



Battery Testing Guide



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About This Guide

Battery testing shows whether a stationary standby battery can carry its DC load when the AC supply fails. The core test is a discharge, or capacity, test: the battery is discharged at a set rate to a set end voltage and timed. This guide covers vented and VRLA lead-acid batteries in substations and plant DC systems: test types, set-up, safety and judging the result.

What a Battery Test Is

A discharge test at a constant current or power to a set end voltage, timed and corrected for temperature to give capacity as a percentage of rating. It is backed by inspections, cell voltages, internal ohmic values and connection resistance.

When It Is Used

On delivery or installation as an acceptance test, within the first years of service, on a cycle set by the battery's expected life, annually late in life, and after a deep discharge, high temperature or damage.

Why It Matters

The substation battery trips breakers to clear a fault when the AC supply is lost. Float voltage can look normal on a battery that will not last the duty. Only a discharge test measures the capacity that is actually there.

Guide at a Glance

Measures

Capacity as a percentage of the manufacturer's rating, corrected to 25 °C.

Method

Constant current or power discharge to a set end voltage, charger disconnected.

Test Duration

About the duty cycle; 5 or 8 hours are common (Megger).

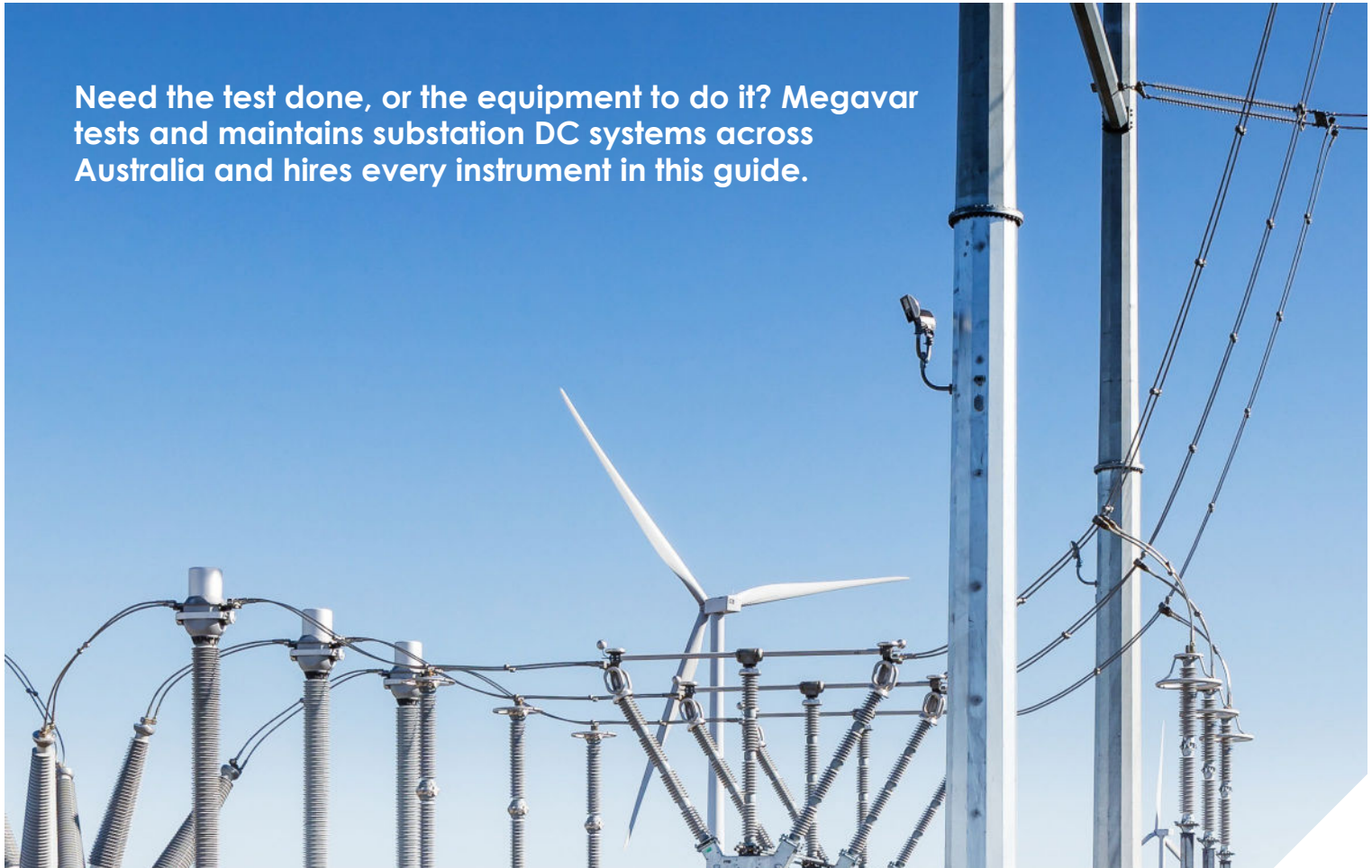
Pass Mark

At least 90% at acceptance; replace below 80% (IEEE 450 and IEEE 1188).

Judged Against

The rating, the previous test, cell end voltages and the asset owner's criteria.

Need the test done, or the equipment to do it? Megavar tests and maintains substation DC systems across Australia and hires every instrument in this guide.



Why Measure Battery Capacity?

Battery Testing in Four Numbers

90%

Minimum capacity of a new battery at acceptance
(IEEE 450, 6.2; IEEE 1188, 5.2)

80%

Capacity below which the battery is replaced
(IEEE 450, CI 8; IEEE 1188, CI 7)

25%

Longest performance test interval, as a share of service life (IEEE 450, 6.3)

20%

Connection resistance rise over the installation value that needs action (IEEE 450, 5.3.2)

Why Capacity Matters

The Battery Clears the Fault

In a substation the battery's main job is to trip breakers and clear a fault, then close breakers to restore supply (as summarised by Battcon, 2012). If it cannot, protection fails when it is needed.

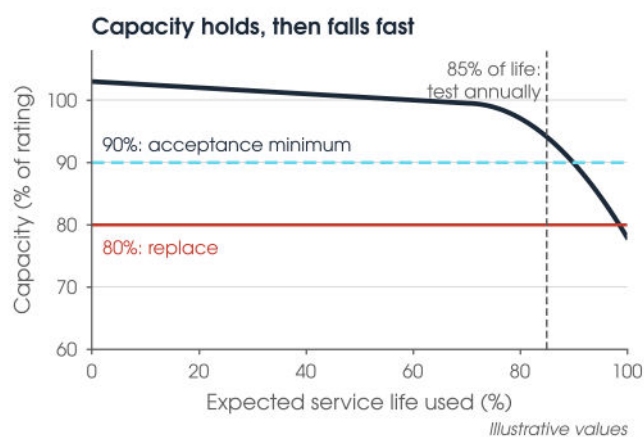
Float Voltage Hides Lost Capacity

Float voltage shows the charger is working and the cell is charged, not that it has full capacity (as summarised by Megger, 2021).

Heat Shortens Life

VRLA life falls by about one half for every 8 °C above 25 °C (IEEE 1188-2025, Annex B.3, informative).

How Capacity Fades



Capacity changes little for most of the battery's life, then falls quickly. IEEE 1188 calls 80% the knee of the curve (Clause 7).

When to Test



Where Is It Used?

Items Tested

Item	What a bad result points to	Test and interval
Vented lead-acid battery	Positive grid corrosion, sulphation, sediment build-up (Megger)	Capacity test on cycle; inspections monthly to yearly (IEEE 450, 5.2)
VRLA battery	Dryout and negative plate failure, which VRLA usually fails by first (IEEE 1188, 5.3.1)	Capacity test on cycle; ohmic values quarterly (IEEE 1188, 4.2.3)
Individual cells or units	Weak cell, short or open cell	Cell voltages; internal ohmic values
Intercell and terminal connections	Loose, corroded or poorly made connections	Connection resistance yearly (IEEE 450, 5.2.4)
Charger and float	Float voltage out of range, rising float current	Monthly (IEEE 450, 5.2.2)
DC system insulation to earth	An earth fault on an unearthed DC system	Earth fault detection and location (USBR FIST 3-6)

Choosing the Test

Acceptance

Proves capacity at the factory or on installation and sets the baseline for trending (IEEE 450, 6.2; IEEE 1188, 5.2).

Performance

Measures capacity in service, at about the duty cycle duration (IEEE 450, 6.3 and 7.3).

Service

Tests the battery as found against its actual duty cycle, with no temperature or age correction (IEEE 450, 7.6).

Modified Performance

One test of capacity and duty cycle: a constant current raised to bound the duty cycle peaks (IEEE 450, 6.5 and Annex I).

Our Recommendation

A performance or modified performance test on the asset owner's cycle, with inspections, ohmic values and connection resistance between tests. The asset owner's specification governs.

Vented or VRLA

Chemistry Sets the Standard

IEEE 450-2020 covers vented lead-acid; IEEE 1188-2025 covers VRLA. Intervals, inspections and float behaviour differ.

Outside This Guide

Nickel-cadmium batteries (IEEE 1106) and grid-scale lithium battery energy storage are not covered here.

Good to Know

Confirm the chemistry before applying any number from either standard.

Keep the same capacity calculation method for the life of the battery (IEEE 450, 7.4).

How Does It Work?

Discharge at a Constant Rate

How It Works

The charger is disconnected and a load bank draws a constant current or power. The test runs until the battery voltage falls to the design minimum volts per cell times the number of cells (IEEE 450, 7.5).

The End Voltage

For 60 cells with a design minimum of 1.75 V per cell the end voltage is $60 \times 1.75 = 105 \text{ V}$ (IEEE 450, 7.5).

From Time to Capacity

Capacity is the actual time to the end voltage over the rated time, corrected for temperature (IEEE 450, 7.4.2). It does not prove short high-rate duty: use a service or modified performance test (IEEE 450, 7.3).

Connection Rules

Cell Voltages Include the Connector

Read each cell between like-polarity posts of adjacent cells, so the intercell connector drop is included (IEEE 450, 7.5).

Protect the Load Leads

Load test leads clean, long enough to avoid accidental arcing, with short-circuit protection (IEEE 450, 4.2).

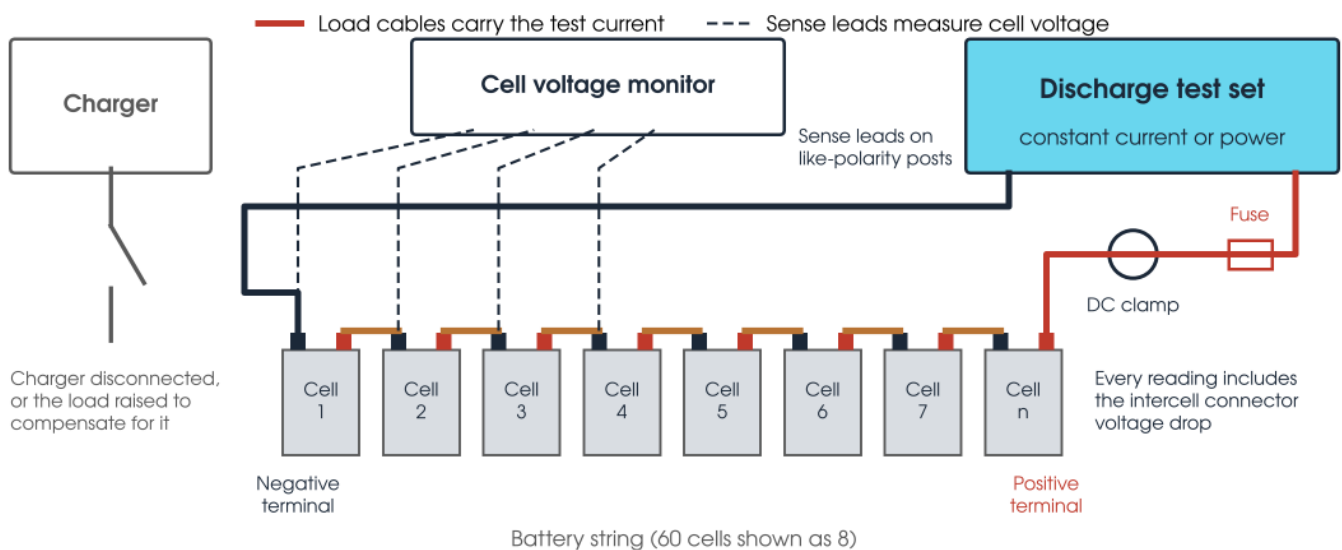
If the Charger Stays On

Increase the load to make up the current the charger supplies (IEEE 450, 7.5).

Good to Know

Size the load cables before test day. One load bank maker suggests no more than 3.0 V drop between battery and load bank (as summarised by Battcon, 2016).

Connection Arrangement



Discharge test connection. The test set holds the rate; sense leads read every cell between like-polarity posts.

How Do I Set Up Safely?

Permits, Isolation and Hazard Control

1 Job Hazard Analysis

Complete one before any work on a battery (IEEE 450, 4.2).

2 Protect the DC Supply

Isolate the battery from critical loads and other batteries so a failure cannot affect them (IEEE 450, 7.2). Where the site cannot be without DC, connect a temporary battery first (USBR FIST 3-6).

3 PPE to the Voltage

Shock PPE above 100 V dc and arc flash PPE above 150 V dc (IEEE 1188, 3.2).

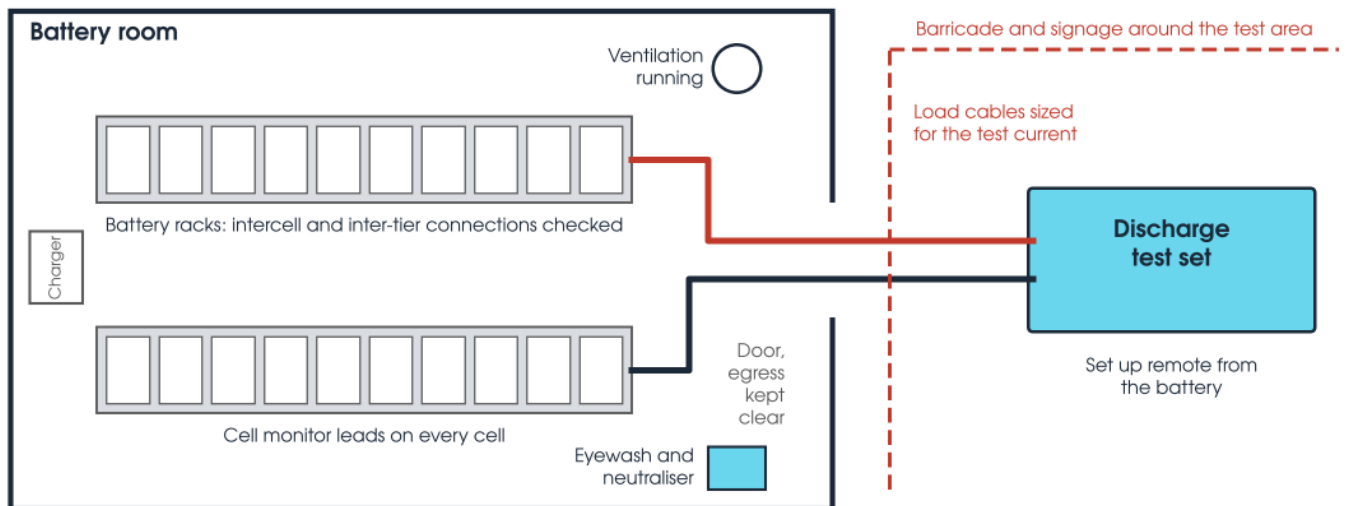
4 Ventilation and Egress

Battery room ventilation running and the exit unobstructed (IEEE 450, 4.2).

Who Should Test

Personnel trained and qualified to work on batteries (IEEE 450, Clause 4), under the asset owner's safety rules and the access permit.

Set-Up in the Battery Room



Keep the test set remote from the battery, the exit clear and the barricade around everything that carries test current.

Important

This guide describes general practice for competent 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.

Battery Hazards

Short-Circuit Energy

Remove jewellery and use insulated tools. Above 1,000 W of short-circuit power, wear thermal hand protection (IEEE 1188, 3.4).

Disconnected Is Not Safe

Disconnecting a battery does not establish an electrically safe work condition (IEEE 1188, 3.5).

Hydrogen and Acid

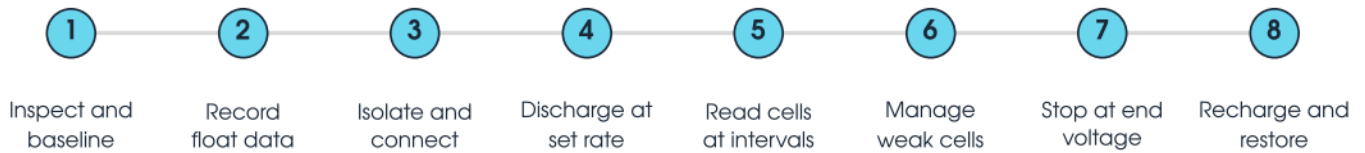
No smoking or open flames. Eyewash, rinse water and bicarbonate of soda solution, 100 g to 1 L of water, on hand (IEEE 450, 4.1 and 4.2).

Never Across a Cell

Do not place ohmmeter probes across a cell (IEEE 1188, Annex D).

How Do I Make the Measurement?

Eight Steps



Steps 1 to 4

1 Inspect and Baseline

Complete the inspections and check every connection resistance (IEEE 450, 6.2 and 7.2). Equalise only if the manufacturer recommends it.

2 Record Float Data

Float current, each cell's float voltage, terminal voltage and the temperature of 10% or more of the cells (IEEE 450, 7.2).

3 Isolate and Connect

Disconnect the charger, connect the load and the cell monitor.

4 Discharge at the Set Rate

Start timing and hold the rate constant (IEEE 450, 7.5).

Steps 5 to 8

5 Read Cells

Cell voltages, current and terminal voltage at the start, at intervals and at the end: at least three sets (IEEE 450, 7.5), five for VRLA (IEEE 1188, 6.6).

6 Manage Weak Cells

Stop to bypass a cell nearing reversal early in the test and set a new end voltage. One downtime only, at most 10% of the test or 6 min, not counted as test time; never in a duty cycle (IEEE 450, 6.5 and 7.5).

7 Stop at the End Voltage

Run to the battery end voltage, then record every cell.

8 Recharge and Restore

Disconnect the test equipment, recharge and return to service (IEEE 450, 7.7).

Good to Know

Scan connectors with a thermal imager during the discharge (IEEE 1188, 6.1).

Common Mistakes

Stopping at 100% of Rated Time

The true capacity is never measured, so degradation is not seen until it falls below 100% (as summarised by Battcon, 2016).

Stopping When the First Cell Reaches Final Voltage

The end point is the battery voltage, not one cell (Battcon, 2016).

Leaving a Failing Cell In

An early failing cell left in skews the capacity result (Battcon, 2016).

More Common Mistakes

Using the Wrong Correction Table

KT rises with temperature and Kc falls. The wrong table gives a plausible wrong capacity (IEEE 450, Tables 1 and 2).

Equalising a VRLA Battery by Habit

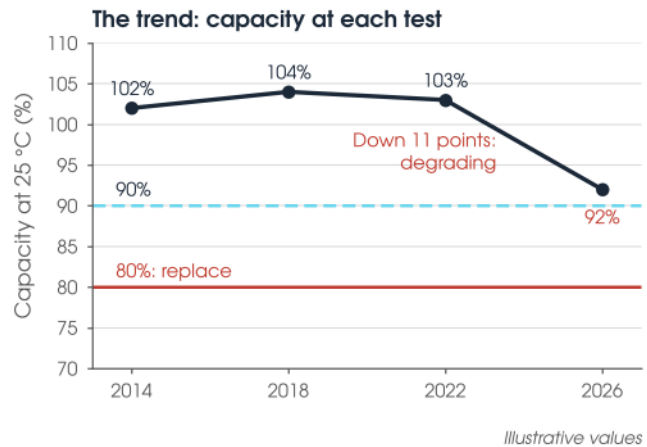
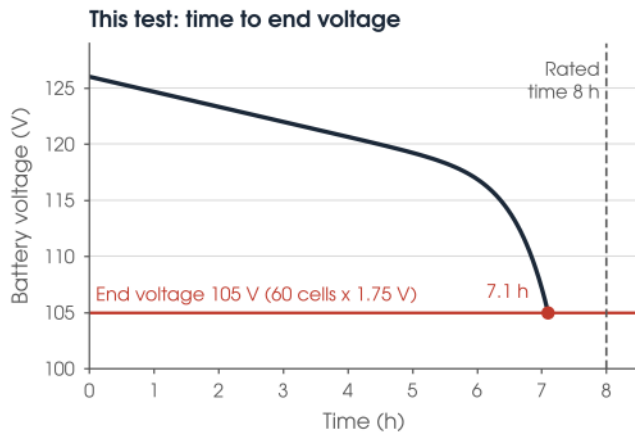
Only if the manufacturer specifically recommends it (IEEE 1188, 6.4).

Undersized Load Cables

The load bank cannot reach the test current (Battcon, 2016).

How Do I Read the Result?

One Test, and the Trend



The latest test gives 92%, above the 80% replacement line but 11 points down on the last test. The battery is degrading and moves to annual testing.

Comparing the Result

Acceptance

Every cell at least 90% of rated capacity (IEEE 450, 6.2).
VRLA: at least 90% of rating unless full capacity is specified (IEEE 1188, 5.2).

Degradation

Capacity more than 10% down on the previous test, or below 90% of rating. Test annually from then on, and at 85% of service life (IEEE 450, 6.3; IEEE 1188, 5.3.1).

Replacement

Replace below 80% of rating (IEEE 1188, Clause 7). Vented: within one year, or at once if rate-adjusted (IEEE 450, Clause 8).

Asset Owner Criterion

The asset owner's specification overrides these where it is stricter.

What a Bad Result Looks Like

Capacity Down Since Last Time

Check the rate, end voltage, temperature and method match the last test, then treat it as degradation.

One Cell Far Below the Rest at the End

A weak cell. Check its ohmic value and connections.

A Cell Reverses

A cell reversing is an indicator for investigation (IEEE 450, Clause 8).

A Hot Connector

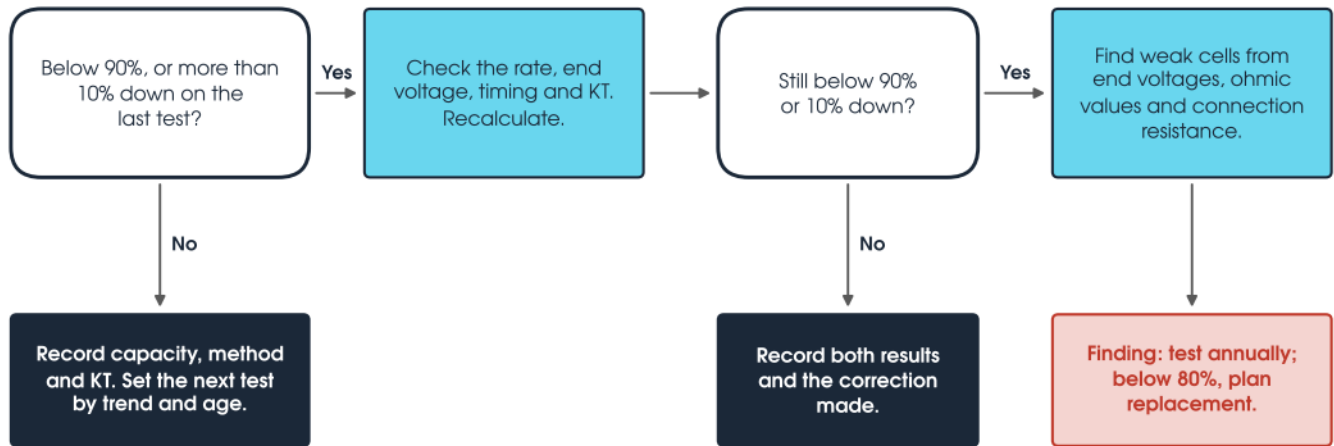
Abnormal intercell connector heating points to a high resistance connection (IEEE 450, 7.5).

Service Test Not Met

Replace unless corrective action gives a satisfactory retest (IEEE 450, Clause 8).

Is My Result OK?

Decision Path



Temperature Correction

A cold battery delivers less. For tests over 1 h, correct the time with the factor KT for the cell temperature before the test (IEEE 450, 7.4.2, Equation 1; IEEE 1188, 6.5.2):

$$C = t_a / (t_s \times KT) \times 100$$

C is capacity at 25 °C (%), t_a the actual time to end voltage and t_s the rated time. KT is 0.942 at 20 °C, 1.000 at 25 °C and 1.045 at 30 °C (IEEE 450, Table 1).

Worked Example

A 60-cell battery rated 8 h to 1.75 V per cell reaches 105 V after 7.1 h at 22 °C (KT 0.966). $C = 7.1 / (8 \times 0.966) \times 100 = 91.9\%$.

What to Report

The Test

Test type, rate, end voltage, actual time, and any bypass downtime.

The Calculation

Method (time or rate adjusted), average cell temperature, KT or Kc, and the capacity at 25 °C.

The Cells

Float voltages before the test, cell voltages at each reading and at the end, and connection resistance.

The Comparison

Change since the last test and the criteria used, on forms that make comparison easy (IEEE 450, Clauses 9 and 10).

What About Ohmic Testing?

Internal Ohmic Values

What Is Measured

Impedance, conductance or resistance of each cell or unit, in seconds and on line. VRLA cells cannot be inspected internally, so ohmic values are the main check between capacity tests (as summarised by EPRI, 2002).

Baseline and Change

Take the VRLA baseline about six months after installation. An impedance rise of 30% to 50%, or a conductance fall of 23% to 33%, is a significant change (IEEE 1188, C.4).

Interpreting Ohmic Values

A Probability, Not a Capacity

There is no direct correlation between an ohmic reading and capacity. At a 30% rise, the chance a cell is below 80% capacity is about 45% (IEEE 1188, C.4).

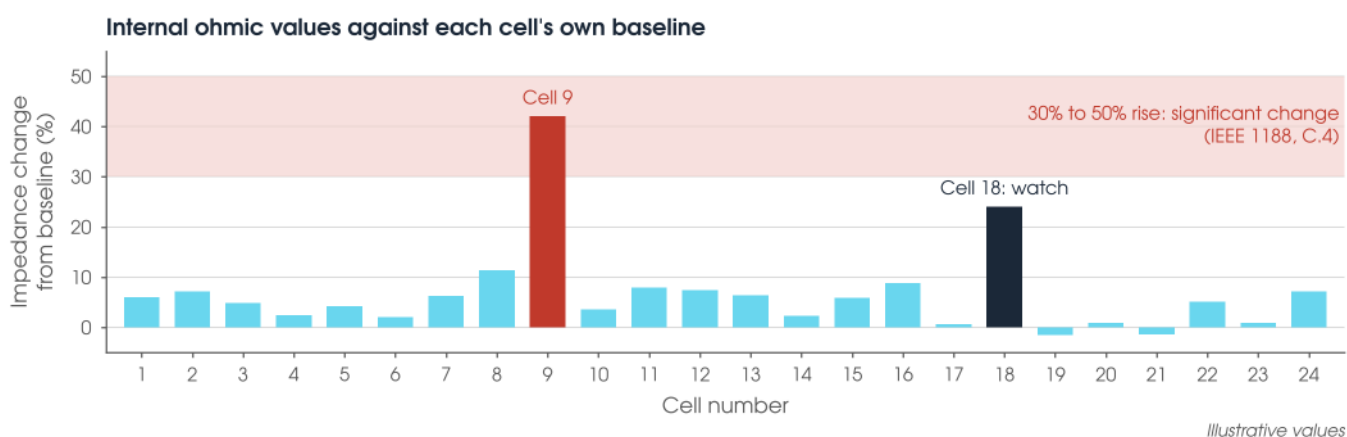
Float Current

More than three times normal float current on VRLA can mean dryout or an internal short (IEEE 1188, C.6).

Good to Know

Monitoring is not a substitute for discharge tests (IEEE 450, 5.2.6).

What an Ohmic Survey Shows



Recommended Solutions

Instrument	Rating	Best used for
Hioki BT3554-50 Battery Tester	6 V and 12 V units, 60 V DC maximum	Internal resistance, voltage and temperature screening of cells and units; handheld
Megger Torkel 930 Discharge Test Set	Up to 300 V DC, 220 A	Capacity tests at constant current, power or resistance, with cell voltage monitoring
Megger TXL870 Extra Load Unit	Adds up to 112 A, 280 V maximum	Larger batteries where the test current exceeds the Torkel 930 alone

Every instrument is calibrated, with Australia-wide delivery and BVM cell voltage modules on request: [battery testing equipment hire](#). Micro-ohmmeters for connection resistance: [micro-ohmmeter hire](#).

Frequently Asked Questions

Common Questions

What is a battery discharge test?

A timed discharge at a constant rate to a set end voltage. The time, corrected for temperature, gives capacity as a percentage of rating.

How often should a substation battery be capacity tested?

Vented within two years of service (IEEE 450, 6.3); VRLA within one year unless acceptance tested on site (IEEE 1188, 5.3.1). Then at no more than 25% of expected life, and annually once degrading or at 85% of life.

Can an impedance tester replace a discharge test?

No. Ohmic values flag weak cells but do not measure capacity (IEEE 1188, C.4).

Can the battery stay on line?

Yes, if the load is raised to make up the charger current (IEEE 450, 7.5). Isolate critical loads first where you can.

Standards and References

IEEE Std 450-2020, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.

IEEE Std 1188-2025, Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications.

Megger, Battery Testing Guide, 2021.

EPRI, Stationary Battery Guide: Design, Application, and Maintenance, 1006757, 2002.

US Bureau of Reclamation, FIST 3-6, Storage Battery Maintenance and Principles, 2020.

Battcon 2016, Performance Testing Lead-Acid Stationary Batteries: Myths, Misunderstandings and Mistakes.

Battcon 2012, Electric Utility Generation and Substation Battery Discharge Testing.

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

More Questions

Does discharge testing wear out the battery?

Not at the IEEE frequency: at most about six discharges over the life of a vented lead-calcium battery that can deliver 40 or more cycles (as summarised by Battcon, 2012).

What end voltage should I use?

The design minimum per cell times the number of cells. 1.75 V and 1.80 V per cell are common for lead-acid (Megger, 2021).

How are DC earth faults found?

By injecting a small signal and tracing it with a clamp-on sensor, without opening circuits. USBR investigates any resistance to earth of 500 kΩ or less (FIST 3-6, section 9).

Does Megavar test as well as hire?

Yes. Our engineers maintain substation DC systems across Australia. Call 1300 730 499.

Hire or Have It Tested

Have It Tested

Megavar's engineers carry out battery maintenance and DC system checks as part of substation maintenance across Australia.

Next Step

[Hire battery testing equipment](#)

[Book substation maintenance](#)

[1300 730 499](tel:1300730499)

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Testing: service@megavar.com.au



Speak to our team today

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