



Insulation Resistance Testing Guide



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About This Guide

An insulation resistance test applies a steady DC voltage across insulation and measures the small current that flows, giving a resistance in megohms or more. It is often called a Megger test. This guide sets out the test voltage to use, the timed readings, how to connect and discharge safely and how to judge a result.

What the Test Is

A DC measurement of the resistance of insulation between a conductor and earth, or between windings. Read as a one-minute spot value, or as timed ratios: the polarisation index (PI) and the dielectric absorption ratio (DAR).

When It Is Used

At commissioning to set a baseline, before any higher voltage test, in routine maintenance, after repairs and after events such as flooding, a fault or long storage.

Why It Matters

Moisture, dirt and ageing open leakage paths through and over insulation long before it fails. An insulation resistance test finds them at a few kilovolts DC, on de-energised plant, without stressing the insulation the way a withstand test does.

Guide at a Glance

Measures

Insulation resistance, from megohms to teraohms.

Method

DC voltage, with readings at 30 s, 1 min and 10 min.

Test Voltage

500 V to 10 kV DC, matched to the rating of the plant.

Key Ratios

PI = 10 min / 1 min; DAR = 60 s / 30 s.

Judged Against

Standard minimums, asset owner criteria, factory results 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 Insulation Resistance?

Insulation Resistance in Four Numbers

2.0

Minimum PI for class 130 (B) and higher, where PI applies (IEEE 43-2013, Table 3, 12.2)

4 x

Minimum earthing time after the test, times the voltage application time (IEEE 43, cl. 4)

1 MΩ

Generally accepted minimum for relaying CT insulation (IEEE C57.13.1-2017, cl. 10)

40 °C

Base temperature for machine insulation resistance (IEEE 43-2013, 6.3)

Why a Megohm Reading Matters

Insulation Keeps Current in Place

Every winding, cable and bushing relies on insulation to keep current off earth and off its neighbours. When moisture, dirt or ageing opens a leakage path, the next step is a fault.

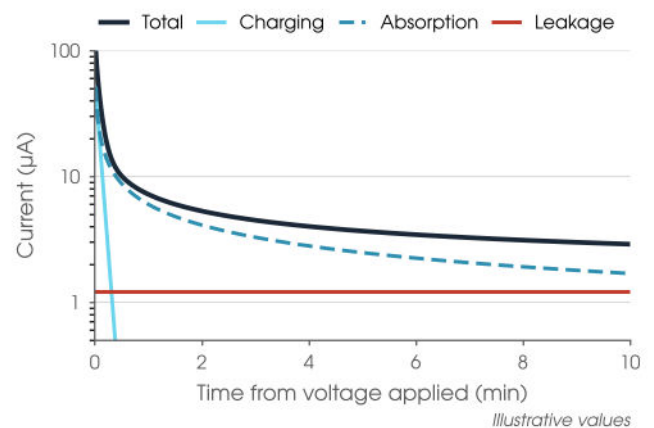
The Gate Before Higher Voltage

IEEE Std 43-2013 (6.2) recommends that a machine with low PI and IR1 readings is not subjected to further high voltage testing. The insulation resistance test is run first for that reason.

What It Does Not Show

Insulation resistance is not directly related to dielectric strength, and a DC test may not find internal voids (IEEE Std 43-2013, 11.3). It is one test of several, not a proof of withstand.

Three Currents in Every Reading



Illustrative values. The charging and absorption currents die away; the leakage current stays. Insulation resistance rises as they fade.

When to Test



Where Is It Used?

Items Tested

Item	What a low reading points to	Test voltage and basis
Motor and generator windings	Moisture, surface contamination, cracked or aged insulation	500 V DC below 1000 V rating, up to 5 to 10 kV above 12 kV (IEEE Std 43-2013, Table 1)
Power transformer windings	Wet paper and oil, a grounded winding, a winding-to-winding short or carbon tracking	Typically 500 V to 5000 V DC, never above the rms applied test voltage (IEEE Std C57.152-2025, 7.2.13.3)
MV XLPE cables	Installation damage, water in joints or terminations	5 kV DC core to screen, 1 kV DC screen to earth (SA Power Networks TS105)
Switchgear and busbars	Tracking, contaminated insulators, moisture in the enclosure	To the manufacturer's and asset owner's specification
CT and VT secondaries and wiring	Damaged wiring, moisture in terminal boxes	1 kV DC (AS 61869.1:2024, 5.4.5.3); consult the relay maker above 500 V (IEEE Std C57.13.1-2017, Clause 10)
Transformer auxiliary wiring	Damaged or wet control wiring	1 kV DC for 1 min on site (AS/NZS 60076.3:2017, Clause 9 note)

Choosing the Test Voltage

Rotating Machines

IEEE Std 43-2013, Table 1, sets the voltage by winding rating, from 500 V below 1000 V to 5000 to 10 000 V above 12 kV.

Transformers

The DC voltage to ground should not exceed the rms low-frequency applied test voltage (IEEE Std C57.12.90-2021, 10.11.3; IEEE Std C57.152-2025, 7.2.13.3).

Cables

SA Power Networks limits field tests on 11 kV and 33 kV cables to 5000 V DC and does not treat 5000 V DC as an HV DC test (TS105, 8.3).

Our Recommendation

Use the asset owner's specification where there is one, then the standard for the plant. Use the same voltage every time, or the results cannot be trended.

Higher or Lower Voltage

Why Not Lower

Some defects only show at higher stress. On machines with stress grading, IEEE Std 43-2013 (5.1) notes more reliable resistance and PI values at 5 kV or more.

Why Not Higher

Wet insulation can break down: Megger advises a 100 V or 250 V tester early in a dry-out. On field-aged XLPE, SA Power Networks prohibits DC above 5000 V because it increases water tree growth.

Good to Know

Record the test voltage with every result.

Insulation resistance may vary with applied voltage, so compare only at the same voltage (IEEE Std C57.152-2025, 7.2.13.3).

How Does It Work?

Ohm's Law, Over Time

How It Works

The tester applies a steady DC voltage and measures the current through and over the insulation. Resistance is voltage divided by current.

Three Currents

A capacitive charging current that falls almost at once, an absorption current that decays over minutes, and a steady leakage current. Moisture and contamination raise the leakage and also change how the absorption current decays.

Why the Ratios Work

Moisture raises leakage faster than absorption, so wet insulation shows a flat reading and a low PI. Temperature and humidity are the same for both readings (IEEE Std C57.152-2025, 7.2.13.5).

Three Terminals

Line

The high voltage lead, on the conductor or winding under test. IEEE Std 43-2013 (5.3) prefers negative polarity on the winding.

Earth

The return, on the earthed tank, screen or frame and on everything not under test.

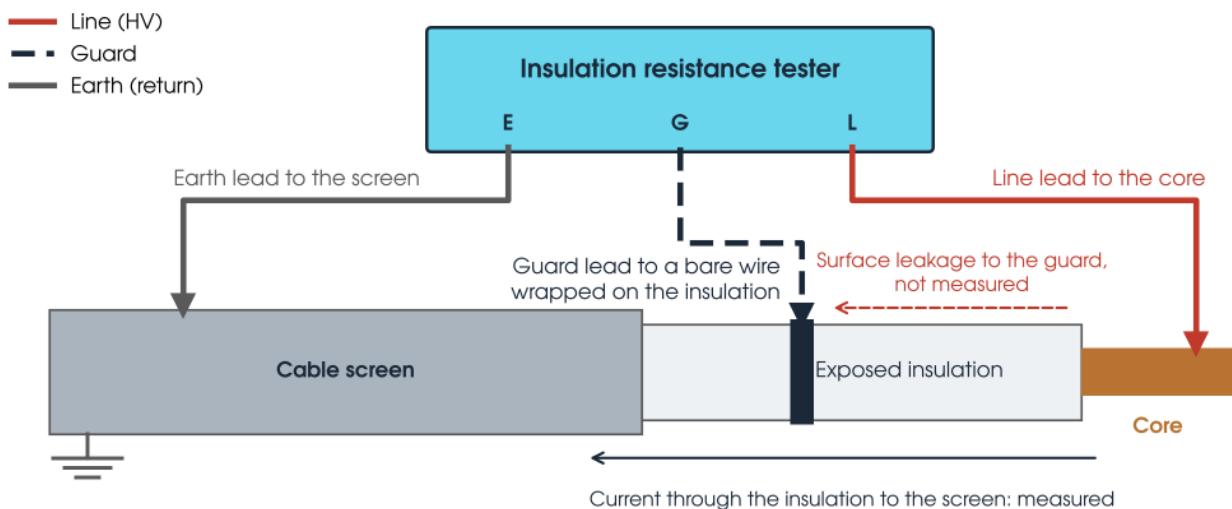
Guard

A third lead that carries surface leakage around the measuring circuit, so the reading is the insulation itself and not the dirt on it.

Good to Know

A guard is not an earth. Record whether it was used: a guarded and an unguarded reading cannot be compared.

Connection Arrangement



Guarded connection on a cable termination. Surface leakage flows to the guard and is not measured.

How Do I Set Up Safely?

Permits, Isolation and Earthing

1 Access Permit

Confirm the permit covers the test, including removing the earth from the item under test. Earths are removed and replaced only by the person the asset owner authorises.

2 Isolated, Proved Dead, Earthed

Each exposed part is treated as energised until it is isolated and tested, and each HV part is earthed once de-energised (Safe Work Australia model Code of Practice, 4.1).

3 Disconnect What Should Not Be Tested

Surge arresters, VTs, capacitors, relays and electronics. Record anything left connected (IEEE Std 43-2013, Clause 8).

4 Barricade Both Ends

Restrict access to everything the test voltage reaches, including the far end of a cable (IEEE Std 43-2013, Clause 4).

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.

Stored Charge and Other Hazards

Stored Charge

A cable or winding charges like a capacitor and can hold a lethal charge after the test. Earth it for at least four times the voltage application time (IEEE Std 43-2013, Clause 4 and 6.5).

Recharge

Absorption current comes back out slowly. A discharged item left unearthed can rebuild a dangerous voltage, so keep it shorted and earthed until it returns to service (Megger, 2021).

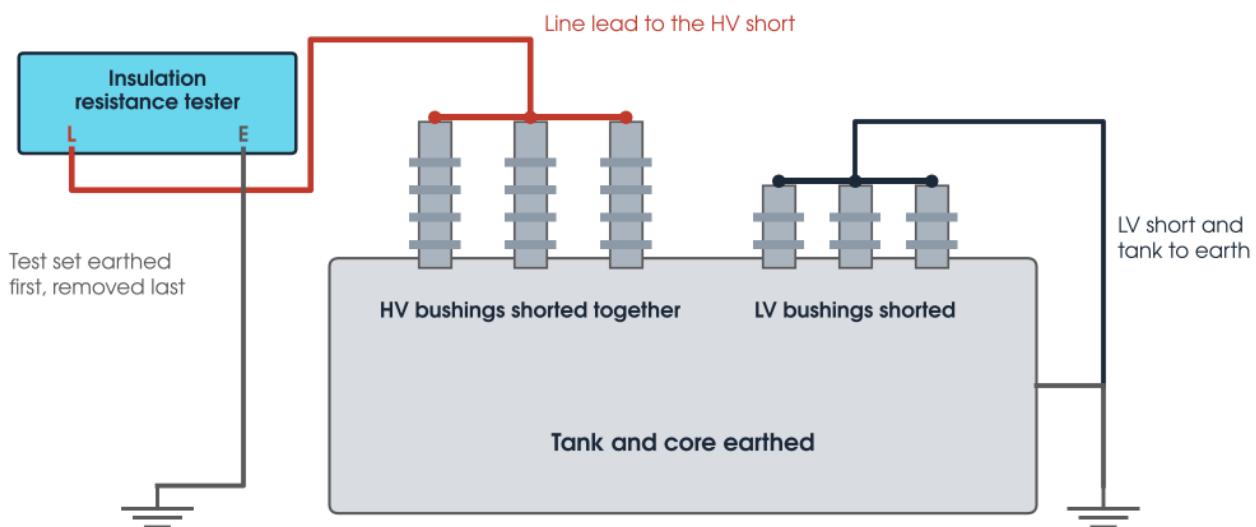
Induced Voltage

Rather than remove a working earth from a line exposed to induction, disconnect the apparatus and leave the line earthed (Megger, 2006).

Vacuum and Electronics

Never test a transformer or CT under vacuum (IEEE Std C57.152-2025, 7.2.13; C57.13.1-2017, Clause 10). Consult the relay maker before exceeding 500 V on circuits with relays (IEEE Std C57.13.1-2017, Clause 10).

Test Connections on a Two-Winding Transformer



This connection measures HV to (LV + earth). Repeat for LV to (HV + earth) and (HV + LV) to earth.

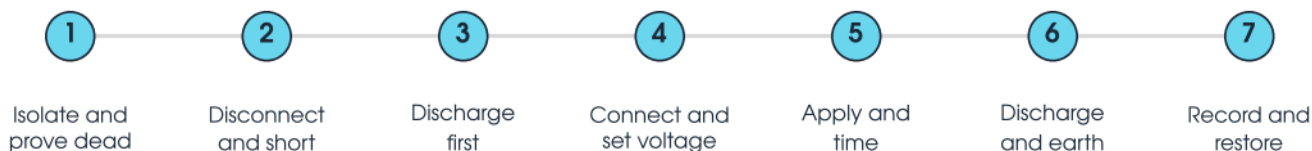
Short each winding at its bushings, earth the tank and core, and test each winding to the other winding and earth (IEEE Std C57.152-2025, 7.2.13).

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 Isolate and Prove Dead

Under the permit, at the plant, with the permit issuer.

2 Disconnect and Short

Disconnect connected plant. Short each winding or core at its terminals and earth everything not under test.

3 Discharge First

Begin only when there is no discernible return voltage, less than about 20 V, after the earth is removed (IEEE Std 43-2013, Clause 4).

4 Connect and Set Voltage

Earth the test set first, then the earth lead, the line lead and the guard if used. Set the voltage used last time.

Steps 5 to 7

5 Apply and Time

Read at 30 s and 1 min for the spot value and DAR, and at 10 min for the PI. Stop at once if the current rises without settling (IEEE Std C57.152-2025, 7.2.13.3).

6 Discharge and Earth

Let the tester discharge the item, then apply an earth for at least four times the test time before touching a lead.

7 Record and Restore

Record the readings and conditions, remove leads, then the test set earth last. Restore connections and earths per the permit.

Good to Know

Test above the dew point. A winding at or below it can carry a moisture film that lowers the reading (IEEE Std 43-2013, 6.2).

Common Mistakes

Different Voltage From Last Time

The two results cannot be compared.

Connected Plant Left In

Every extra item lowers the reading and masks the item under test.

Recording Infinity

Over-range is not a number; record it as greater than the tester's maximum.

No Temperature Recorded

The reading cannot be corrected or trended.

More Common Mistakes

Guard Used Inconsistently

A guarded reading is compared with an unguarded one.

Leads Touching

Above 100 GΩ, leads touching each other or the ground add leakage (Megger, 2021).

Disconnecting Too Soon

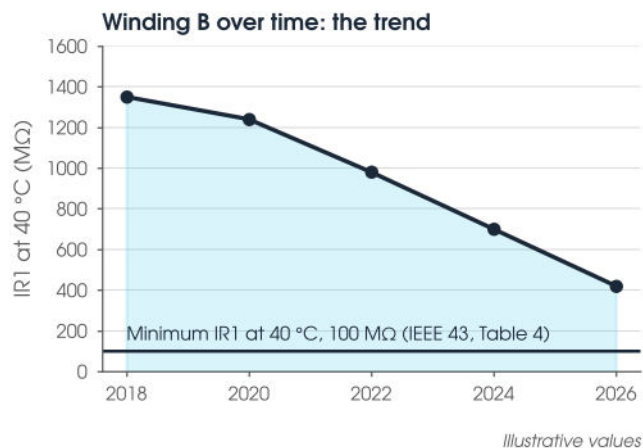
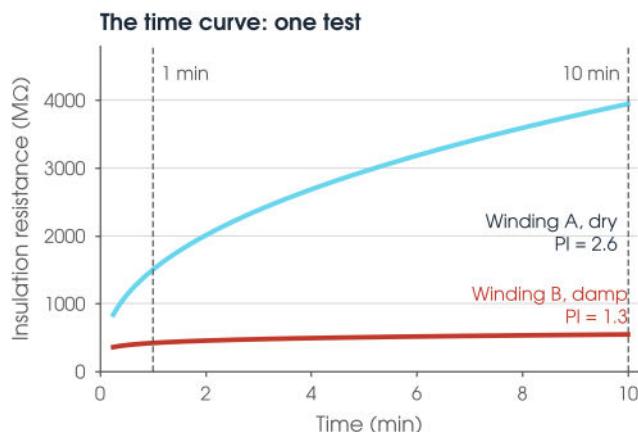
Leads removed before the item is discharged and earthed.

One Phase Floating

Phases not under test left unearthed carry induced or stored charge.

How Do I Read the Result?

The Time Curve and the Trend



Winding B is well above its minimum, but its curve is flat, its PI is 1.3 and its trend is falling. It warrants investigation now.

Comparing the Result

Rotating Machines

Minimum PI 1.5 for class 105 (A) and 2.0 for class 130 (B) and above, unless IR1 at 40 °C exceeds 5000 MΩ or PI does not apply to the winding (IEEE Std 43-2013, Table 3, 12.2).

Minimum IR1 at 40 °C, whole winding: kV + 1 for most pre-1970 and all field windings, 100 MΩ for most post-1970 form-wound AC windings, 5 MΩ for random-wound, below 1 kV and DC armatures (Table 4).

Transformers

Comparison with factory or previous results is more significant than the absolute megohms (IEEE Std C57.152-2025, 7.2.13.4).

Asset Owner Criteria

For example, SA Power Networks sets 1000 MΩ minimum at 5 kV for new 11 kV and 33 kV XLPE cable, core to screen (TS105, Table 1).

DAR

AEMC gives below 1.25 as inadequate and above 1.6 as excellent. IEEE Std 43-2013 (Annex A) sets no agreed criteria for it.

What a Bad Result Looks Like

Low and Flat

Leakage masks absorption: moisture or contamination.

Zero or Very Low

A grounded winding, a winding-to-winding short or heavy carbon tracking (IEEE Std C57.152-2025, 7.2.13.4).

Current Rising, Not Settling

Stop the test. The insulation is heading for breakdown.

Lower at Higher Voltage

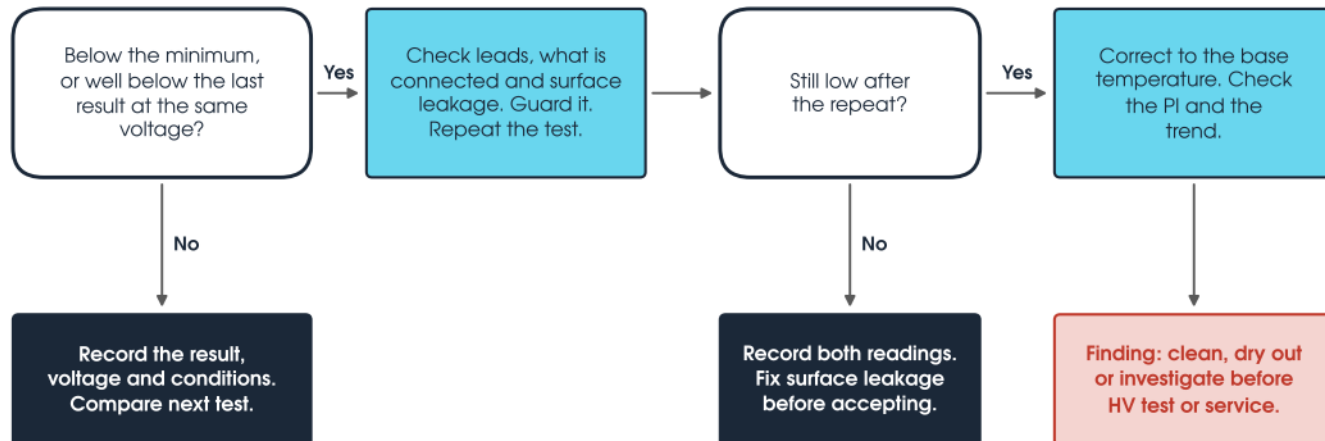
A significant fall in IR with voltage may indicate insulation problems (IEEE Std 43-2013, 6.4).

Very High PI on Old Insulation

A PI above 8, for example, on asphaltic or shellac stators may mean thermal ageing and brittle insulation (IEEE Std 43-2013, 11.2).

Is My Result OK?

Decision Path



Temperature Correction

Insulation resistance falls as temperature rises, so correct readings to a base temperature before comparing them. For machines the base is 40 °C (IEEE Std 43-2013, 6.3):

$$R_c = K_T \times R_T$$

For thermoplastic insulation $K_T = 0.5^{((40 - T)/10)}$. For thermosetting insulation between 10 °C and 40 °C, $K_T = \exp[-1245 (1/(T + 273) - 1/313)]$.

Worked Example

A thermoplastic winding reads 500 MΩ at 35 °C. $K_T = 0.5^{0.5} = 0.707$, so the corrected value is 354 MΩ at 40 °C.

Transformers and PI

Transformer IR is read near 20 °C (IEEE Std C57.152-2025, 7.2.13.3). PI needs no correction (IEEE Std 43-2013, 6.3.4).

What to Report

Readings

Test voltage and polarity, connection tested, 30 s, 1 min and 10 min values, PI and DAR.

Conditions

Winding and ambient temperature, relative humidity, dew point and time out of service (IEEE Std 43-2013, Clause 7).

The Comparison

The minimum or criterion used, the corrected value and the change since the last test.

Traceability

Instrument model, serial number and calibration date, and whether the guard was used.

What About Step Voltage and Discharge Tests?

Step Voltage

How It Works

Raise the voltage in equal steps, holding each for 1 min. Clean, dry insulation reads about the same at every step (IEEE Std 43-2013, 6.4); C57.152 gives steps typically from 1 kV to 5 kV (7.2.13.3).

Dielectric Discharge (DD)

Measures the current flowing 1 min after a long charge is removed, to find one faulty layer in multilayer insulation. Megger summarises EdF's figures: below 2 OK, above 7 bad.

Interpreting the Steps

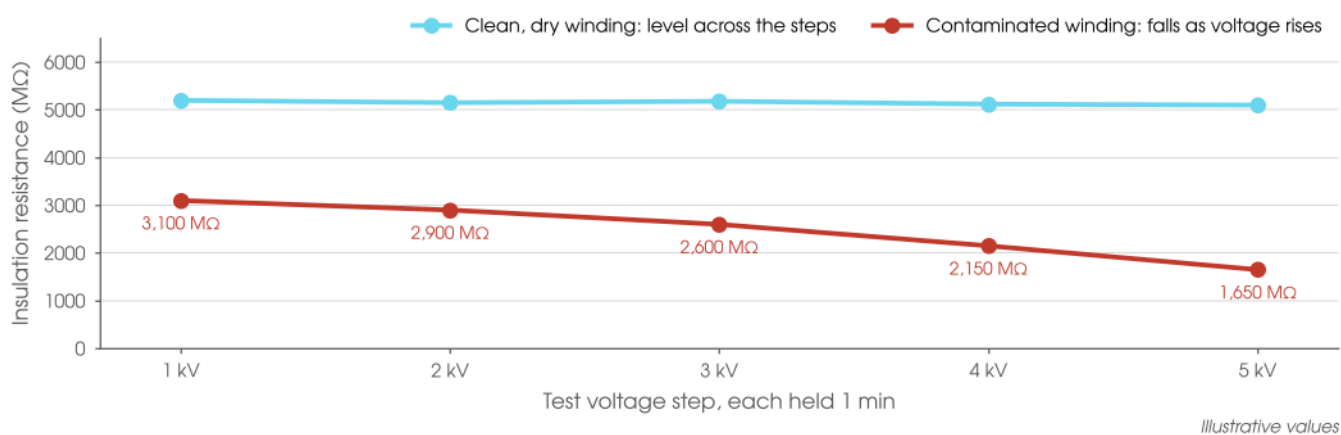
A Change Worth Acting On

Megger reports that a 25% fall in resistance across a 1 to 5 voltage ratio, such as 500 V to 2500 V, usually means excessive moisture or contamination.

Good to Know

Step voltage is an undervoltage test with limited power. It is not a withstand test, and it does not replace one.

What a Step Voltage Test Shows



Recommended Solutions

Instrument	Test voltage	Best used for
Megger MIT520 5 kV	250 V to 5 kV	Cables, transformers, switchgear and motors; PI, DAR and step voltage; to 10 TΩ
Megger MIT1020 10 kV	250 V to 10 kV	Large generators and the highest voltage plant; adds dielectric discharge; to 35 TΩ

Both instruments are available calibrated, with leads, from Hobart, Launceston, Adelaide and Newcastle: [insulation resistance testing equipment hire](#).

Frequently Asked Questions

Common Questions

Is an insulation resistance test the same as a Megger test?

Yes. Megger is a brand that became the everyday name for the insulation resistance tester and the test.

What is a bad reading for insulation resistance?

One below the standard or asset owner minimum, a flat curve with a PI near 1 where PI applies, or a sharp fall from the last result at the same voltage.

Is PI useful on an oil-filled transformer?

With care. IEEE Std C57.152-2025 (7.2.13.5) says PI should not be used to assess new power transformers, and oil alone gives a PI close to 1.

How long should I discharge after a test?

At least four times the voltage application time (IEEE Std 43-2013, 6.5), then keep it earthed.

Standards and References

IEEE Std 43-2013 (Inactive-Reserved), Testing Insulation Resistance of Electric Machinery.

IEEE Std C57.152-2025, Field Diagnostics of Liquid-Filled Transformers, 7.2.13; IEEE Std C57.12.90-2021, 10.11.

IEEE Std C57.13.1-2017, Field Testing of Relaying Current Transformers, Clause 10.

AS 61869.1:2024, Instrument transformers, Part 1, 5.4.5.3; AS/NZS 60076.3:2017 Amd 1:2020, Clause 9.

AS/NZS 1429.1:2006, MV polymeric cables, Appendix F.

Megger, A Stitch in Time, 2006; A Guide to Diagnostic Insulation Testing Above 1 kV, 2021.

AEMC Instruments, Understanding Insulation Resistance Testing, 2025.

SA Power Networks, TS105 Testing Standard, 2021.

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

More Questions

Can the test damage insulation?

Rarely at the right voltage; it is low energy. Wet insulation can break down, so start low on wet plant.

Why did two tests on the same winding differ?

Different voltage, temperature, humidity, guarding or connected plant. Correct and compare like with like.

What minimum applies to CT secondaries?

IEEE Std C57.13.1-2017 (Clause 10) gives 1 MΩ as the generally accepted field minimum.

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 [high voltage testing](#), [HV cable testing](#) and [transformer testing](#) across Australia.

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