



Mysteries: Cable That Melted at 60% Load

11 June 2026

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Emeritus Professor Akhtar Kalam

EIT EMERITUS PROFESSOR



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- Bachelor of Engineering Technology in Electrical Engineering (SAQA 123645)

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- For the Engineering College of Technology (ECT) visit: <https://www.ect.ac.uk/>
- For the Engineering College of Science and Technology (ECST) visit: <https://www.ecst.ac.za/>

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Introduction – Presenter



Emeritus Professor Akhtar Kalam

Emeritus Professor at Victoria University and EIT.

Academic Director and Chair of the Academic Board - Texila College Australia.

Director of Al-Kalam Educational Solutions.

Editor-in-Chief of AJEEE

Distinguished Professor/Adjunct Faculty in Australia, India, Malaysia and Oman.

He has published over 610 publications in his area of expertise and has written over 29 books.

Supervised 51 postgraduate research students to graduation, including 39 PhD's and 12 MEngs. Currently, 10 postgraduate research students (four PhD students at VU and six DEng students at EIT) are being supervised.

Public, University, and Motivational Lecturer.

Consultant for the electricity supply industries in Australia and overseas.

Assisted in change management plans for Universities and the higher education sector.

Education

The University of Bath, Bath, UK, D.Eng., Electrical Engineering

The University of Oklahoma, Norman, USA, MS, Electrical Engineering

Aligarh Muslim University, Aligarh, India, BSc. Eng., Electrical Engineering

St Xavier's College, Calcutta, India, Applied Science

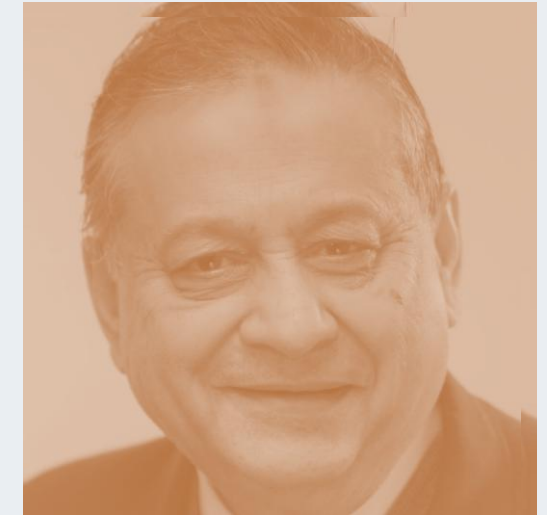
Professional Society Activities

Australian Institute of Energy – Fellow

Engineers Australia – Fellow

The Institution of Engineers and Technology, UK – Fellow.

The Institution of Electrical and Electronic Engineers, USA –Life Senior Member.



“My vision is to provide exciting higher education science and engineering courses, research, consultancy and collaborate in development work of the industry and communities within Australia and beyond.”

Agenda

1	Learning Objectives
2	The Incident
3	Understanding Ampacity
4	Standards Applied
5	Lessons Learned
6	Discussion Exercise
7	Q&A



Learning Objectives

By the end, participants should:

- Understand cable ampacity assumptions
- Analyse thermal failure mechanisms
- Evaluate hidden derating factors
- Apply standards in troubleshooting
- Investigate practical failures systematically



The Incident

Actual field report

Industrial plant:

- 415V three-phase feeder
- XLPE cable
- 240A measured load
- Cable rated 400A
- Cable temperature reached: 130°C
- Insulation softened
- Outer sheath melted

Load = only 60%

Question:

Why?



Initial Assumption

Typical engineering thought process

Rated current: 400A

Actual: 240A

Loading: $240/400 = 60\%$

Expected: Safe operation

Actual: Failure



Cable Rating Is Conditional

Cable ratings assume:

- Ambient temperature
- Free air or known installation
- Standard soil conditions
- Single cable installation
- Limited harmonics
- Balanced loading



CABLE SIZING MADE SIMPLE: THE 5-STEP COMMERCIAL INSTALL CHEAT SHEET (UK)

Commercial cable sizing is easiest when you follow a repeatable workflow. Use this quick guide for confident commercial cable sizing that supports compliance, performance, and fewer call-backs

- Define the Load**
Calculate design current (I_b), duty cycle, and sensible diversity to prevent oversizing or risky assumptions.
- Choose Protection**
Match MCB/MCCB/fuse, then confirm real cable current rating after derating factors.
- Apply Derating**
Allow for heat, grouping, insulation, and harmonics to keep the installation stable.
- Check Voltage Drop**
Run a clear voltage drop calculation for long routes and sensitive equipment.
- Prove Fault Safety**
Confirm PFC, CPC sizing, and disconnection times for solid BS 7671 cable sizing.

www.meteorelectrical.com

Understanding Ampacity

Ampacity definition:

Maximum current without exceeding temperature limits

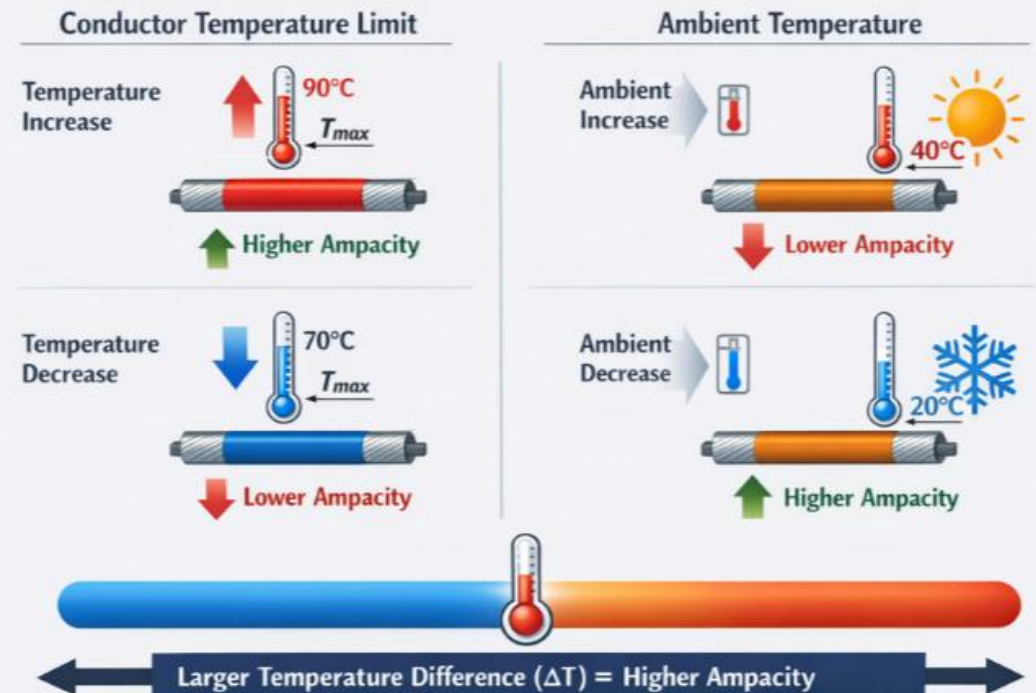
Heat generated: $P = I^2R$

Heat removed: Conduction + convection + radiation

Failure occurs when:

Heat generation > heat dissipation

Conductor Ampacity & Temperature Relationship



Cable Thermal Model

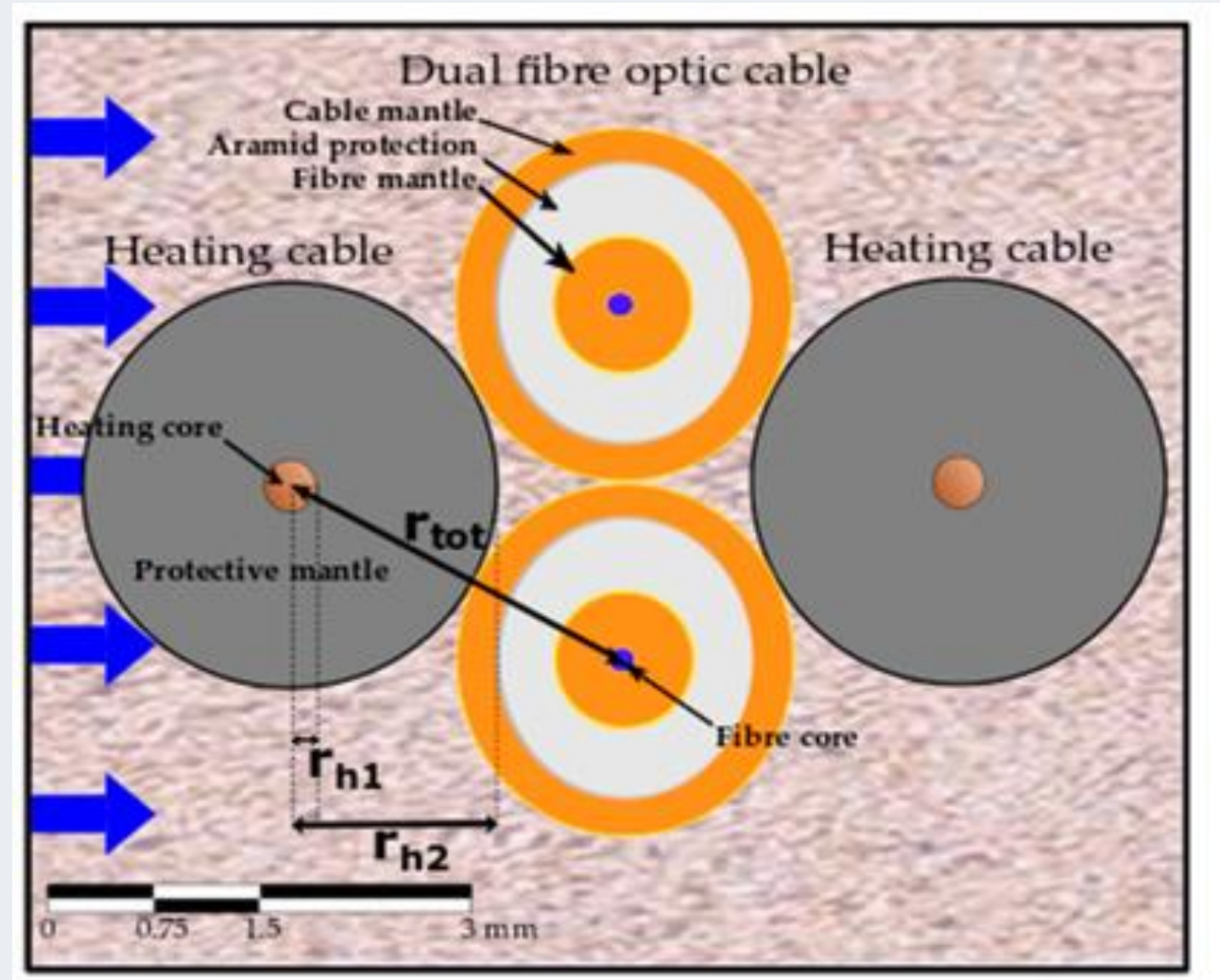
Heat source: Conductor losses

Heat path: Conductor

→ insulation

→ sheath

→ surrounding environment



Where Things Went Wrong?

Investigation revealed:

- Multiple feeders bundled
- Installed in a tray
- Near steam pipes
- VFD-driven motors
- Harmonics present



Cable Grouping Effect

Cable ampacity drops with grouping

Examples:

2 circuits → factor 0.8

6 circuits → factor 0.57

10 circuits → factor 0.5



Derating Example

Original rating: 400A

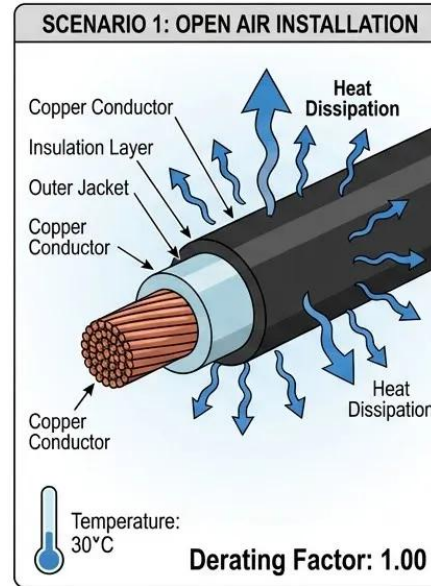
Grouping factor: 0.57

Corrected: $400 \times 0.57 = 228A$

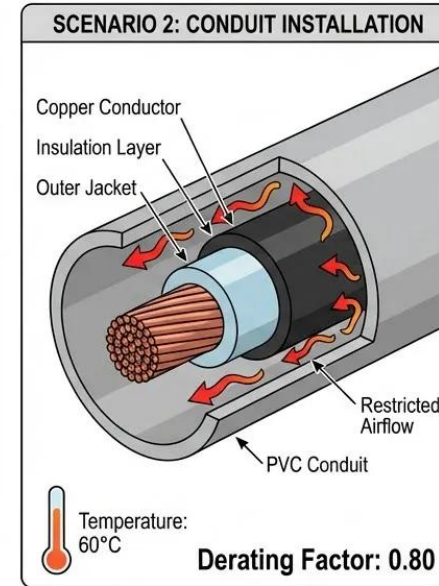
Actual load: 240A

Problem appears.

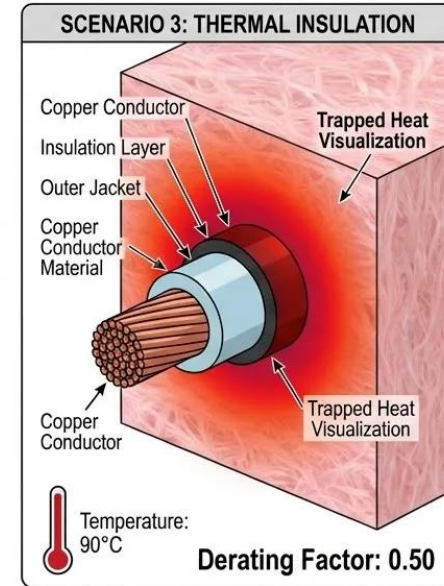
CABLE AMPACITY DERATING SCENARIOS



Heat easily dissipates into ambient air.
No ampacity derating required.



Limited air movement reduces heat dissipation efficiency. Ampacity derating necessary.



Insulation significantly inhibits heat escape, causing rapid temperature rise. Substantial ampacity derating required.

Ambient Temperature Problem

Rating assumption: 40°C

Actual environment: 55°C

Near steam pipes: 65°C



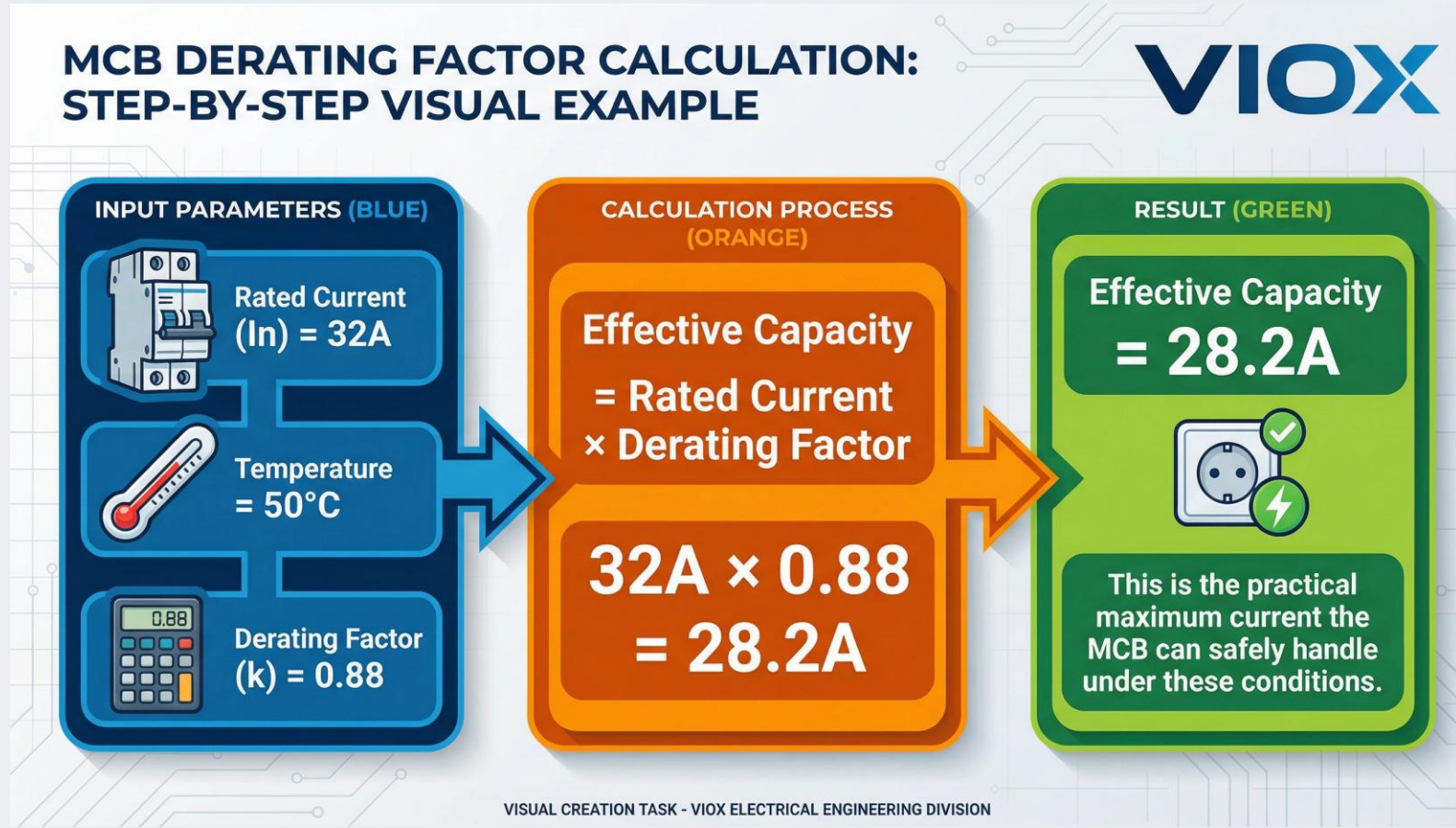
Ambient Temperature Derating | | |

Correction factor: 0.82

New ampacity:

$$228 \times 0.82 = 187\text{A}$$

Actual: 240A



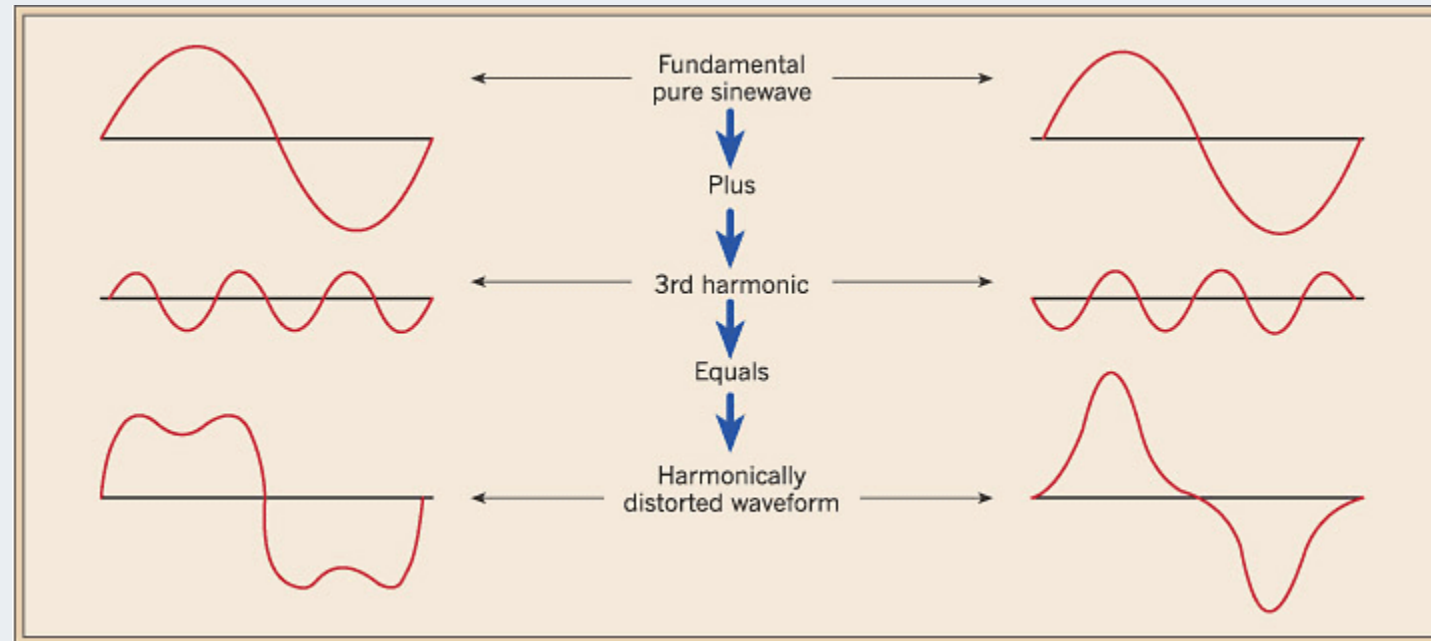
Harmonic Currents

Variable-speed drives introduce:

- 3rd harmonic
- 5th harmonic
- 7th harmonic

Additional heating:

- Skin effect
- Proximity effect
- Neutral heating



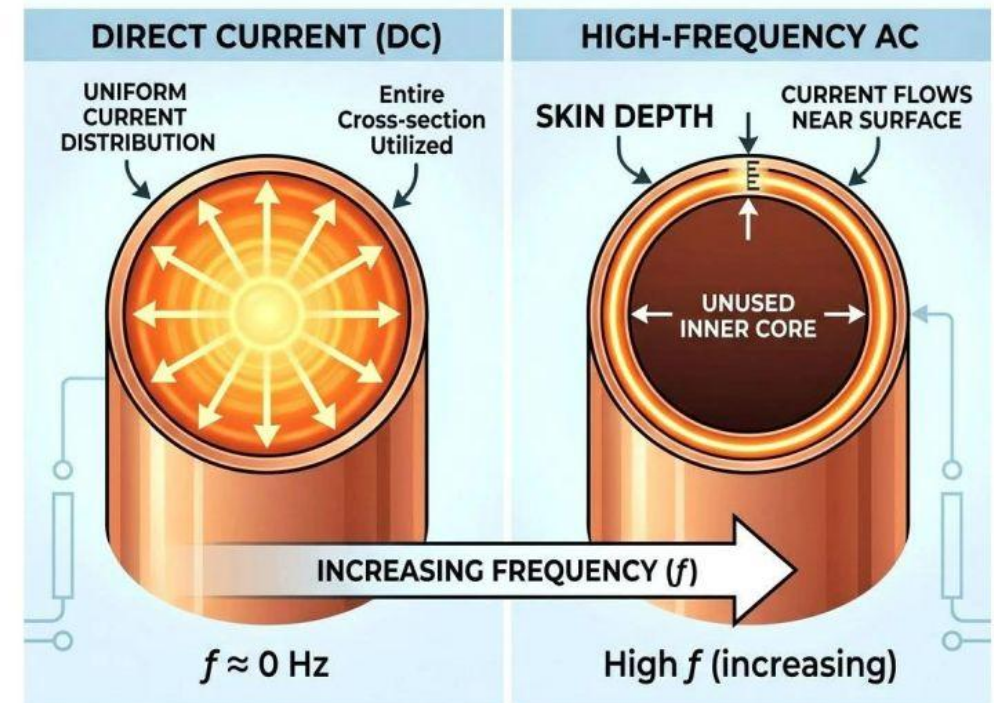
Harmonic Heating Mechanism

AC resistance: $R_{ac} > R_{dc}$

Higher frequency: More losses

Losses: $P = I^2 R_{ac}$

SKIN EFFECT IN CONDUCTORS



Thermal Camera Findings

Infrared survey:

- ❑ Cable surface: 89°C
- ❑ Tray hotspot: 115°C
- ❑ Termination: 127°C



Why do Terminations Matter?

Loose terminations:

Increase resistance

Localised heating: $P = I^2R$



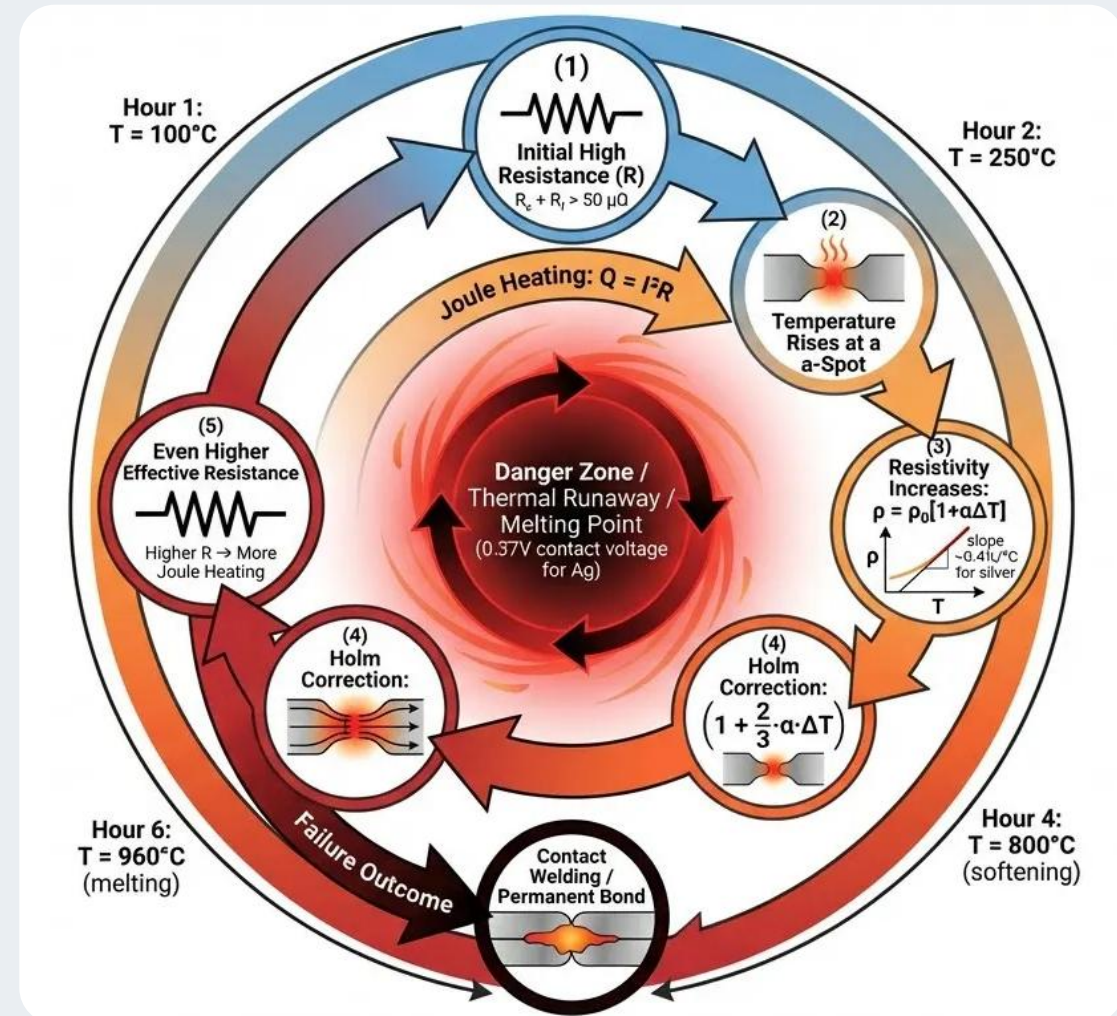
Contact Resistance Example

Resistance: 0.001Ω

Current: 240A

Power: 57.6W

At one connection



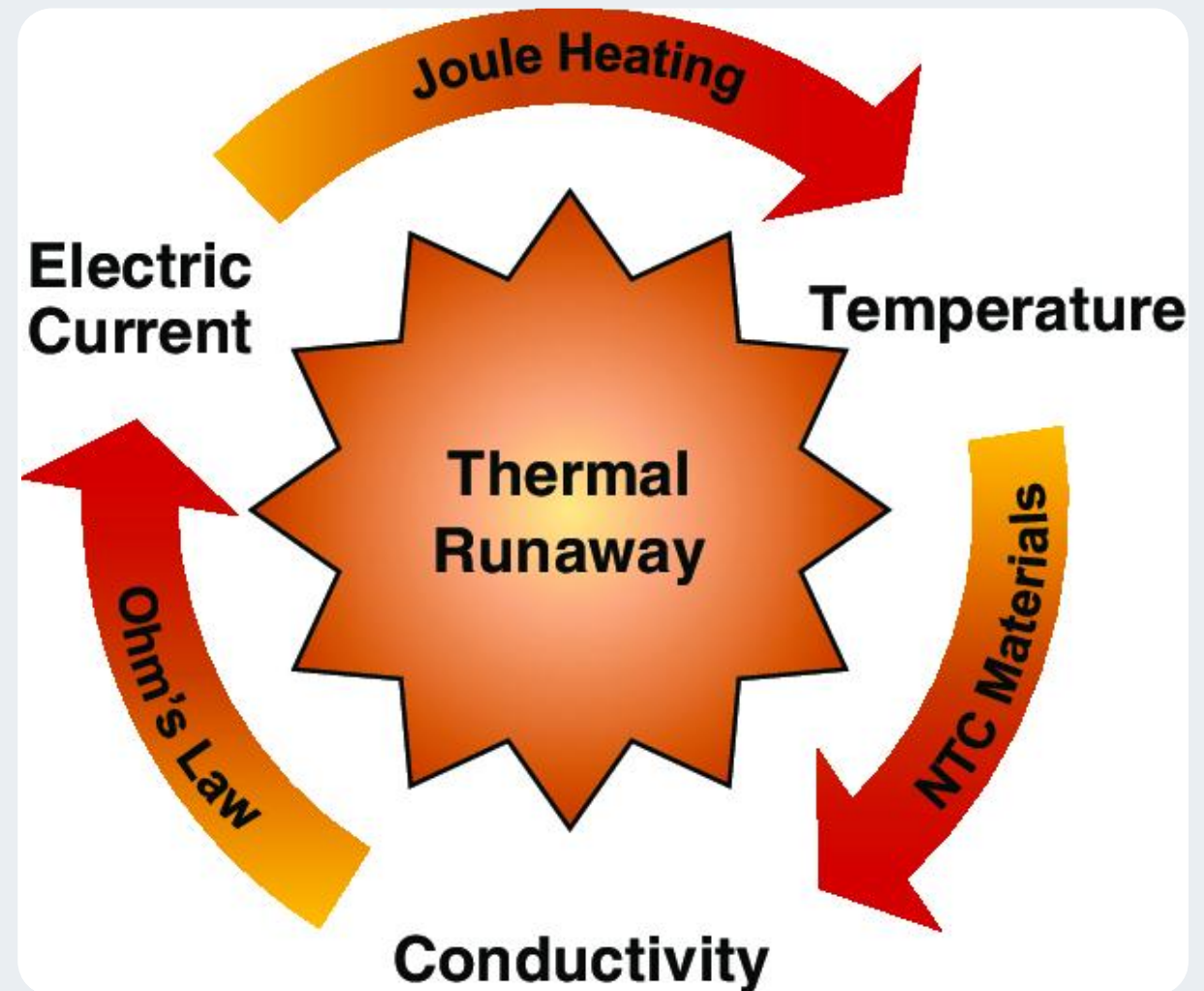
Thermal Runaway

Heating increases resistance

Resistance increases heating

Positive feedback loop:

Heat \rightarrow resistance \rightarrow more heat



Cable Aging Effects

Aged insulation:

- Cracks
- Moisture ingress
- Oxidation
- Reduced thermal conductivity



Installation Error

Unexpected discovery:

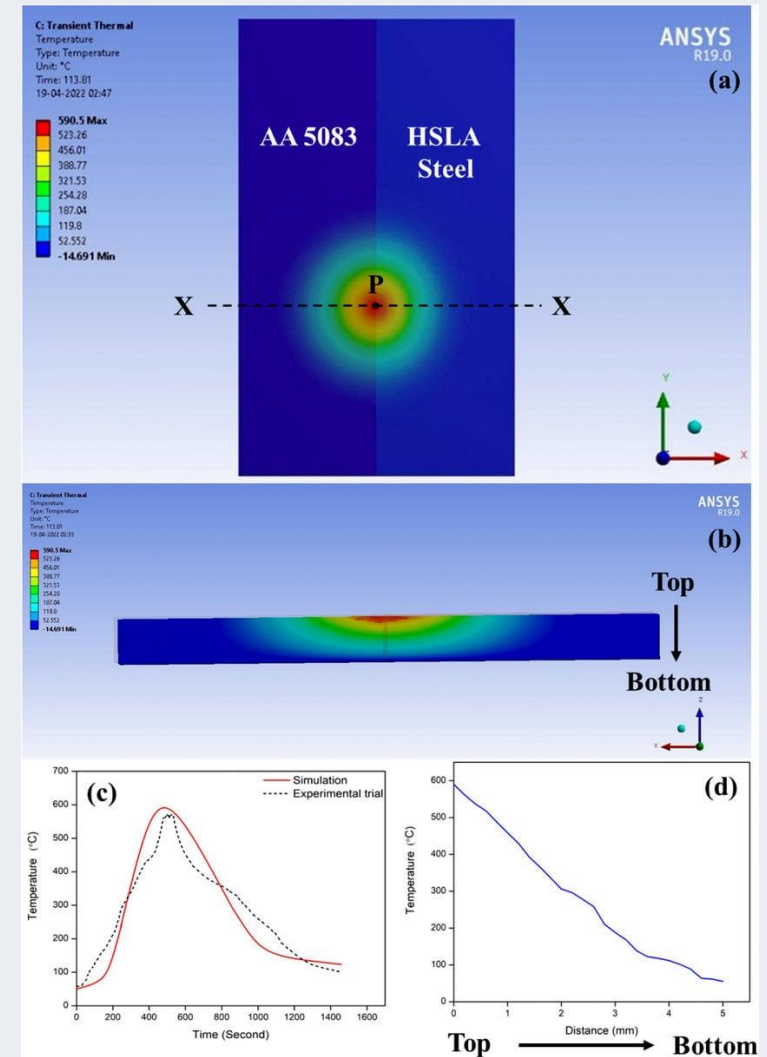
- Insulation debris trapped beneath the tray
- Blocked airflow



Simulation Results

Finite-element thermal simulation:

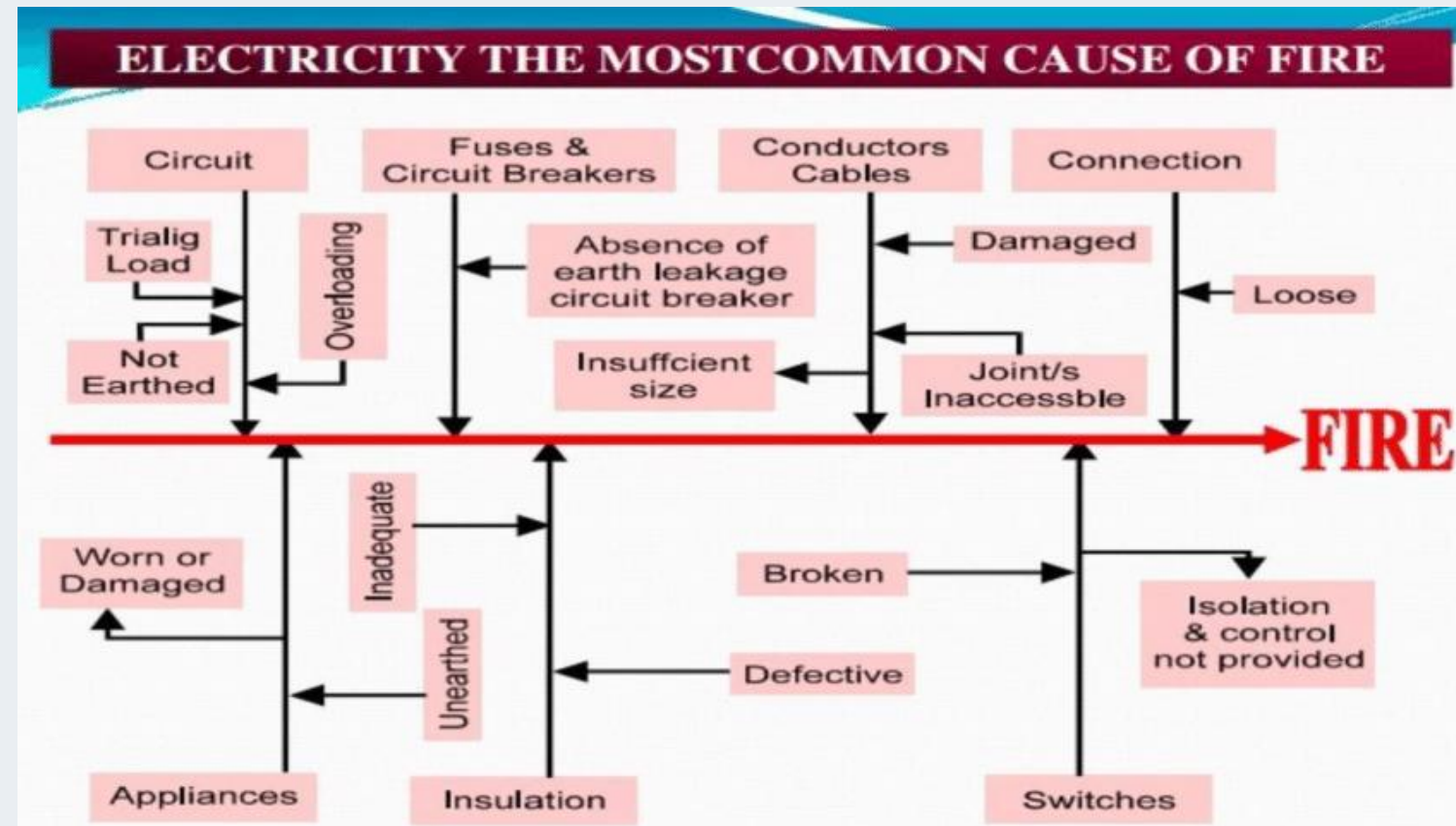
- Expected: 72°C
- Observed: 132°C
- After corrections: 127°C



Root Cause Analysis

Contributing factors:

- ❖ grouping
- ❖ ambient temperature
- ❖ harmonics
- ❖ termination heating
- ❖ airflow restriction



Standards Applied

Relevant standards:

- IEC 60287
- IEC 60364
- AS/NZS 3008
- IEEE 835

IEC vs. IEEE Impulse Testing Standards

Key Differences in High-Voltage Equipment Testing

IEC 60060-1

Geographic Focus
Global (icon: globe)

Key Waveform
1.2/50 μ s (lightning impulse)

Rise Time Calculation
90% to 30% of peak $\times 1.67$

Temperature Basis
20°C (68°F)

Transformer Testing Requirements
 Full wave (mandatory)
 Chopped wave (mandatory)

Voltage Level Terminology
LIWV (Lightning Impulse Withstand Voltage)

IEEE Std 4

Geographic Focus
North America (icon: North America map)

Key Waveform
1.2/50 μ s (lightning impulse)

Rise Time Calculation
90% to 10% of peak

Temperature Basis
30°C (86°F)

Transformer Testing Requirements
 Full wave
 Chopped wave (optional)

Voltage Level Terminology
BIL (Basic Insulation Level)

IEC 60060-1 vs IEEE Std 4 Comparison

Geographic Focus
Both: 1.2/50 μ s (lightning impulse)

Transformer Testing Requirements
 Full wave (mandatory)
 Chopped wave (mandatory)

Front Time Tolerance
 IEC: 15%-100% for $U_m > 800$ kV
 IEEE: ~10%

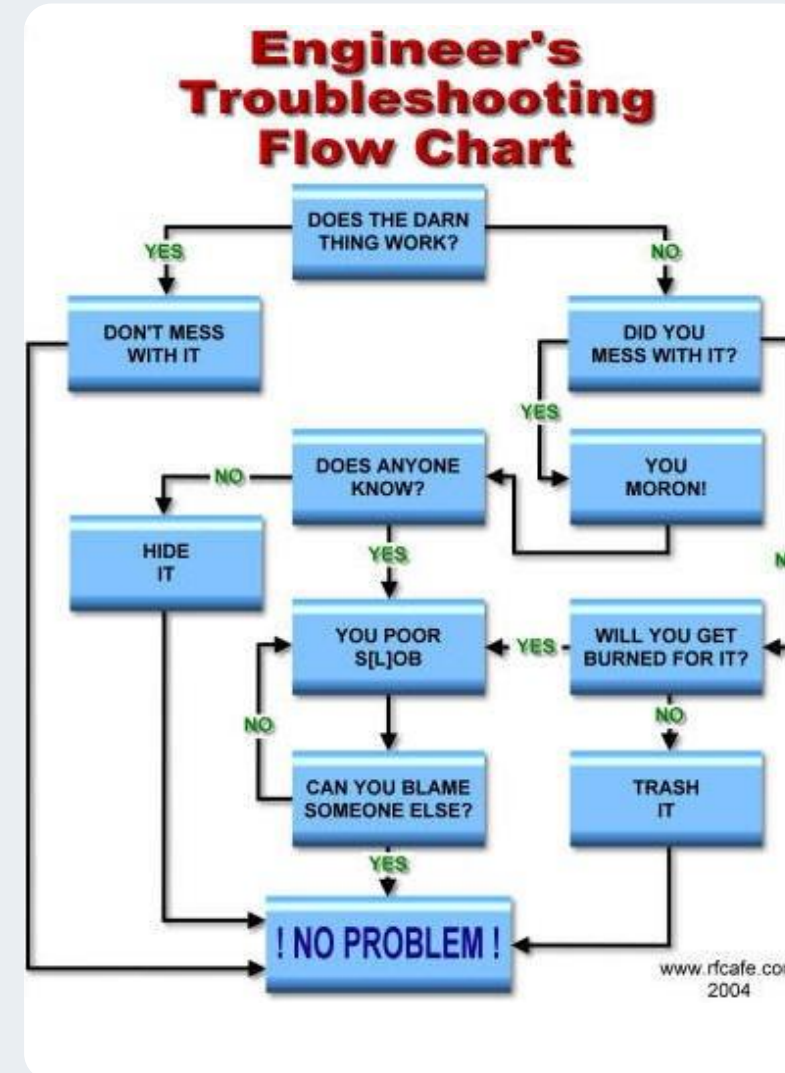
Sample Voltage Levels Table

System Voltage	IEC LIWV (blue theme)	IEEE BIL (orange theme)
66 kV	325 kV	-
132 kV	550 kV	Higher
220 kV	1,050 kV	Similar
400 kV	1,425 kV	-

⚠ Mismatched standards can lead to costly redesigns and project delays. Always verify compatibility with regional requirements.

Engineering Investigation Method

1. Verify load
2. Measure temperatures
3. Review installation
4. Check harmonics
5. Inspect terminations
6. Apply derating



Lessons Learned

Never trust: Current alone

Always consider:

Environment + installation + harmonics



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Discussion Exercise

If a cable carries a 50% load

Installed:

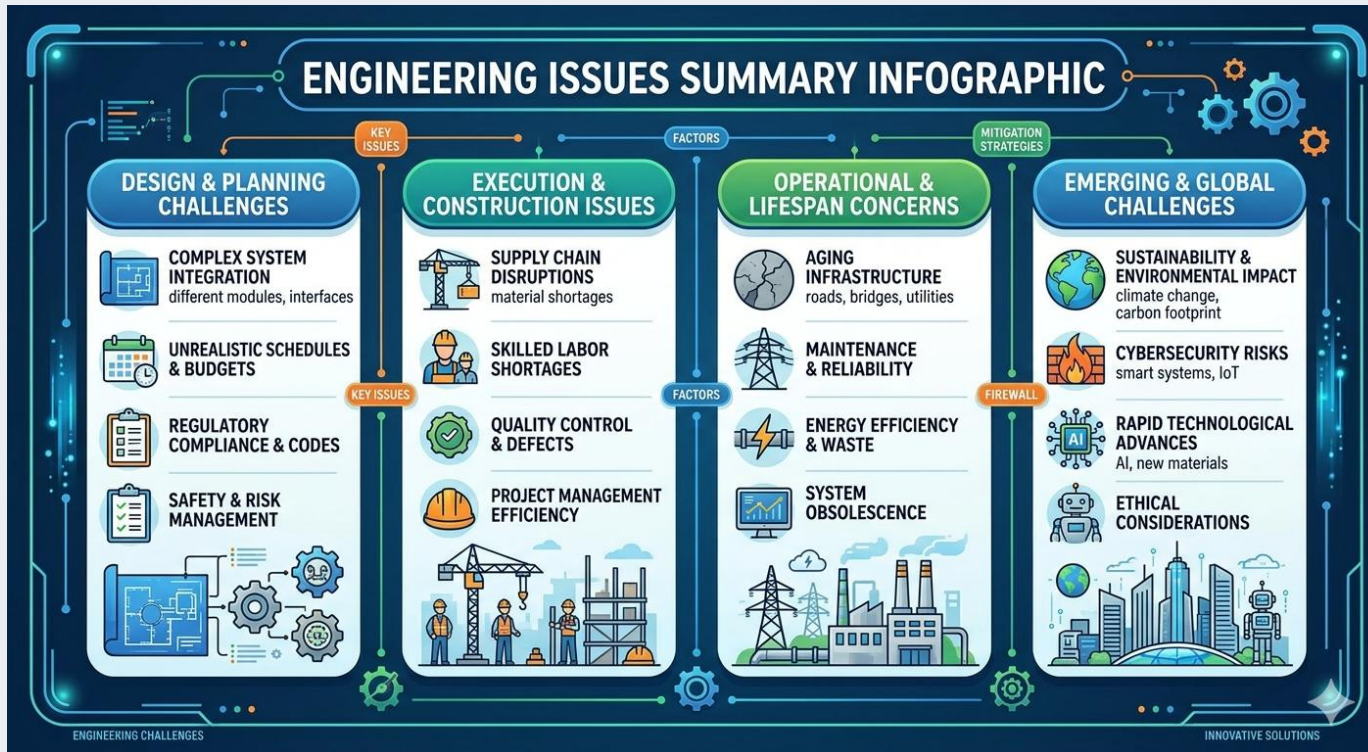
- bundled
- underground
- high harmonic environment

Can it fail?

Discuss.



Key Takeaways



- Cable ratings are conditional
- Derating factors multiply
- Harmonics create hidden heating
- Thermal imaging is essential
- Small errors cause major failures

Upcoming Mysteries Webinars



Register now!

18 June - The Phantom Neutral - Why the Feeder Voltage Floated Overnight?

9 July – The Relay That Refused to See a Short

16 July - The Capacitor Bank That Blew Itself Up Quietly

13 August – The Motor That Wouldn't Start - Unless It Was Empty

20 August - The Neon Sign That Pulsed with Passing Trucks

10 September – The Battery Bank That Lost Capacity Overnight

17 September - The Streetlight That Kept Turning on at Noon

12 November – The Transformer That Changed Tap Position by Itself

19 November – The Circuit That Lost Half Its Phase Over the Years

10 December – The PLC That Spoke Back - A Control Loop with a Mind of Its Own

17 December - The Resonant Substation - Lights Flicker Without Load Change

27 January - The Induced Voltage That Woke the Cattle



Thank You!

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Please note: courses listed below are subject to their own regulatory requirements, refer to the relevant website for further information.

Engineering Institute of Technology (EIT) <i>Australian Accredited Qualifications & Short Courses</i>	Start Date
Graduate Diploma of Engineering (Electrical Systems)	29 June 2026
Master of Engineering – Applied Research (Electrical Systems)	29 June 2026
Online - Master of Engineering (Electrical Systems)	29 June 2026
Graduate Certificate in Power System Analysis and Design	29 June 2026
Professional Certificate of Competency in Electrical Power System Protection	14 July 2026
Bachelor of Science (Electrical Engineering)	20 July 2026
Associate Degree in Electrical Engineering	20 July 2026
Doctor of Engineering	20 July 2026
Professional Certificate of Competency in Fundamentals of Electric Vehicles	11 August 2026
Professional Certificate of Competency in Battery Energy Storage and Applications	8 September 2026
Professional Certificate of Competency in Circuit Breakers, Switchgear and Power Transformers	13 October 2026

Upcoming Courses



Please note: courses listed below are offered by separate institutions in the UK and South Africa, each subject to their own regulatory requirements - refer to the relevant website for location-specific details.

Engineering College of Technology (ECT) <i>UK qualifications</i>	Start Date
Bachelor of Engineering (Honours) in Industrial Automation	21 September 2026
Bachelor of Engineering (Honours) in Electrical Engineering	21 September 2026
Master of Science (Power System Analysis and Renewable Integration)	5 October 2026
Master of Science (Industrial Automation and Instrumentation Control)	5 October 2026

Engineering College of Science and Technology (ECST) <i>South African accredited qualification & ECSA-endorsed</i>	Start Date
Bachelor of Engineering Technology in Electrical Engineering	3 August 2026

Q&A



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Courses

<https://www.eit.edu.au/schedule/>



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Outside UK: +44 208 335 4014



Programmes

<https://www.ect.ac.uk/programmes/>



Website

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Programmes

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types/bachelor-of-engineering/](http://www.ecst.ac.za/course-types/bachelor-of-engineering/)