ELI FIELD CHECKLIST • L2 HAZARD

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# Termination Verification: Torque + Thermographic Field Checklist

## A two-stage checklist for industrial terminations — install and inspect

A loose aluminum lug, undertorqued at install and never re-checked, was sufficient to destroy a generator transfer switch and start a fire two years later. The fire happened because the protection against this failure mode is not the breaker — breakers don't trip on resistive heating within their rating. The protection is the torque wrench at install and the IR camera at maintenance.

Use Section A on every new termination at install or after any work that disturbs a connection. Use Section B on a defined cycle for every distribution panel, transfer switch, and feeder termination in the plant. File completed checklists with the equipment maintenance record.

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**COMPANION RCA**

275 In-Lbs: How a Loose Aluminum Termination Burned Down a Transfer Switch

**AUDIENCE**

E&I journeymen, commissioning agents, plant maintenance

**STANDARDS**

CEC §12, NEC 110.14(D), NETA MTS, CSA C22.2 No. 65

**Use this checklist on every termination during commissioning and as part of every periodic thermographic survey of distribution equipment.** Each item must be verified by a qualified person and signed off on the work order. The procedures here are general industry guidance — verify your site's specific torque values from the equipment label and your IR thresholds from your governing standard before relying on them in the field.

## A.1 CONDUCTOR AND CONNECTOR PREPARATION (COMMISSIONING)

- [ ] **Connector listing verified.**
  Verify the connector listing (AL, CU, or AL/CU) matches the conductor type. CU-only connectors on aluminum conductors will degrade and fail regardless of torque. Inspect the marking on the lug body before install.

- [ ] **Conductor stripped to manufacturer-specified length.**
  Strip length per the connector data sheet. Inspect for nicked or broken strands — damaged conductors must be cut back and re-stripped, not installed.

- [ ] **Aluminum conductors wire-brushed through anti-oxidant compound.**
  Apply listed anti-oxidant compound to the conductor before insertion, then wire-brush through the compound to break the oxide layer while the compound seals the freshly exposed metal. Wire-brushing the bare aluminum first and then applying compound does not break the oxide the same way — sequence matters.

- [ ] **Compound type listed for use with the specific connector.**
  Verify the anti-oxidant compound is listed for use with both the conductor and the connector. Generic substitutes are not acceptable. Excess compound on insulation should be wiped clean before insertion to prevent tracking.

**COMPOUND APPLICATION SEQUENCE**

Apply listed anti-oxidant compound to the aluminum conductor *before* wire-brushing. Wire-brush *through* the compound to break the oxide layer while the compound seals the freshly exposed metal. The compound is not a finishing step — it is part of the preparation. Excess compound on insulation should be wiped clean before insertion to prevent surface tracking.

## A.2 TORQUE APPLICATION AND VERIFICATION (COMMISSIONING)

- [ ] **Torque value read from the equipment label or manufacturer data sheet.**
  Do not rely on memory or rules of thumb. Read the torque value from the printed source for this specific connector. Equipment labels often supersede the data sheet — verify both.

- [ ] **Calibrated torque tool used.**
  Calibration date within the last 12 months per ANSI/NETA MTS-2023 Section 5.3. Hand-tight or calibrated-by-feel torque is not an acceptable substitute, regardless of installer experience.

- [ ] **Torque applied in a single smooth motion to the spec value.**
  Do not over-shoot and back off. Do not bounce the wrench. A single smooth pull to the click or to the displayed value is the only valid technique.

- [ ] **Actual torqued value documented per termination.**
  Record the actual value applied, not 'torqued to spec.' One row per termination on the commissioning record. This is your audit trail if anything fails years later.

- [ ] **Witness sign-off where required by site procedure.**
  Site procedures may require a second qualified person to witness and co-sign. Verify the site requirement and document accordingly.

> **TORQUE TOOL CALIBRATION — NETA MTS-2023 SECTION 5.3**
>
> Verify the torque tool calibration sticker shows a date within the last 12 months. Hand torque (calibrated by feel) is not an acceptable substitute. Document the actual torque value applied — not `'torqued to spec'` — on the commissioning record.

## A.3 RE-TORQUE AFTER FIRST THERMAL CYCLE (COMMISSIONING)

- [ ] **Connector data sheet checked for re-torque requirement.**
  Some aluminum connector listings require a re-torque step after the first major thermal cycle to compensate for cold-flow settling. Verify the requirement from the data sheet — do not assume.

- [ ] **First thermal cycle completed under normal load.**
  The joint must experience real load and corresponding heating before the re-torque is meaningful. A cold re-torque immediately after install is not the same operation.

- [ ] **Re-torque applied to the same specification as initial install.**

Use the same calibrated torque tool at the same spec value. The connector is expected to accept additional rotation at the spec value as the conductor settles.

- [ ] **Re-torque value documented on the commissioning record.**
  Re-torque is a hold-point. Document the date of the thermal cycle, the load condition, and the re-torque value. Equipment is not released to service without this record.

**ALUMINUM COLD-FLOW RE-TORQUE**

Aluminum conductors deform plastically under the pressure of a torqued lug — known as cold flow. After the first major thermal cycle, the conductor settles and the joint relaxes. The re-torque step restores the design clamping force.

**IF THE CONNECTOR DATA SHEET SPECIFIES RE-TORQUE, TREAT IT AS A HOLD-POINT — DO NOT RELEASE THE EQUIPMENT TO SERVICE WITHOUT IT.**

## B.1 THERMOGRAPHIC SURVEY PRE-CONDITIONS (MAINTENANCE)

- [ ] **Survey scheduled at minimum 40% of normal load.**
  Per ANSI/NETA MTS-2023 Section 9, surveys should be performed during periods of maximum possible loading, with a minimum of 40% load. Surveys at light load may miss developing high-resistance joints because temperature rise scales with the square of the current.

- [ ] **Panel covers removed or IR-transparent windows in service.**
  Closed panels prevent direct line-of-sight to terminations. Either remove covers under appropriate energized-work procedures, or use permanently installed IR windows rated for the equipment class.

- [ ] **Camera capable of detecting minimum 1°C ΔT at 30°C ambient.**
  Minimum sensitivity per NETA MTS Section 9.3. Lower-end consumer cameras may not resolve developing joints at the threshold values in Table 100.18.

- [ ] **Ambient air temperature and load conditions recorded.**
  Recorded at the time of inspection on the survey report. ΔT values cannot be interpreted without these reference conditions.

- [ ] **Qualified IR thermographer performs the survey.**
  Level I thermographer minimum; Level II preferred for distribution equipment. Qualifications recorded on the survey report. An uncertified user with a thermal camera is not a thermographic survey.

**SURVEY CONDITIONS — NETA MTS-2023 SECTION 9**

Surveys must be performed under load — minimum 40% of normal operating load. Heating at a high-resistance joint scales with $I^2R$, so a joint that shows ΔT of 8°C at full load may show only ΔT of 1°C at 25% load — below the action threshold and invisible to the survey.

## B.2 ACTION THRESHOLDS — NETA MTS TABLE 100.18 (MAINTENANCE)

- [ ] **ΔT between similar components under similar loading evaluated.**
  Compare the suspect termination against an adjacent termination of the same type carrying similar load. This comparison removes ambient and load variation from the assessment.

- [ ] **ΔT between component and ambient air evaluated.**
  Use this comparison when no similar component is available for reference. Thresholds are higher because ambient is colder than an energized adjacent termination.

- [ ] **Discrepancy classification recorded per Table 100.18.**
  Record the classification and corresponding recommended action. This is the link between the survey and the work order.

- [ ] **Hot spots photographed with both visual and thermal images.**
  Required documentation per NETA MTS Section 9.2. Both images are needed for the maintenance team to locate the finding and act on it.

**NETA MTS TABLE 100.18 — SUGGESTED ACTIONS BASED ON TEMPERATURE RISE**

`ΔT 1–3°C similar / 1–10°C ambient` → possible deficiency, warrants investigation. `ΔT 4–15°C similar / 11–20°C ambient` → probable deficiency, repair as time permits. `ΔT 21–40°C ambient` (no similar comparison) → monitor until corrective measures can be accomplished. `ΔT >15°C similar / >40°C ambient` → major discrepancy, repair immediately.

## B.3 SURVEY DOCUMENTATION AND TRENDING (MAINTENANCE)

- [ ] **Each finding recorded with full data.**
  Location, ΔT (similar and ambient), classification, recommended action, photographs, ambient and load conditions. One row per finding on the survey report.

- [ ] **Findings entered into the equipment maintenance record.**
  Findings live in the asset record, not just the survey report. The next survey compares against this baseline.

- [ ] **Repeat surveys compared against previous baseline at the same load.**

A termination showing ΔT growth between cycles is degrading even if the absolute value is below the action threshold. Trending is the early-warning system.

- [ ] **Repaired items re-scanned to verify correction.**
  A repair without verification is not a repair. Re-scan after re-energization at the same load condition; record the post-repair ΔT in the asset record.

**TRENDING — THE VALUE OF REPEAT SURVEYS**

A single survey shows a snapshot of joint health. A trending program shows whether a joint is degrading.
**INVESTIGATE ANY TERMINATION SHOWING ΔT GROWTH BETWEEN CYCLES, EVEN IF THE ABSOLUTE VALUE IS BELOW THE TABLE 100.18 ACTION THRESHOLD.**

Joints don't fail suddenly — they degrade for months or years before they ignite.

## REFERENCE STANDARDS

- **CSA C22.1 (CEC) §12** — Wiring methods; conductor terminations; torque to manufacturer specification
- **CSA C22.2 No. 65** — Wire connectors — mechanical and performance requirements
- **NFPA 70 (NEC) 110.14(D)** — Calibrated torque tool required where numeric torque is specified
- **ANSI/NETA MTS-2023 §9** — Thermographic survey procedure; action thresholds (Table 100.18)
- **ANSI/NETA MTS-2023 §5.3** — Test instrument calibration (12-month cycle)
- **NFPA 70B** — Recommended Practice for Electrical Equipment Maintenance
- **IEEE 142 (Green Book)** — Industrial and commercial power systems grounding and bonding

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