Monitoring of Large Electric Motor Power Terminations for Effective Detection of Hot Connections

Date: 11 August 2014

Forum: EPRI LEMUG

Venue: Crowne Plaza Hotel, Cromwell, CT, USA

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Introduction

Eskom & others have had UCLF due to motor hot connections

- Can a hot-connection be prevented/detected with off-line test methods?
  - Acceptable phase resistance imbalance at motor & breaker ends has not
- Is a tight connection ≅ good current flow contact?
  - It may be a hot connection
  - Maximizing the area of low resistance to current flow is the joint objective
- How effective is periodic IR Thermography?
  - Requirements for skill – these tools are not typical point-and-shoot cameras
  - Access to bare terminals while on-load is virtually impossible – personnel safety
- How effective is monitoring air temperature within the Terminal Box?
  - An Eskom initiative after resultant flashovers experienced within TBs

Purpose of Presentation

1. The consequences of hot connections on electric motor power terminals
2. Deficiencies with techniques presently applied to identify hot connections
3. Findings from the experiment conducted to determine the effectiveness of applied techniques

Consequences of Hot Connections

Komati P.S EFP Motor in 2012

Flashover in Neutral Terminal Box

Consequences of Hot Connections

Matla P.S PA Fan Motor in 2006 **Flashover in Line Terminal Box**

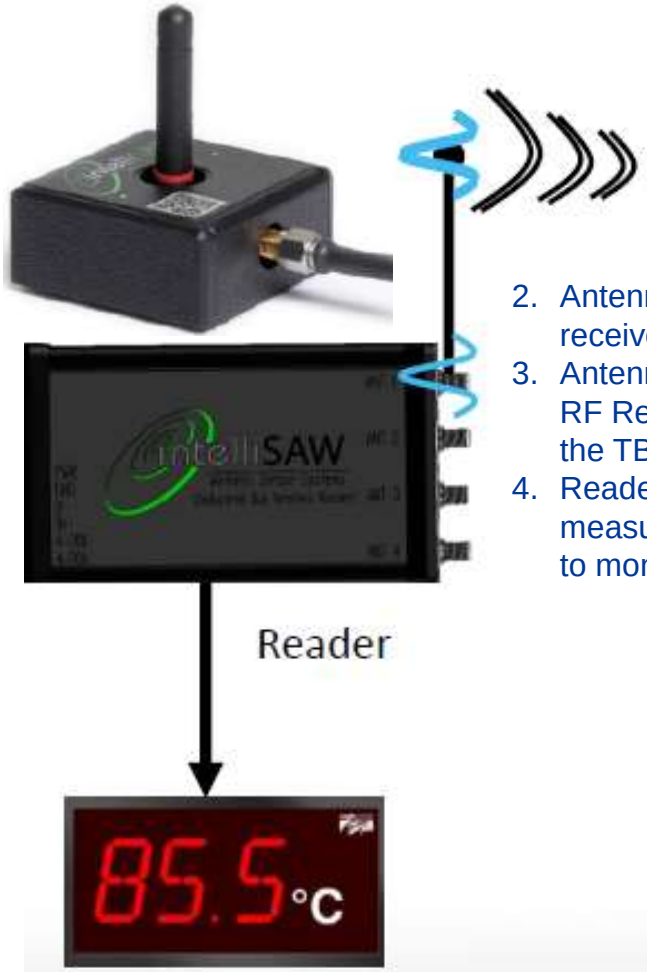
Consequences of Hot Connections

1. Thermal damage to power terminal/s, insulator/s and tail lead/s
   - Localized arcing on loose current carrying terminal/s
   - Overheating on conductors with high resistance to current flow
2. Flashover within terminal box/es
   - 3-phase short circuits
   - Equipment damage and potential personnel injury
3. Production losses
   - For the duration of motor Time to Restore
4. Costs for damaged motor replacement and repair.
   - Damaged tail leads may necessitate winding replacement
   - Motors without flashover vents have had extensive stator core damage

Hot Connection Detection Techniques

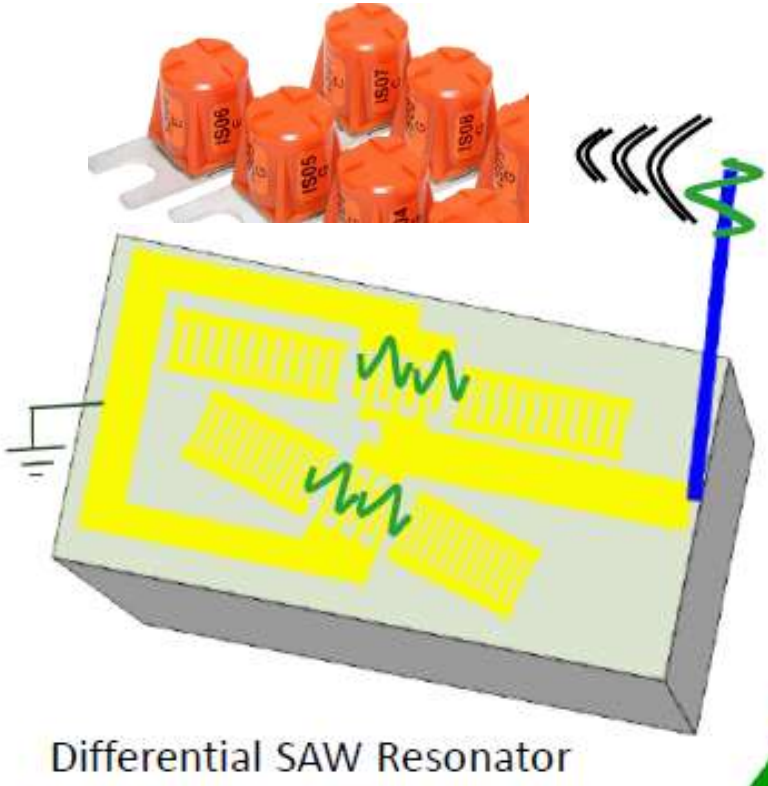
1. Infrared Thermography Scanning
   - Periodic, 3-monthly being the norm
   - Motor scanning, not focused on power TBs
   - Requires skilled thermographer
2. Monitoring Terminal Box Internal Air Temperature
   - Continuously on-line
   - Basis: Hot connection raises air temperature within the TB
3. Direct Temperature Measurement of Power Terminals
   - As applied on Switchgear using wireless sensor systems, e.g IntelliSAW IS485
   - Continuously on-line

Wireless Technology Operating Principle



2. Antenna within TB receives Sensor RF
3. Antenna hard-wired to RF Reader external to the TB
4. Reader communicates measured temperatures to monitoring system

1. Passive Sensors on each Terminal operate at unique frequency



Experiment Conducted

Purpose:

To test the effectiveness of 3-methods;

1. Terminal Box Thermography Scan

2. Terminal Box Internal Air Temp.

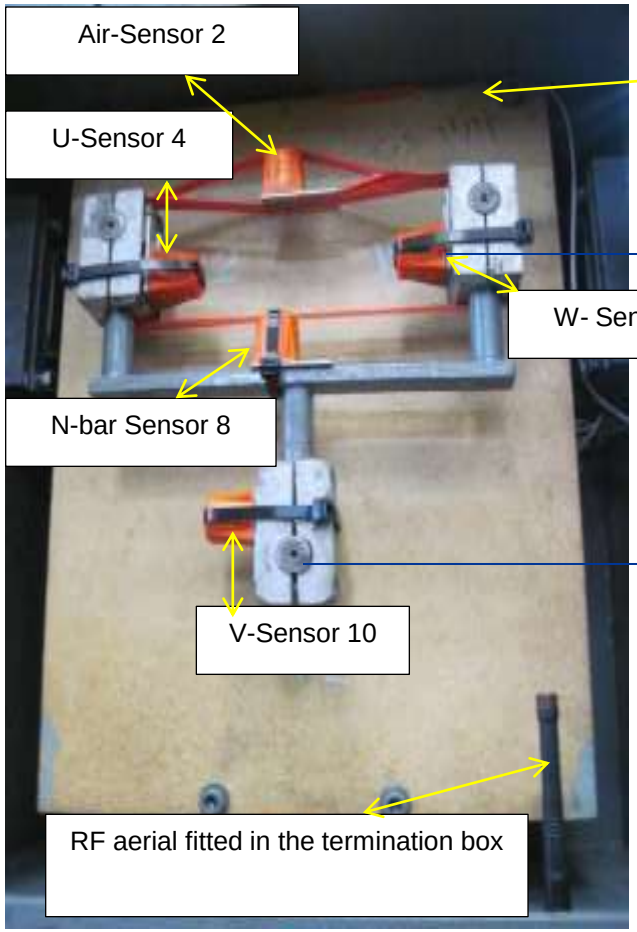
3. Direct Terminal Temp. Monitoring

Method:

1. Induce a hot, but tight, joint on one of three power terminals

1. Run motor (6.6 kV, 3.72 MW) at no load (112 Amps) for 1-Hour

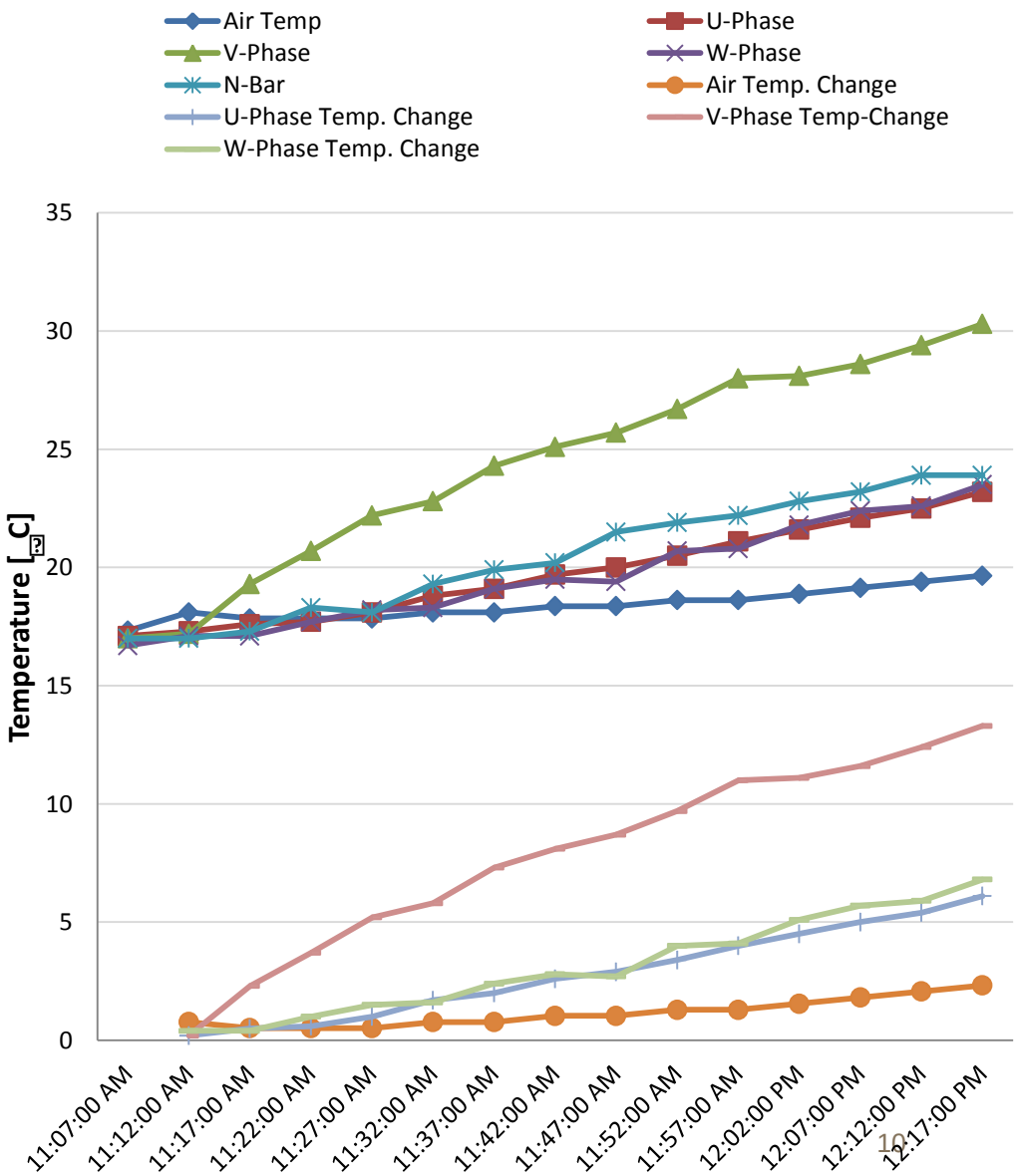
2. Monitor nominal and change in measured temperatures by the three methods



Air temperature RTD

Hot connection induced at V-phase Terminal

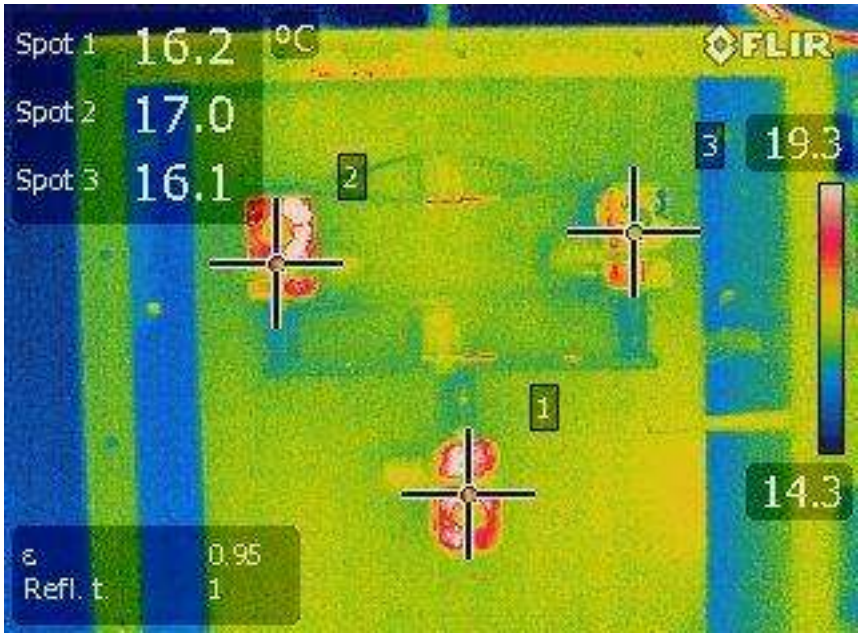
Experiment Results



1. Imbalance of winding resistances was well within limits (0.21%)
2. IR Thermography scans on the closed terminal box showed no change in skin temperature over the test duration
3. Internal air temperature change was the lowest and 2nd least representative of the hot connection on one of the terminals
4. The change in nominal temperatures of the three terminals indicated a defect within 10-minutes of motor operation and throughout the routine test period

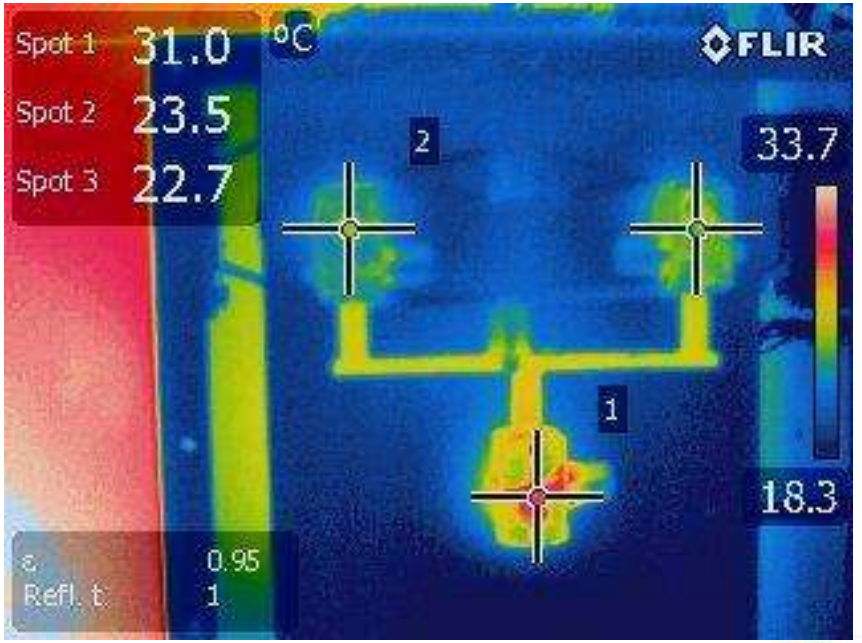
Open TB Thermography Scans

Terminals Start Temps

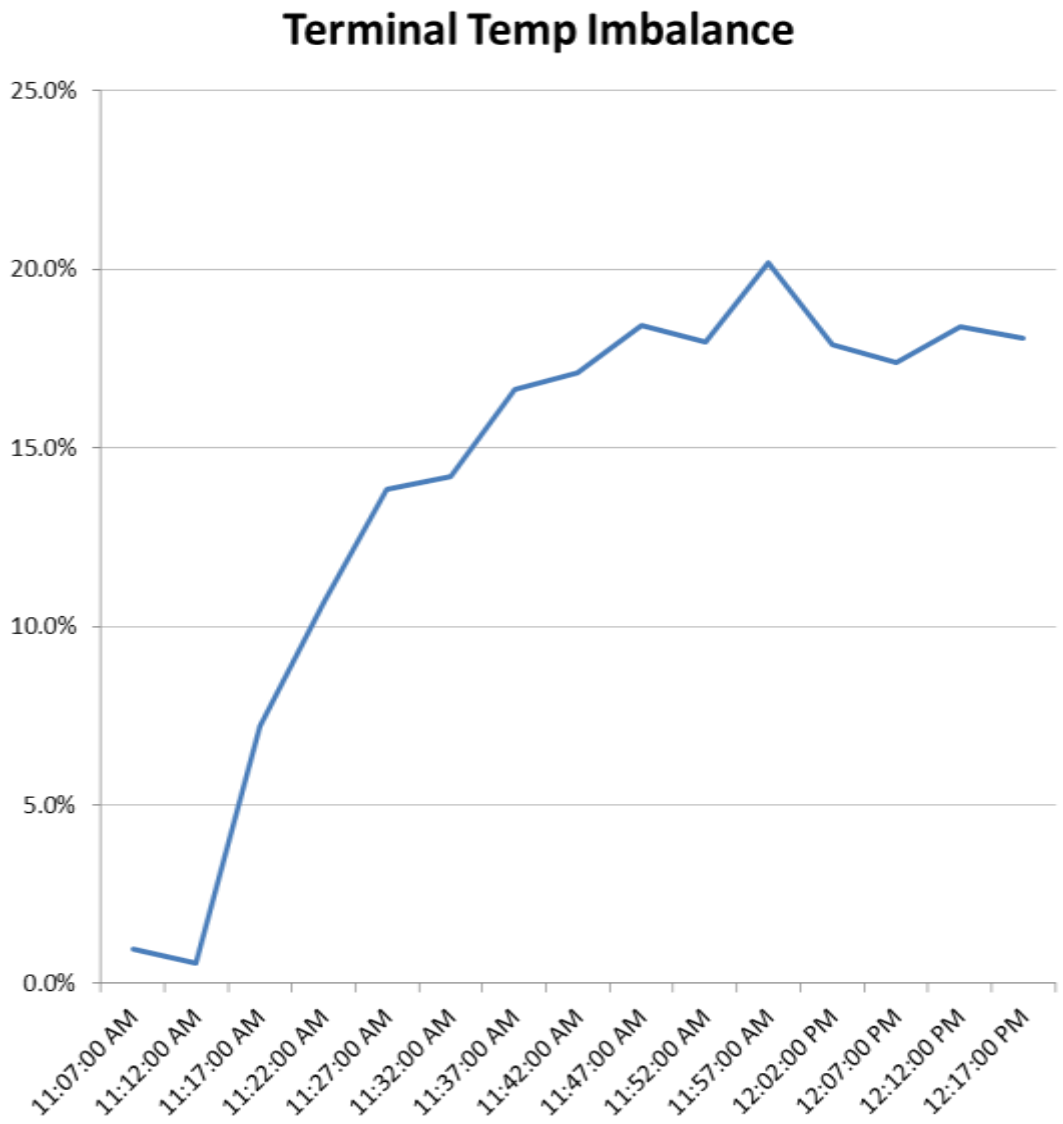


Terminals End-Temps

- Same as wireless system end-temps



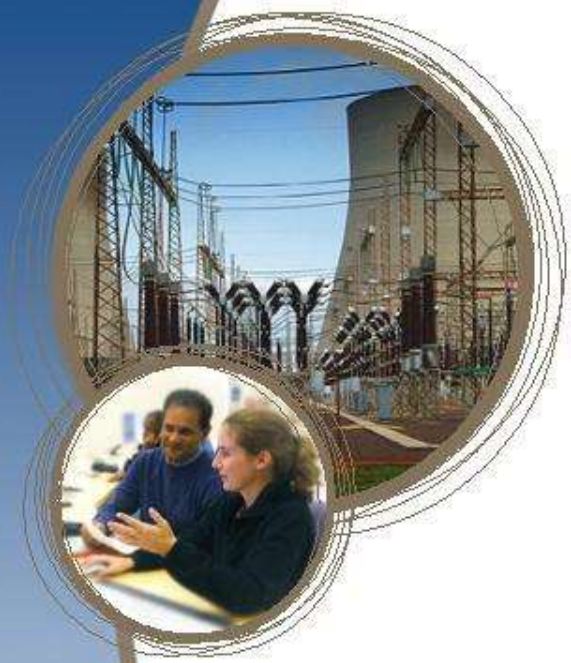
Lessons Learnt



- Only the direct measurement method can provide comparison of actual terminal temperatures
- On-line continuous recording of all terminal temperatures is the most useful strategy that can be adopted
- Monitoring and alarming on temperature imbalance is the quickest and most effective method for detecting hot connections to enable elimination of any during initial motor start-up, well before thermal damage occurs

Conclusion

1. Hot connections on motor power terminals result from;
   - Loose connections, but
   - Tight connections can also be hot if resistance to current flow is high
2. Hot motor power terminations cause flashovers that may lead to costly plant equipment, production losses, and personnel injury
3. The following are ineffective hot connection prevention and detection techniques;
   - Off-line measurement of motor circuit resistance imbalance
   - Periodic IR Thermography scans – the least effective method
   - On-line monitoring of air temperature within terminal boxes – slow indicator
4. Directly measuring the temperature of power terminals is the most effective technique for detecting hot connections.



Thank you