



Thermal Imaging Guide



MEGAVAR

PARTNERS IN
POWER

About This Guide

Electrical thermal imaging finds connections, contacts and components running hotter than they should, on energised plant, without touching it. An infrared camera maps the surface temperature of switchboards, switchgear and substation plant under load, and a hot spot is judged by how far it sits above a similar component or the ambient air. This guide covers what the image can and cannot show, safe inspection and classifying a finding.

What Thermal Imaging Is

A non-contact survey of surface temperature with an infrared camera. Also called electrical thermography or an infrared inspection. Most electrical work is comparative: one phase or connection against its neighbours under the same load.

When It Is Used

On energised plant under load: at first load after commissioning, on the asset owner's routine survey cycle, after work on connections, after overload or fault events, and before an outage to target ductor testing.

Why It Matters

Heat in a connection rises with the square of the current, and a high resistance joint on a loaded board is a fire and failure risk. Imaging finds it in service, before the outage, from outside the arc flash boundary. It is the only routine test that sees the plant working.

Guide at a Glance

Measures

Surface temperature and the temperature difference (delta-T) between a component and a reference.

Method

Infrared camera, energised plant under load, comparing like with like.

Load

Some standards recommend at least 40% of normal load, or the highest normal load (as summarised by Fluke).

Typical Classification

NETA MTS Table 100.18, as reproduced by Fluke: 1 to 3 °C above a similar component warrants investigation; above 15 °C, repair immediately.

Judged Against

A similar component under similar load, the ambient air, the asset owner's severity criteria and the item's own history.

Need the survey done, or the camera to do it? Megavar surveys energised plant across Australia and hires the thermal imaging camera in this guide.



Why Measure Temperature Rise?

Thermal Imaging in Four Numbers

1 to 3 °C

Above a similar component:
warrants investigation
(NETA MTS, via Fluke)

> 40 °C

Above ambient: repair
immediately
(NETA MTS, via Fluke)

40%

Minimum load some
standards recommend
(Fluke)

0.01 vs 0.88

Emissivity, polished copper
against oxidised copper
(Fluke)

Why a Few Degrees Matter

Heat Follows Resistance

Power lost in a connection is $P = I^2R$, so a loose or corroded joint turns load current into heat. Fluke reports a moulded case breaker terminal more than 110 °C above its neighbours from a loose, arc-pitted termination.

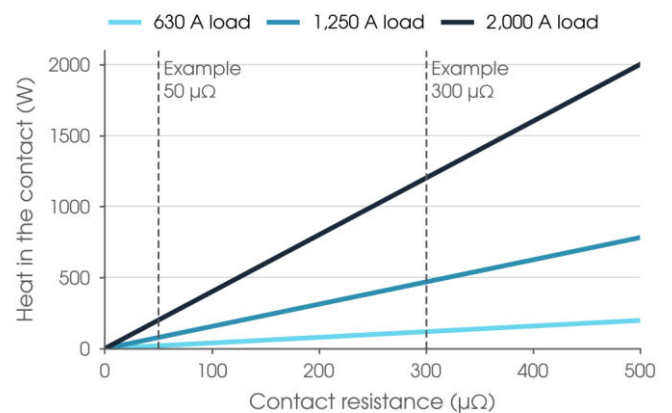
A Self-Feeding Cycle

Heat accelerates oxidation, oxidation raises resistance and higher resistance produces more heat. On a loaded board the end point is a burnt termination, a welded contact or a fire.

Why Other Tests Miss It

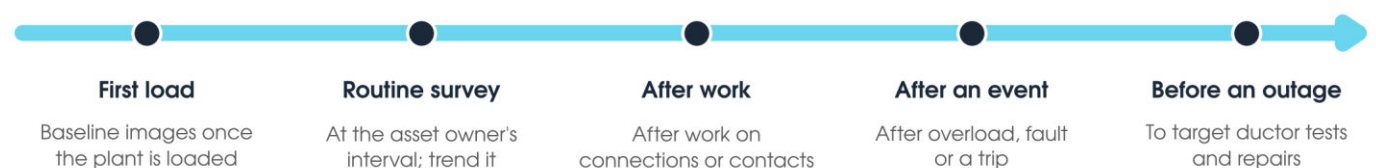
A ductor test finds the joint, but only on de-energised plant at an outage. Imaging sees the joint carrying its real load, so it can target the outage work, but it needs load to see anything.

Heat in a Connection



Illustrative values from $P = I^2R$ at three load currents. Example resistances, not acceptance limits.

When to Survey



Where Is It Used?

Plant Surveyed

Item	What a hot spot points to	Reading type
LV switchboards, MCCs and distribution boards	Loose terminations, worn breaker contacts, phase imbalance, overloaded conductors	Direct, with doors open or through windows
MV switchgear	Hot cable terminations and busbar joints behind panels; only visible through inspection windows	Direct through a window; indirect through a cover
Outdoor substation busbar, clamps and disconnectors	Loose or corroded clamps, misaligned disconnecter jaws, worn contacts	Direct, at a distance
Transformer bushings, tap changers and radiators	Bushing heating, tap changer contact heating, blocked radiators or failed fans; infrared is a recommended in-service test (IEEE C57.152-2025, Table 1)	Indirect: the fault is inside oil
Cable terminations and joints	Poor crimps, loose lugs, water ingress	Direct on bare lugs; indirect through insulation
Oil circuit breakers, bus ducts, pad mount transformers	Internal connection faults seen as a small surface rise	Indirect

Choosing the Reference

A Similar Component

Compare the phase or connection with its neighbours under similar load. NETA MTS Table 100.18, as reproduced by Fluke, bands this difference: 1 to 3 °C, 4 to 15 °C, above 15 °C.

The Ambient Air

The same NETA table also bands the rise over ambient: 1 to 10 °C, 11 to 20 °C, 21 to 40 °C, above 40 °C. EPRI's general categories run from 0.5 to 8 °C (advisory) to above 56 °C (critical).

Our Recommendation

Use the asset owner's written severity criteria where they exist. Where they do not, report the delta-T against a similar component and against ambient, state which scale was applied, and keep direct and indirect readings on separate criteria.

Direct or Indirect

Direct

Little or nothing between the camera and the hot part: a bare lug, a busbar joint, a clamp. The published bands apply.

Indirect

The fault is behind oil, insulation or a cover. EPRI measured an internal bus duct rise about 25 times the rise on the duct surface, and reports a 5 °C rise on an oil circuit breaker often indicating a critical problem. A few degrees can be serious.

Good to Know

Never apply direct-reading bands to an indirect target. One organisation that used 10 °C as its report threshold for everything left an 8 °C rise unreported; a fire followed three weeks later (EPRI).

How Does It Work?

What the Camera Sees

Emitted and Reflected Energy

Every surface emits infrared energy with its temperature. The camera receives that energy plus whatever the surface reflects from its surroundings, and converts the total to a temperature using the emissivity and reflected temperature it has been given.

Emissivity

The fraction of energy a surface emits compared with a perfect emitter. Fluke's table gives 0.01 for polished copper, 0.05 for polished aluminium, 0.88 for copper oxidised black and 0.95 for black electrical tape. Bare, shiny metal emits little and reflects a great deal.

Accuracy

On a high emissivity, moderately warm surface inside the camera's measurement resolution, Fluke gives typical accuracy of $\pm 2^\circ\text{C}$ or 2% of the reading. Below an emissivity of about 0.6 the error grows quickly.

Camera Rules

Set Emissivity and Reflected Temperature

Both are needed for a true temperature. EPRI puts the practical error limit at an emissivity of 0.5; below that, use a high emissivity target, or fit tape or paint only during an authorised isolation, never on live plant.

Know the Spot Size Ratio

A ratio of 250:1 means a target 1 unit across needs the camera within 250 units (EPRI). A target smaller than the measurement spot reads cooler than it is.

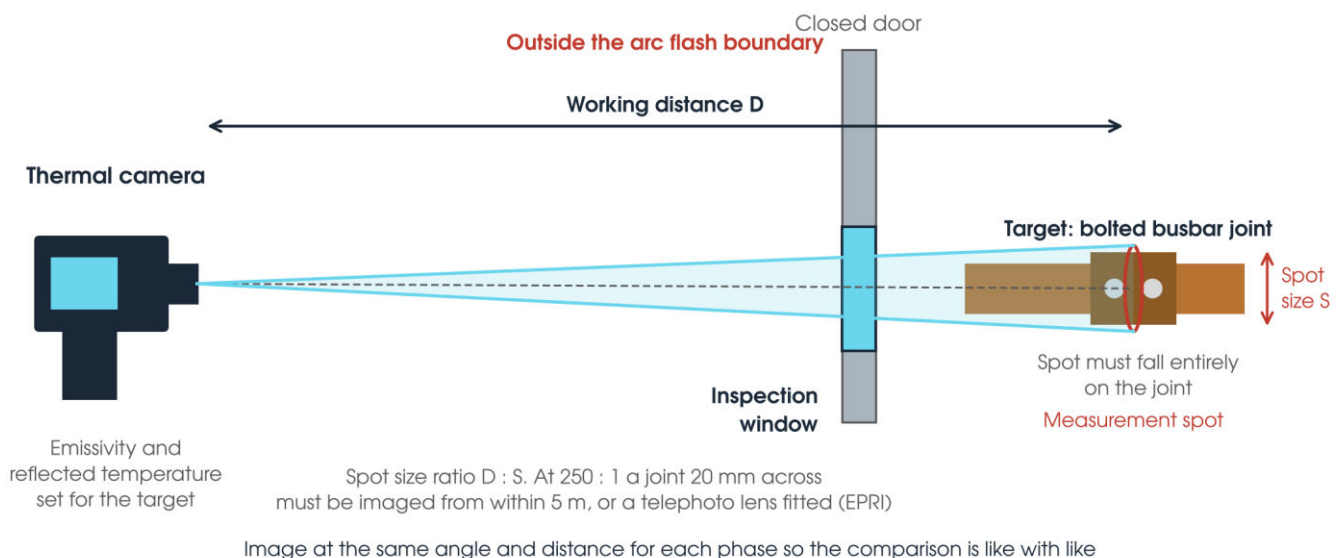
Focus, Then Measure

EPRI shows a focused hot spot losing about a third of its measured rise when defocused at the same distance. Focus matters most on small targets against a cold background such as sky.

Good to Know

If the target is at the same temperature as its background, the camera reads that temperature whatever emissivity is set (EPRI). Emissivity errors appear only where there is a real difference.

Inspection Geometry



The measurement spot must fall entirely on the target. Moving closer or fitting a telephoto lens shrinks the spot; an inspection window keeps the door closed.

How Do I Set Up Safely?

Live Work Under the Asset Owner's Rules

1 It Is Energised Work

The plant stays live and loaded, so the survey is energised electrical work under the WHS Regulations. The Safe Work Australia Code of Practice allows it only where an exception applies, such as the equipment needing to be energised for the work to be done properly.

2 Risk Assessment and SWMS

A competent person assesses the risk, including arc flash, and the work follows a safe work method statement with suitable, tested PPE. A safety observer is needed unless the work is testing only and the assessment shows no serious risk.

3 Windows Before Doors

Image through fitted inspection windows with the enclosure closed. Open a door only under the asset owner's live work rules and permit.

4 Stay Outside the Boundary

Keep outside the arc flash boundary from the asset owner's arc flash study, in the PPE it calls for. Nothing enters the enclosure.

Arc Flash and Plant Hazards

Opening a Door

Fluke warns that opening a door can trigger an arc flash if the latch is defective or dust, debris or pests inside are disturbed. Only authorised, trained people open enclosures containing energised equipment.

MV Switchgear Covers

Never remove covers from energised MV switchgear without an approved method from the asset owner. Without windows, the terminations wait for the next outage.

Attention on the Screen

EPRI's rule: stop, look, identify the plant and its hazards, then raise the camera. Where a safe distance cannot be kept, freeze the image and leave.

Set-Up on an LV Switchboard

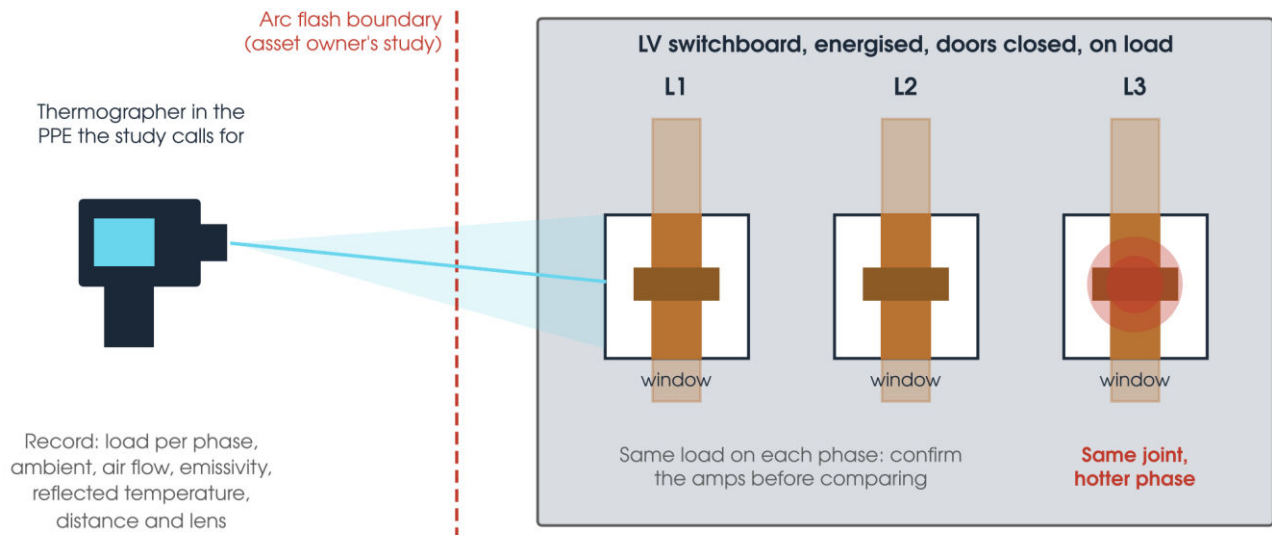


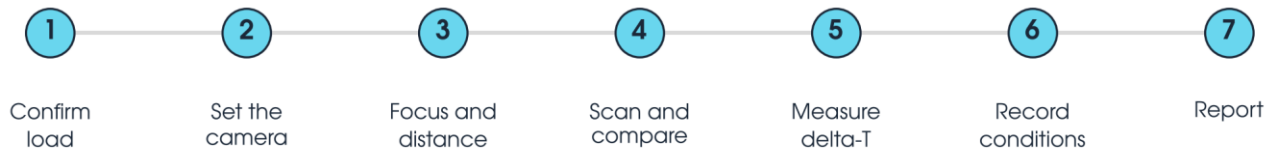
Image each phase from the same position through the fitted windows, on load, doors closed. Compare L1, L2 and L3 at the same joint.

Important

This guide describes general practice for trained thermographers and competent electrical personnel. It is not a work procedure. Work under the asset owner's safety rules, live work rules and arc flash study, 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 Confirm Load

Read the load on each phase and confirm it has been steady. EPRI notes a problem area can take up to an hour to reach its full temperature after a load change. Record the amps.

2 Set the Camera

Enter the emissivity and reflected temperature; through a window, also its transmission and temperature compensation. Set a range above the hottest target.

3 Focus and Distance

Work within the spot size ratio for the lens fitted, focus sharply on the target and image from the same angle for each phase.

4 Scan and Compare

Scan the board or bay for any component that differs from its neighbours, then image each suspect joint with its reference phase in the same frame.

Steps 5 to 7

5 Measure Delta-T

Spot the hot and similar components; measure ambient air with a separate sensor. Record both differences.

6 Record Conditions

Load, ambient temperature, wind or air flow, sun, emissivity and reflected temperature used, distance and lens, direct or indirect reading.

7 Report

Classify each finding on the stated scale, pair the thermal image with a visual image, and name the location so the repair crew finds the same joint.

Good to Know

A phase that is cooler than its neighbours can be a finding too: a failed or open component carries no current and no heat (Fluke).

Common Mistakes

Surveying at Light Load

A high resistance joint at 20% load may show no rise at all. Fluke notes some standards recommend 40% minimum load or the highest normal load.

Reading Bare Metal as Measured

A shiny lug at emissivity 0.1 reflects its surroundings; the number on screen is not its temperature.

Taking a Reflection for a Hot Spot

A hot spot that moves when the camera moves is a reflection. The reflected background still has to be compensated after it moves out of view (EPRI).

Too Far Away

Beyond the spot size ratio the hot spot is diluted by its surroundings. EPRI records a rise dropping from about 96 °C to 89 °C with distance alone.

More Common Mistakes

Ignoring Wind and Air Flow

EPRI reports a 5 km/h breeze cutting the rise of a hot spot in half, and recommends surveys below about 16 km/h. Air conditioning does the same indoors.

Classifying an Indirect Target as Direct

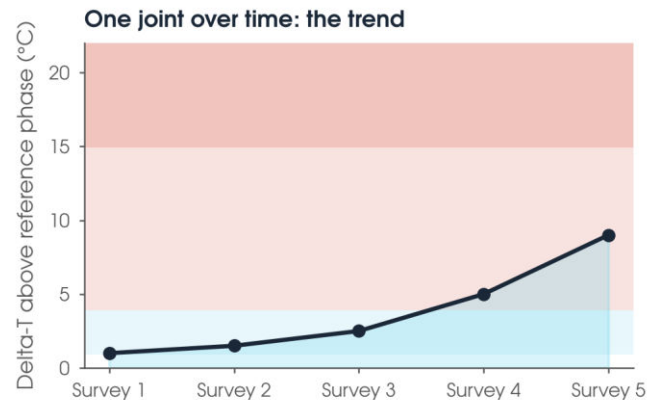
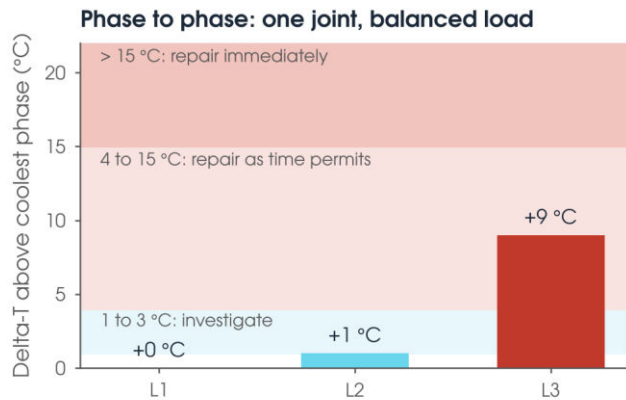
A small surface rise over oil or insulation can be a serious internal fault.

Load Not Recorded

Without the amps, the finding cannot be classified or compared with the next survey.

How Do I Read the Result?

Three Phases, One Joint, and the Trend



Illustrative values. Bands: NETA MTS Table 100.18, as reproduced by Fluke.

L3 is 9 °C above the coolest phase at the same joint under balanced load: a probable deficiency on the NETA scale, as reproduced by Fluke, and climbing survey on survey.

Comparing the Result

Similar Component

NETA MTS Table 100.18, as reproduced by Fluke: 1 to 3 °C above a similar component under similar load is a possible deficiency that warrants investigation; 4 to 15 °C a probable deficiency to repair as time permits; above 15 °C a major discrepancy to repair immediately.

Over Ambient

The same table: 1 to 10 °C investigate; 11 to 20 °C repair as time permits; 21 to 40 °C monitor until corrected; above 40 °C repair immediately.

Asset Owner Criterion

Where the owner has written severity criteria, they apply. EPRI recommends every programme writes its own, with temperature rise as a key parameter and direct separated from indirect.

Trend

Compare with the last survey at a similar load. A joint that is a little warmer every survey is deteriorating even while it stays in the lowest band.

What a Bad Result Looks Like

One Phase Hotter at One Joint

With balanced load, a high resistance connection at that joint. Check the load first: Fluke's example of 30/70/30 A loading is imbalance, not a bad joint.

One Phase Cooler

A component that has failed open, a blown fuse or a lost phase.

A Whole Board Warm

Overload, blocked ventilation or a hot room rather than a single joint. Compare with ambient and with the room.

A Small Rise on an Indirect Target

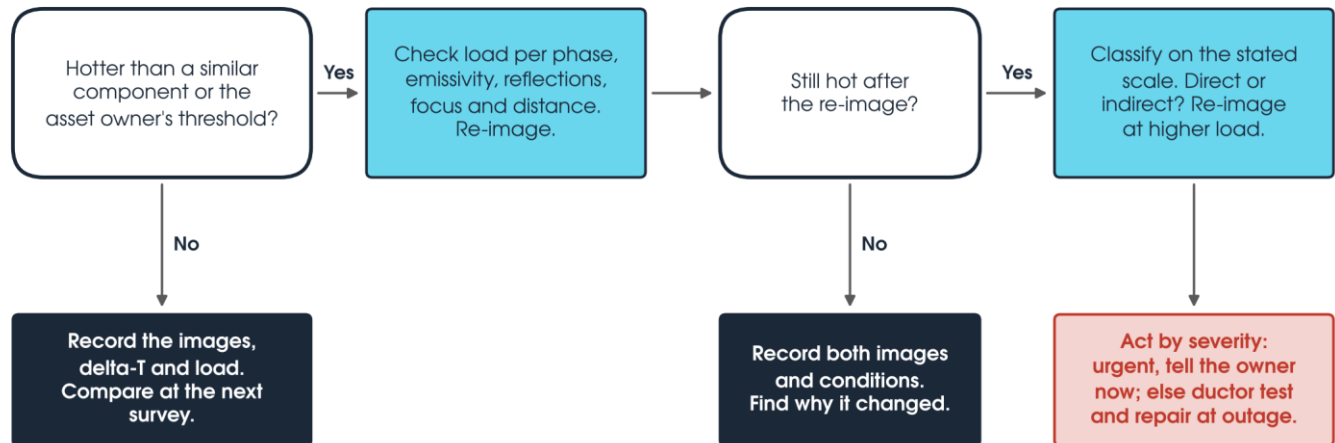
Treat it as potentially serious. EPRI: a problem seen on an indirect target at partial load is probably already critical.

A Hot Spot That Moves

A reflection of a lamp, the sun or the thermographer.

Is My Result OK?

Decision Path



Load Correction

Heat is I^2R , but EPRI shows temperature rise does not follow the square of the load change: radiation varies with the fourth power of temperature, and the measured exponent n lies between about 0.6 and 1.8.

$$\Delta T(\text{full load}) = \Delta T(\text{measured}) \times (100 / \% \text{ load})^n$$

The square law ($n = 2$) is the maximum. EPRI reports full load typically moving a direct finding up one, two or even three categories.

Worked Example

A joint reads 8 °C above its reference phase at 50% load. The square law gives 32 °C at full load; EPRI's exponent range gives 12 to 28 °C. Report the measured 8 °C and the load, note the finding may be two categories higher at full load, and re-image under load rather than reporting a calculated number as measured.

What to Report

For Each Finding

Thermal and visual image, location, the hot spot temperature, the delta-T against a similar component and against ambient, and the scale used to classify it.

The Conditions

Load per phase, ambient, wind or air flow, sun, emissivity and reflected temperature set, distance and lens, direct or indirect.

The Comparison

The change since the last survey at a comparable load.

Traceability

Camera model, serial number and calibration date, and the thermographer's certification.

How Do I Classify a Hot Spot?

Three Published Scales

NETA MTS Table 100.18

As reproduced by Fluke: delta-T against a similar component under similar loading (1 to 3, 4 to 15, above 15 °C) or against ambient (1 to 10, 11 to 20, 21 to 40, above 40 °C), with a recommended action for each band. Fluke describes it as reasonable guidance in the absence of a consensus standard.

EPRI General Categories

Rise above an established reference: advisory 0.5 to 8 °C, intermediate 9 to 28 °C, serious 29 to 56 °C, critical above 56 °C.

MIL-STD-2194

As reproduced by EPRI, rise above ambient: desirable 10 to 24 °C, important 25 to 39 °C, mandatory 40 to 69 °C, immediate 70 °C or more.

Using Them

Choose and State the Scale

The scales do not agree, so a report that gives a category without naming the scale cannot be checked. State the scale, the reference used and the load.

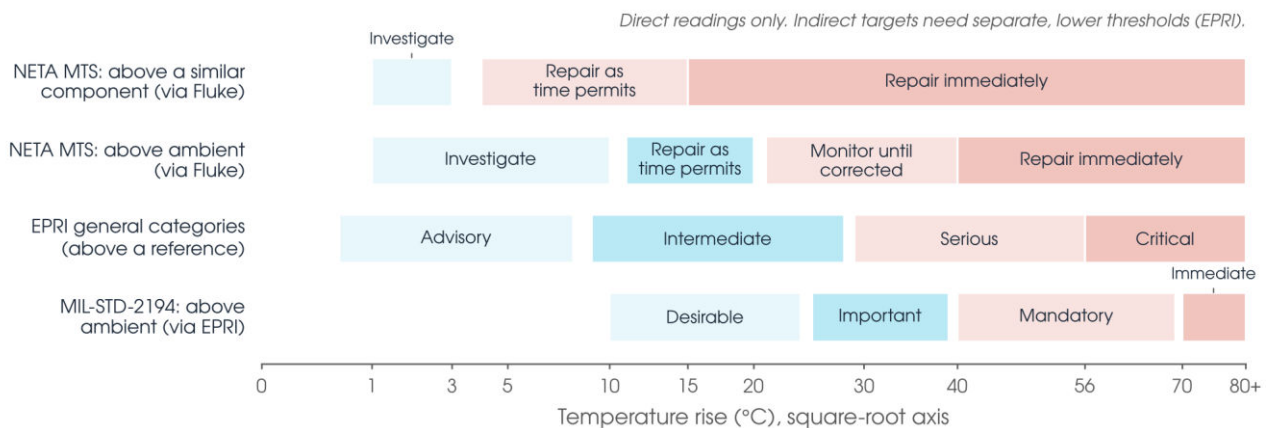
Direct Targets Only

All three scales are written for direct readings. EPRI's position is that any published criteria that do not separate direct from indirect ought to be revised; use separate, lower thresholds for indirect targets.

Good to Know

Temperature is not the only input. EPRI weighs load, spot size and distance, wind, emissivity, ambient and background, sun, and how direct the reading is before assigning severity, and then the criticality of the plant.

The Scales Side by Side



Recommended Solutions

Instrument	Resolution and range	Best used for
FLIR E75	320 × 240; -20 to 650 °C; 42°, 24° and 14° lens options	Switchboards, MCCs and switchgear through inspection windows; outdoor substation busbar, clamps and bushings at a safe standoff with the telephoto lens

The camera is available calibrated, with lenses and software, from Hobart, Launceston, Adelaide and Newcastle: [thermal imaging camera hire](#).

Frequently Asked Questions

Common Questions

What is the main purpose of thermal imaging in electrical systems?

To find connections, contacts and components running hotter than their neighbours while the plant is energised and loaded, before they fail. Most of the work is comparing one phase or joint with a similar one under the same load.

What are the electrical thermal imaging standards in Australia?

There is no Australian standard that sets hot spot limits. ISO 18434-1 gives general thermography procedures and ISO 18436-7 the thermographer certification framework that AINDT administers; energised work sits under the WHS Regulations and the Safe Work Australia Code of Practice, with AS/NZS 4836 for LV work. Severity bands come from publishers such as NETA and EPRI and from the asset owner.

Can electricians do thermal imaging?

Yes, with training. The camera is simple; the interpretation is not. Fluke notes imagers are often used ineffectively, and EPRI shows how load, wind, distance and emissivity change the reading. Asset owners commonly specify AINDT-certified thermographers for survey work.

How much load does the plant need?

Enough to make a bad joint warm. Fluke notes some standards recommend a 40% minimum load or the highest normal load, and EPRI reports many thermographers will not survey below 40 to 50% load.

Standards and References

ISO 18434-1:2008, Condition monitoring and diagnostics of machines, Thermography, Part 1: General procedures.

ISO 18436-7, Condition monitoring and diagnostics of machines, Requirements for qualification and assessment of personnel, Part 7: Thermography.

AS/NZS 4836:2023, Safe working on or near low-voltage and extra-low voltage electrical installations and equipment.

Safe Work Australia, model Code of Practice: Managing Electrical Risks in the Workplace, Chapter 6 (energised electrical work).

IEEE Std C57.152-2025, Guide for Diagnostic Field Testing of Fluid-Filled Power Transformers, Regulators, and Reactors, Table 1 and Annex C (infrared).

Fluke, Electrical Inspections Using Thermal Imaging (J. White, Shermco), reproducing ANSI/NETA MTS Table 100.18.

Fluke, Introduction to Thermography Principles, 2009.

EPRI, Infrared Thermography Program Guideline, 1004019, 2001, including Appendix D (common misconceptions) and MIL-STD-2194 (1988) criteria.

More Questions

Can the camera see inside sealed switchgear?

No. It sees surfaces. Fit inspection windows, or treat the reading as indirect with its own lower thresholds, and use ductor testing at the outage.

Why does bare copper read cooler than the tape next to it?

Emissivity. Polished copper is about 0.01 and black tape 0.95 (Fluke). The copper reflects its surroundings instead of emitting; the two can be the same temperature.

How often should switchboards be surveyed?

At the interval in the asset owner's maintenance plan, adjusted for criticality, condition and previous findings. Re-image after a repair under comparable load.

Does Megavar survey as well as hire?

Yes. Our AINDT-certified thermographers survey substations, switchboards and renewable plant across Australia. Call 1300 730 499.

Hire or Have It Tested

Have It Surveyed

Megavar's engineers carry out thermography surveys within substation maintenance, substation commissioning and circuit breaker testing across Australia.

Next Step

[Hire a thermal imaging camera](#)

[Book a thermography survey](#)

[1300 730 499](#)

Hire: rentals@megavar.com.au

Testing: service@megavar.com.au



Speak to our team today

megavar.com.au



service@megavar.com.au

1300 730 499