$\text{Limit (ms)} = \text{fraction} \times 1,000 / f$$

At 50 Hz one cycle is 20 ms, so 1/6 cycle is 3.3 ms on opening and 1/4 cycle is 5.0 ms on closing.

Worked Example

Opening times of 31.2, 32.0 and 34.9 ms are each inside a 25 to 40 ms window, but the spread is $34.9 - 31.2 = 3.7$ ms. That exceeds 3.3 ms, so it is a finding.

What to Report

For Each Operation

Opening and closing time of each pole, pole spread, travel, velocity, and the coil current trace.

The Conditions

Supply voltage at the coil, mechanism pressure, temperature, and whether it was the first operation.

The Criteria Used

The maker's limits, the 6.101 spread limits and the earlier results compared.

Traceability

Analyser model, serial number and calibration date, transducer position and conversion factor.

What About Travel and Coil Analysis?

Travel and Velocity

What Travel Shows

Total travel, overtravel, rebound and contact wipe, from a transducer on the mechanism (OMICRON).

Velocity

Calculated between two points the maker defines, usually through the arcing zone. Too slow and the arc may not clear; too fast and the breaker can be damaged (USBR FIST 3-16).

Envelope

Production units stay within the 10% band about the reference curve (Annex G).

Coil, Voltage and Motor

Coil Current Signature

Shows armature movement, latch release and the auxiliary contact opening. Compare its shape with earlier traces (OMICRON).

Minimum Pick-Up

Step the coil voltage up, about 5 V at a time, until the breaker operates. Most healthy coils operate below 50% of rated voltage, as OMICRON observes; not an official limit.

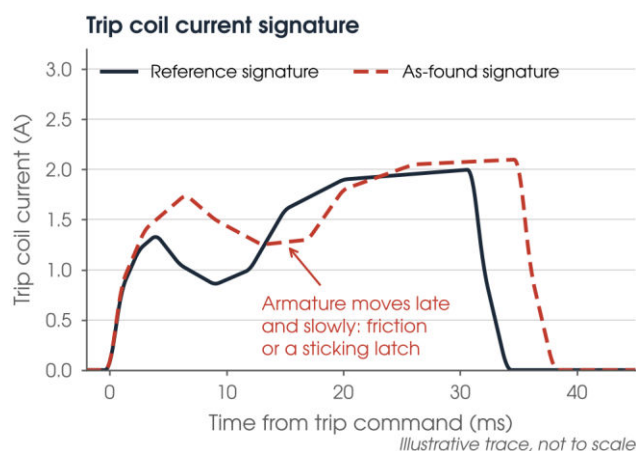
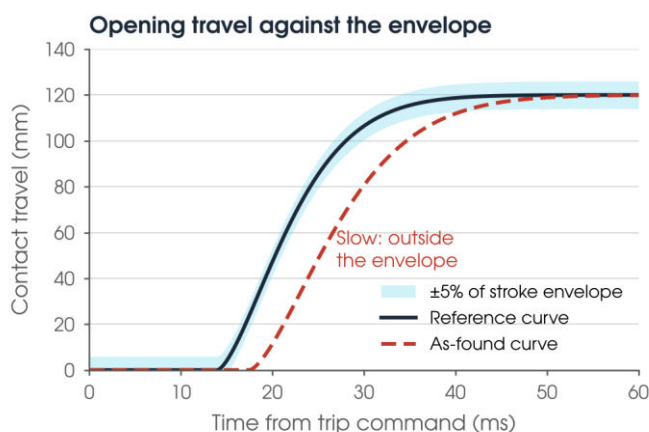
Motor and DRM

Time the spring recharge after a close (11.3.102.2.5.2). Dynamic resistance (DRM) needs an analyser and high DC current.

Good to Know

IEEE C37.100.1-2018, 5.9.2, notes its closing voltage ranges apply to coils when cold. A hot coil can need more.

What Travel and Coil Traces Show



Recommended Solutions

Instrument	Type	Best used for
OMICRON CIBANO 500	Breaker analyser	Timing, travel, coil and motor current, minimum pick-up; supplies the coils; tests with grounded terminals
Megger TM1600	Timing analyser	Opening, closing, bounce and reclose times; motion and coil current with optional modules
OMICRON CPX 200	Multifunction set	Timing of MV breakers using its 125 V DC battery emulation for the coils
NOJA Power OSM-27 Test Box	Recloser interface	Trip and close simulation and trip timing on NOJA OSM reclosers, through the RC control cubicle

Every instrument is available calibrated, with leads, from Hobart, Launceston, Adelaide and Newcastle: [circuit breaker test equipment hire](#).

Frequently Asked Questions

Common Questions

How do I test an electrical circuit breaker?

Isolate and earth it under a permit, connect an analyser, then time open, close, close-open and reclose operations at rated and minimum control voltage.

What is the IEC standard used for circuit breaker testing?

IEC 62271-100, adopted in Australia as AS/NZS 62271.100:2026, read with AS 62271.1:2019.

What is the CRM test in VCB?

Contact resistance measurement on a vacuum circuit breaker: a static micro-ohm test of the closed contacts, separate from timing.

What pole spread is acceptable?

1/6 cycle on opening and 1/4 cycle on closing (6.101), or the maker's tighter value.

Standards and References

AS/NZS 62271.100:2026, AC circuit-breakers: 3.7, 5.104, 6.101, 6.105, 8.101, 11.3.102, Annex G.

AS 62271.1:2019, Common specifications: 6.9.2, 6.9.3.

IEEE Std C37.09-2018, Test Procedures for AC High-Voltage Circuit Breakers: 5.11, 5.12, Clause 7.

IEEE Std C37.100.1-2018, Common Requirements for High Voltage Power Switchgear: 5.9.2.

Megger, Circuit Breaker Testing Guide, 2012.

OMICRON, A Systematic Approach to HV Circuit Breaker Testing, 2016; Diagnostic Testing and Monitoring on HV Switchgear, 2026; PTM and CIBANO 500 application note, 2020.

EPRI, TR-112783, Circuit Breaker Timing and Travel Analysis, 1999.

US Bureau of Reclamation, FIST 3-16, Maintenance of Power Circuit Breakers, 2020.

Doble, Safely Testing Circuit Breakers Using a Dual Ground Method, 2024.

More Questions

Why test at minimum voltage?

To prove the breaker trips and closes on a depleted battery: 70% (DC) for opening, 85% for closing (AS 62271.1, 6.9).

What is a first trip test?

Timing the first trip of a breaker that has been in service, using clamps on the trip coil and CT secondary circuits.

Can I time a breaker with both sides earthed?

Yes, with an analyser that has a dual earth method.

Does Megavar test as well as hire?

Yes. Our engineers test circuit breakers across Australia. Call 1300 730 499.

Hire or Have It Tested

Have It Tested

Megavar's engineers carry out [circuit breaker testing](#), [substation maintenance](#) and [substation commissioning](#) across Australia.

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