



Ductor Testing Guide



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POWER

About This Guide

Ductor testing measures the resistance of circuit breaker contacts, busbar joints, cable lugs and earth bonds in micro-ohms. A known DC current is passed through the item and the voltage across it is measured with a separate pair of leads. This guide sets out the test current to use, how to connect the instrument, the safety framework around the test and how to judge a result.

What a Ductor Test Is

A four-wire micro-ohm measurement of a contact, joint or bond. Also called a contact resistance, low resistance or DLRO test. The instrument is a micro-ohmmeter, often called a ductor tester.

When It Is Used

At commissioning to set a baseline, in routine maintenance, after work on contacts or joints, and after events such as heavy fault interruption.

Why It Matters

Heat in a connection rises with the square of the current. A joint that degrades from 20 to 200 $\mu\Omega$ at 2,000 A goes from 80 W to 800 W, concentrated in a few square centimetres. Insulation tests do not find it; a ductor test does, before the plant is energised.

Guide at a Glance

Measures

Resistance from a fraction of a micro-ohm to a few ohms.

Method

Four-wire (Kelvin), DC, forward and reverse.

Test Current

Typically 100 A DC for circuit breakers; up to 10 A for small joints and bonds.

Typical Result

10 to 100 $\mu\Omega$ for HV switchgear main contacts (OMICRON).

Judged Against

Manufacturer's limit, asset owner criterion, other poles and the item's own history.

Need the test done, or the instrument to do it? Megavar tests HV plant across Australia and hires every instrument in this guide.



Why Measure Contact Resistance?

Ductor Testing in Four Numbers

100 A

Production test minimum
for breaker contacts
(IEEE C37.09, clause 5.14)

10 to 100 $\mu\Omega$

Typical HV switchgear
main contact resistance
(OMICRON)

50%

Pole deviation that
warrants investigation
(NETA, per Schneider)

234.5

Copper constant for
temperature correction
(IEEE C57.12.90, clause 5.2)

Why a Few Micro-Ohms Matter

Heat Follows Resistance

Power lost in a connection is $P = I^2R$. At 2,000 A, a healthy 20 $\mu\Omega$ joint dissipates 80 W; at 200 $\mu\Omega$ it dissipates 800 W.

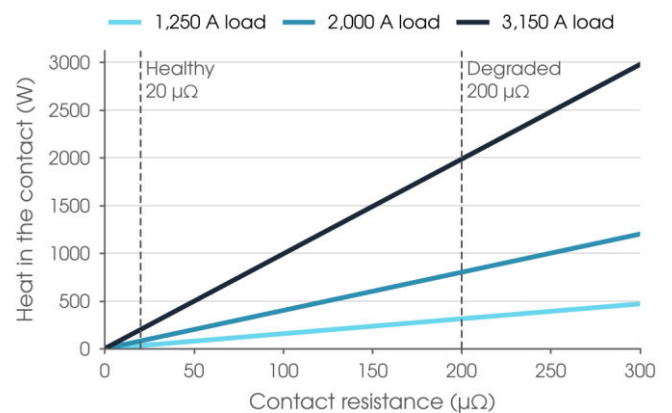
A Self-Feeding Cycle

Heat accelerates oxidation, oxidation raises resistance and higher resistance produces more heat. Left alone, it ends in a failed joint or contact.

Why Other Tests Miss It

Insulation resistance does not see it, and thermal imaging only sees it under load. A ductor test finds it on de-energised plant.

Heat in a Contact



Illustrative values from $P = I^2R$ at three load currents. Ten times the resistance is ten times the heat.

When to Test



Where Is It Used?

Items Tested

Item	What a high reading points to	Test current
Circuit breaker main contacts	Pitting, erosion, low contact pressure, misalignment or contamination	100 A or more
Disconnectors and earth switches	Blade misalignment, corroded jaws, weak contact springs	100 A or more
Busbar, switchboard and GIS joints	Loose, over-tightened or contaminated joints	10 A on small joints; 100 A or more on main busbars
Cable lugs, crimps and joints	Under-crimped lug, wrong die, strands not fully inserted	10 A to 100 A
Earth bonds	Loose or corroded bonds, failed exothermic welds	Up to 10 A
Battery intercell connectors	Loose or corroded links, measured on a live battery	To the instrument maker's method

Choosing the Test Current

AS 62271.1:2019

DC at any convenient value from 50 A up to the rated continuous current, or at rated current where that is 50 A or less (clause 7.4.4.1). AS/NZS 62271.100:2026 calls it up for circuit breakers.

IEEE C37.09-2018

At least 100 A DC, with the result not to exceed the manufacturer's limit (clause 5.14).

US Bureau of Reclamation FIST 3-16

Minimum 100 A for breaker contact resistance (2020).

Our Recommendation

Use 100 A DC on circuit breakers where the equipment and method allow, within the standard's range and the manufacturer's instructions. Use 10 A or less on small joints, bonds and conductors. Resolve any conflict between the owner's specification and the standards before testing.

Higher or Lower Current

Why Not Lower

Oxide or contamination films can make a low-current reading high and unstable. Higher current is closer to service conditions and gives a steadier result.

Can High Current Hide a Problem

Yes. High current can break through contamination and give a good number on an unhealthy contact. If a 10 A reading is markedly higher than a 100 A reading, treat the difference as a finding.

Good to Know

Record the test current with every result.

Repeat future tests at the same current for reliable trending, and record any change.

How Does It Work?

Why a Four-Wire Measurement

How It Works

One pair of leads drives the test current and a second pair measures the voltage. The voltage leads carry almost no current, so lead and clamp resistance drops out of the result.

Why Two-Wire Fails

A two-wire meter measures its own leads and clamps, which are in milliohms and can be a hundred times a healthy $30\ \mu\Omega$ contact.

Transformer Windings

Winding resistance uses the same four-wire principle, but the winding is highly inductive and needs its own method and instrument settings.

Clamp Rules

Current Clamps Outside

C1 and C2 go furthest from the item under test.

Potential Clamps Inside

P1 and P2 sit between the current clamps and the item, so only the intended path is measured.

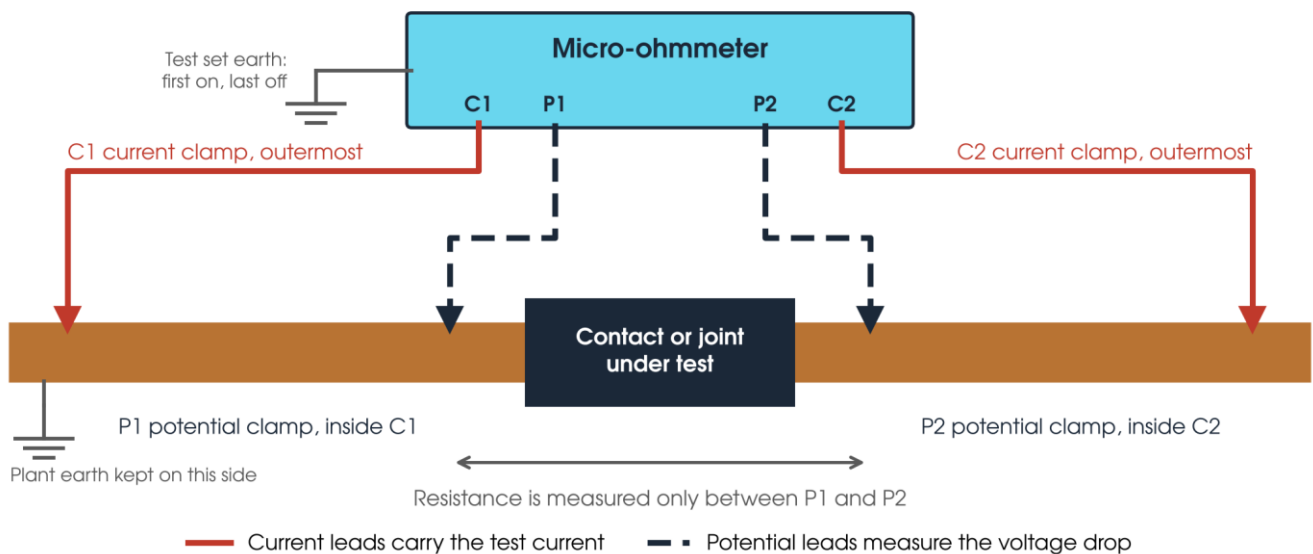
Clean, Repeatable Connections

Clamp onto bare metal, not paint or oxide, and record clamp positions so the next test measures the same length.

Good to Know

Lead length does not add to a four-wire reading, though long current leads can limit the current the set will drive. Potential clamp position does change the reading.

Connection Arrangement



Four-wire connection. The reading covers only the path between the potential clamps P1 and P2.

How Do I Set Up Safely?

Permits, Isolation and Earthing

1 Access Permit

Confirm the permit covers the test, including any temporary removal of earths. Permit earths are removed and replaced only 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

Cover every point that will carry test current or could be reached during the test.

4 Earth the Test Set First

Connect the test set 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. At Megavar, assessed testers; less experienced staff work under direct supervision.

Induced Voltage and Protection

One Side Earthed

With the conventional method one side loses its earth and can pick up induced voltage from adjacent circuits. Keep the earth on the side with the greatest induction risk.

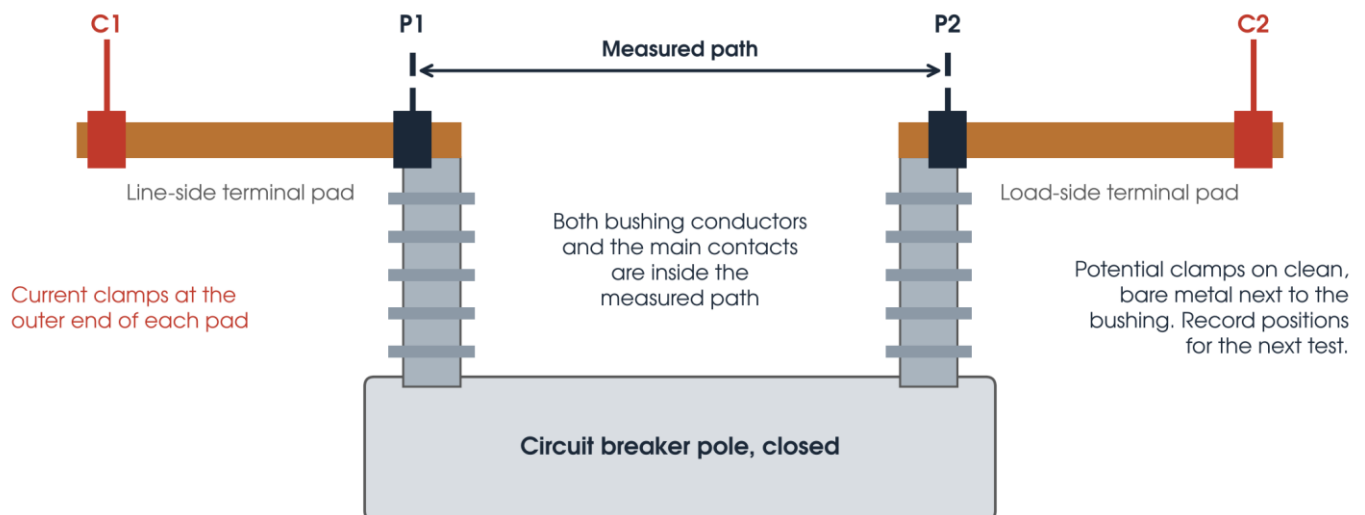
Both Sides Earthed

A conventional micro-ohmmeter then measures the contact in parallel with the earth loop and reads low. Use a method designed for it, such as OMICRON's grounded contact resistance method on CIBANO 500.

Current Transformers

DC through bushing or ring CTs magnetises the core, and a current step or ripple can look like a fault to connected protection. Short the secondaries at the approved terminals before isolating protection, keep the secondary earth, and use smoothed or ramped DC.

Clamp Placement on a Circuit Breaker Pole



Test one pole at a time. Current clamps go at the outer ends of the terminal pads; potential clamps go on bare metal next to the bushings.

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 Close and Confirm

Close the breaker or switch under its operating procedure and confirm it is mechanically closed.

2 Connect

Clean clamp points to bare metal without damaging plating. Current clamps outside, potential clamps inside, one pole at a time.

3 Inject and Settle

Apply the test current and wait for the reading to settle. Inductive paths take longer.

4 Forward and Reverse

Average forward and reverse readings to cancel thermoelectric voltage at dissimilar metals.

Steps 5 to 7

5 Record

Resistance, test current, temperature, clamp positions, instrument serial number and calibration date.

6 Discharge

On inductive paths, let the instrument finish its discharge before touching a lead. Never break the circuit while current flows.

7 Restore

Remove leads, then the test set earth last. Demagnetise affected CT cores, then restore earths and secondary circuits under the permit.

Good to Know

Clean plated contact surfaces with a non-abrasive pad so the plating is not removed.

Common Mistakes

Potential Clamps Outside

Clamp contact resistance is added to the reading.

Clamping on Paint or Oxide

High or unstable reading, or the instrument will not start.

Breaker Tested Below the Specified Current

Below 100 A it is under the IEEE C37.09-2018, clause 5.14, production test current, though AS 62271.1:2019, clause 7.4.4.1, allows 50 A or more. Follow the specified standard, manufacturer and owner.

Test Current Not Recorded

Reliable trending against the next test is lost.

More Common Mistakes

No Temperature Correction

Normal temperature change is read as deterioration.

Conventional Set, Both Sides Earthed

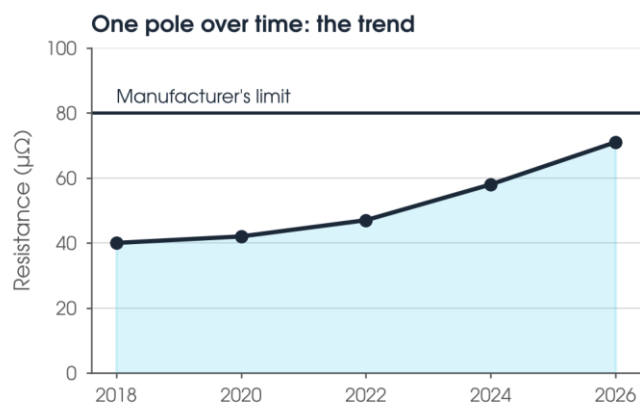
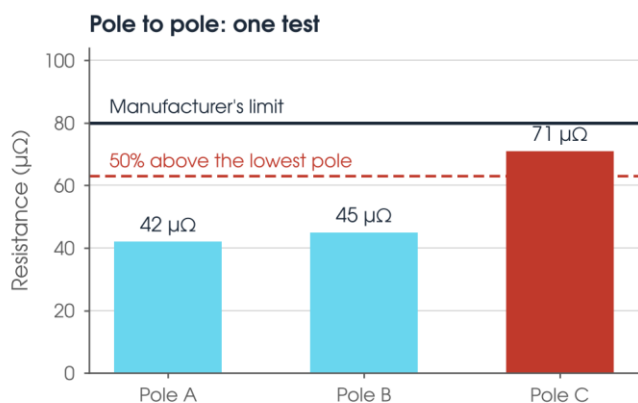
The earth loop is measured in parallel and the reading is falsely low.

Injecting Through In-Service CTs

Risk of protection operation and an unplanned trip.

How Do I Read the Result?

Three Poles, One Test, and the Trend



Illustrative values

Illustrative values. Pole C is inside the manufacturer's limit but more than 50% above the lowest pole and rising. It warrants investigation now.

Comparing the Result

Manufacturer's Limit

The O&M manual or factory certificate. USBR FIST 3-16 calls for further investigation when it is exceeded, which may mean opening the breaker to inspect the contacts. For the factory routine test, AS 62271.1:2019, clause 8.4, allows not more than 1.2 R_u , where R_u is the type-tested unit's value.

Asset Owner Criterion

For example, TasNetworks' testing specification for underground developments sets less than 300 $\mu\Omega$ for HV and LV switchgear.

Pole to Pole

NETA guidance, as reported by Schneider Electric, suggests investigating any pole more than 50% above the lowest pole. NETA does not present it as pass or fail. USBR FIST 3-16, clause 2.4, applies the same 50% test to power circuit breakers where no manufacturer limit or factory data exists.

Trend

Compare with previous results at the same current, corrected to the same temperature. A steady rise is the warning.

What a Bad Result Looks Like

One Pole Far Above the Others

A problem at that contact or joint. Recheck clamps and repeat; if it holds, inspect and repair.

All Poles Higher Than Last Time

First check current, temperature and clamp positions match the last test.

Reading Will Not Settle

Loose or dirty clamp, induced current, or an inductive path still stabilising.

Reading Lower Than Expected

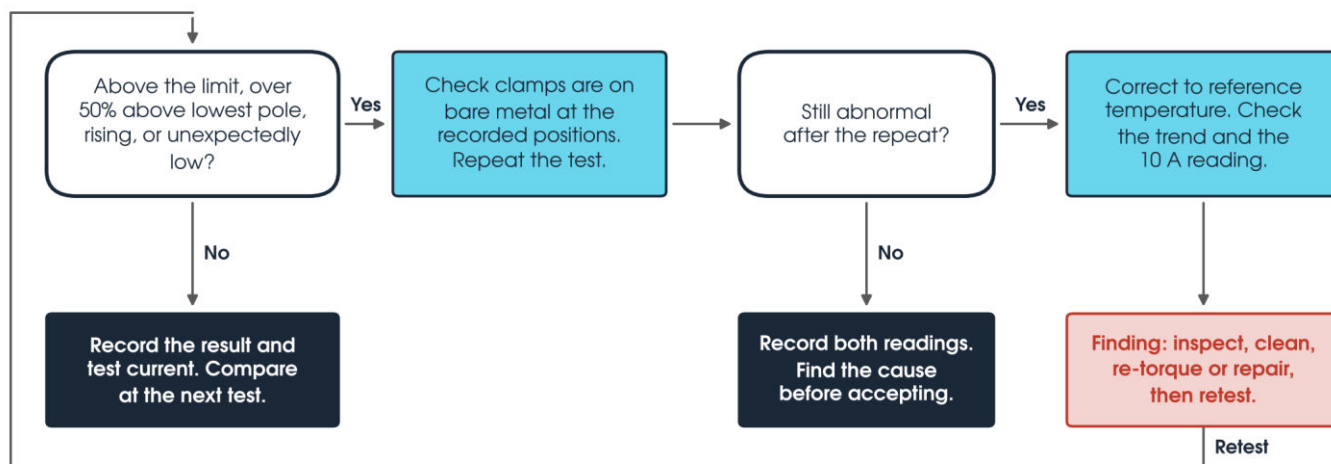
A parallel path, commonly an earth loop with both sides earthed.

10 A Much Higher Than 100 A

Possible contamination that high current breaks through. Treat it as a finding.

Is My Result OK?

Decision Path



Temperature Correction

Compare readings at similar temperatures. For copper or aluminium conductors, IEEE Std C57.12.90-2021, clause 5.2, gives this correction; use it on assembled contacts only where the manufacturer accepts it:

$$R2 = R1 \times (Tk + T2) / (Tk + T1)$$

R1 is measured at T1 (°C), R2 is at the reference temperature T2, and Tk is 234.5 °C for copper or 225 °C for aluminium.

Worked Example

A copper conductor reads 50.0 µΩ at 15 °C. At 35 °C it would read $50.0 \times 269.5 / 249.5 = 54.0$ µΩ. That 8% rise is temperature alone.

What to Report

For Each Pole or Joint

Measured resistance, test current, temperature, and any correction applied with its basis.

The Criteria Used

The manufacturer's limit or asset owner criterion the result was judged against.

The Comparison

Pole-to-pole spread and the change since the last test.

Traceability

Instrument model, serial number and calibration date, and the clamp positions used.

What About Dynamic Testing?

Static and Dynamic Resistance

Static

Measures the main contacts of a closed breaker. This is the routine ductor test.

Dynamic (DRM)

Records resistance, current and contact travel while the breaker opens, revealing the arcing contacts in SF6 puffer interrupters that a static test cannot reach. Typically at least 100 A DC.

Interpreting DRM

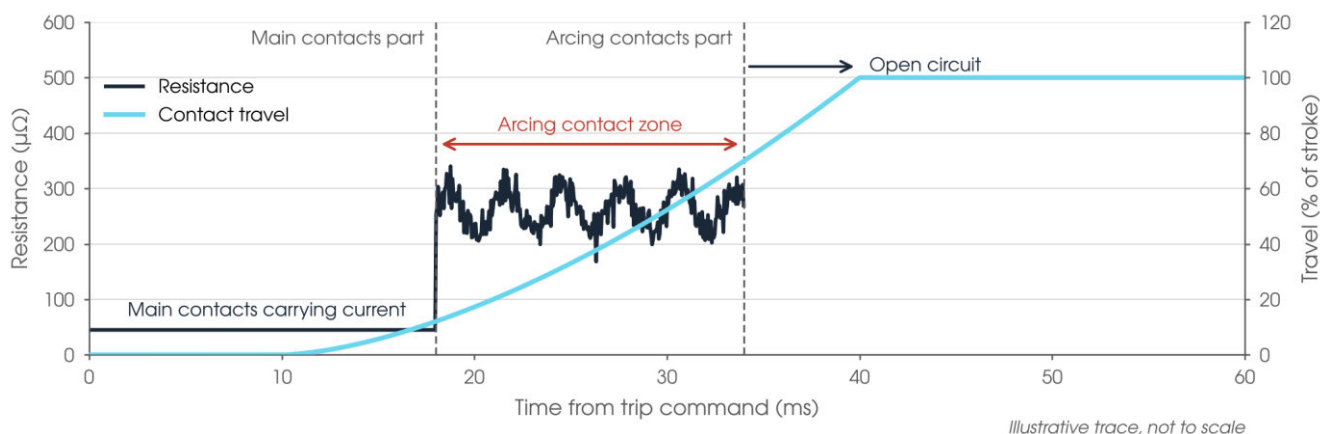
A Specialist Diagnostic

The measurement is fast and lead and stray reactance affect it. It is run with a circuit breaker analyser alongside timing and travel tests.

Good to Know

Compare DRM traces with the same breaker's earlier traces or a sister unit, not with a single number.

What a DRM Trace Shows



Recommended Solutions

Instrument	Test current	Best used for
Megger DLRO 10A	10 A	Joints, bonds, conductors and small connections; compact and lightweight
Megger DLRO 100EB	100 A	Breakers, disconnectors and busbar joints; battery powered
Megger MOM3 Handheld	300 A	Breaker contacts where a light, handheld high current set is needed
Megger DLRO 600A	600 A	Large breakers and high current paths
OMICRON CIBANO 500	200 A DC	Contact resistance with timing, coil and motor tests; grounded contact resistance method with both sides earthed
OMICRON CPC 100	400 A DC	Contact and winding resistance in a multi-function primary test set

Every instrument is available calibrated, with leads, from Hobart, Launceston, Adelaide and Newcastle: [micro-ohmmeter and ductor testing equipment hire](#).

Frequently Asked Questions

Common Questions

What is a ductor test?

A four-wire micro-ohm measurement of a contact, joint or bond, named after the early Ducter instruments. It is the same test as a contact resistance or DLRO test.

What is a typical result for an HV circuit breaker?

OMICRON gives 10 to 100 $\mu\Omega$ for HV switchgear main contacts. Judge each breaker against its manufacturer's limit and the asset owner's criterion.

Why do two instruments read differently?

Different test current, clamp positions or temperature, or instrument accuracy. A typical specification is $\pm 0.2\%$ of reading plus 2 digits.

Can I test with both sides earthed?

Not with a conventional micro-ohmmeter; use a method designed for it, such as OMICRON's grounded contact resistance method.

Standards and References

AS 62271.1:2019, High-voltage switchgear and controlgear, Part 1: Common specifications for alternating current switchgear and controlgear.

AS/NZS 62271.100:2026, High-voltage switchgear and controlgear, Part 100: Alternating-current circuit-breakers.

IEEE Std C37.09-2018 with Cor 1-2021 and C37.09a-2025, Standard Test Procedures for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V.

IEEE Std C57.12.90-2021, Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers, clause 5.2.

Megger, A Guide to Low Resistance Testing, 2020.

OMICRON, Diagnostic Testing of HV and MV Switchgear, 2026; A Systematic Approach to HV Circuit Breaker Testing, 2016.

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

Schneider Electric, Data Bulletin 0600DB1901 (NETA guidance).

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

TasNetworks, Electrical Testing Specification: Underground Developments, 2016.

Safe Work Australia, model Code of Practice: Managing Electrical Risks in the Workplace.

More Questions

Will the test affect CTs and protection?

It can. DC magnetises CT cores, and a current step can look like a fault. Short the secondaries before isolating protection, keep the secondary earth, use smoothed or ramped DC and demagnetise afterwards.

How often should contacts be tested?

At commissioning for a baseline, then at the asset owner's maintenance interval, after work on contacts or joints, and after heavy fault interruption.

Is a continuity tester good enough?

No. A typical continuity tester resolves to 0.01 Ω , which is ten thousand micro-ohms. It cannot tell a good contact from a degraded one.

Does Megavar test as well as hire?

Yes. Our engineers test, commission and maintain HV plant 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.

Next Step

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