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Partial Discharge Essentials: Testing Methodologies and Practical Application for Real-World Assets

9 July 2026

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Introduction – Presenter

Thomas Whyte

Thomas is the Senior Engineer at EA Technology Australia and works with utilities and businesses to maintain safe, reliable and efficient power networks. He specializes in high and low voltage network solutions and is recognized as an industry expert in partial discharge (PD) detection, asset health and condition monitoring. As a trusted technical advisor, Thomas plays a key role in identifying, assessing, and mitigating faults in both the high and low voltage network infrastructure. Using data analytics, he delivers proactive maintenance strategies that enhances the reliability of assets, extends its lifespan and prevents failures.

EA Technology

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At a glance

We have been innovating for power network operators since 1966

59
YEARS

We have 5 offices across 4 continents

5
GLOBAL OFFICES

Serving **large DSOs and corporates** worldwide

SP ENERGY NETWORKS
Northern Ireland Electricity Networks
RWE
NHS
EURO TUNNEL
CITIPOWER
Scottish & Southern Electricity Networks
VEOLIA
Schneider Electric
UK Power Networks
Orion
TEPCO Power Grid
NetworkRail
Google
SA Power Networks
NORTHERN POWERGRID
港燈 HK Electric
nationalgrid
SOUTHERN CALIFORNIA EDISON Energy for What's Ahead

Leading Electrical Network Innovation for over 50 years

1966
Started as the UK's Electricity Council Research Centre

1990
Electricity privatisation

Transition to commercial provider of technology services

1994
Emerged as EA Technology

2004
Staff buy-out inspires new commercial offerings

2019
Leaders in electrical network/investment modelling and monitoring

2024+
Facilitating the transition to NetZero

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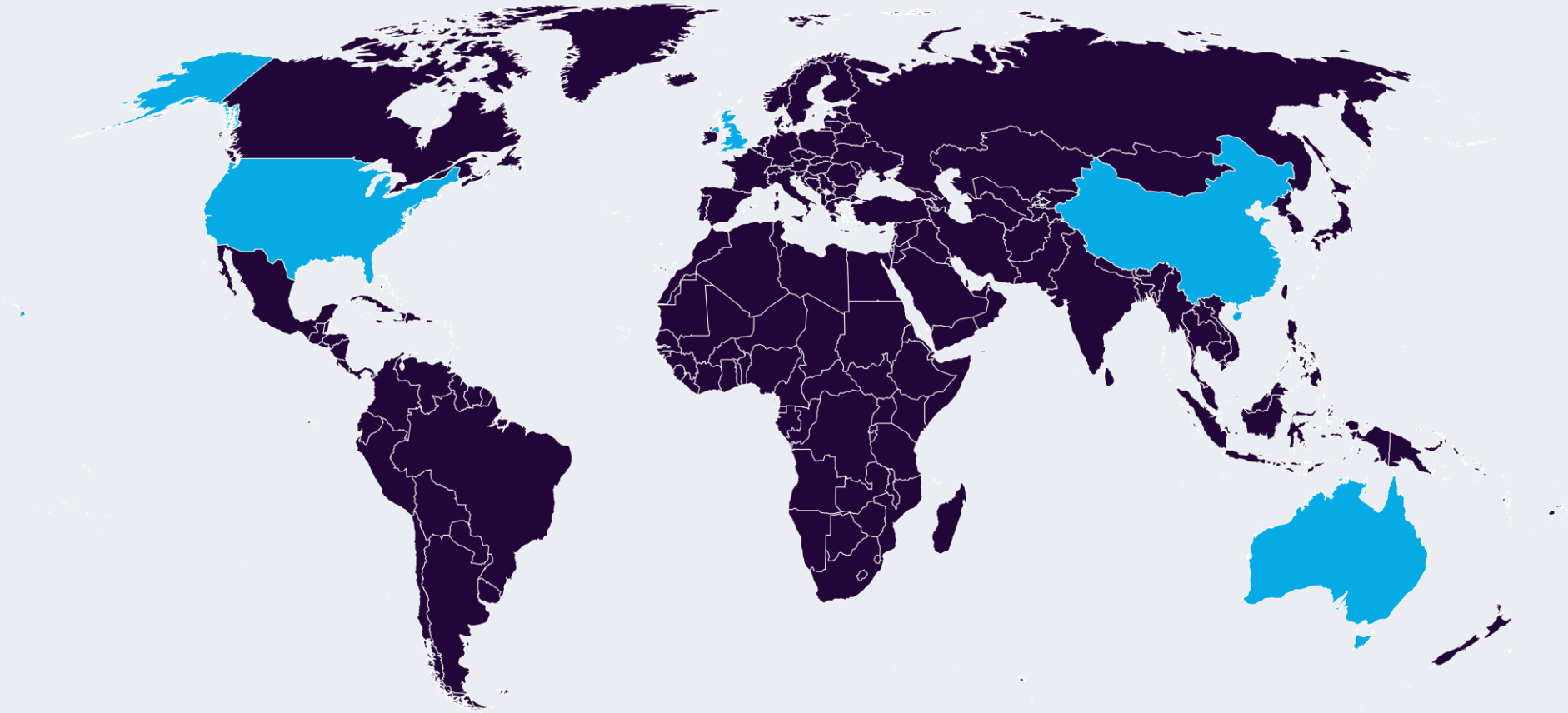
Global reach from offices in the UK, USA, Australia, Singapore and China



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What is Partial Discharge and Why Does it Matter?

Why Condition Assess?

Operational

Extend Maintenance Intervals

Prevent Failures

Improved Safety

Asset Manager

Manage Risk

Determine Optimum Replacement Strategy

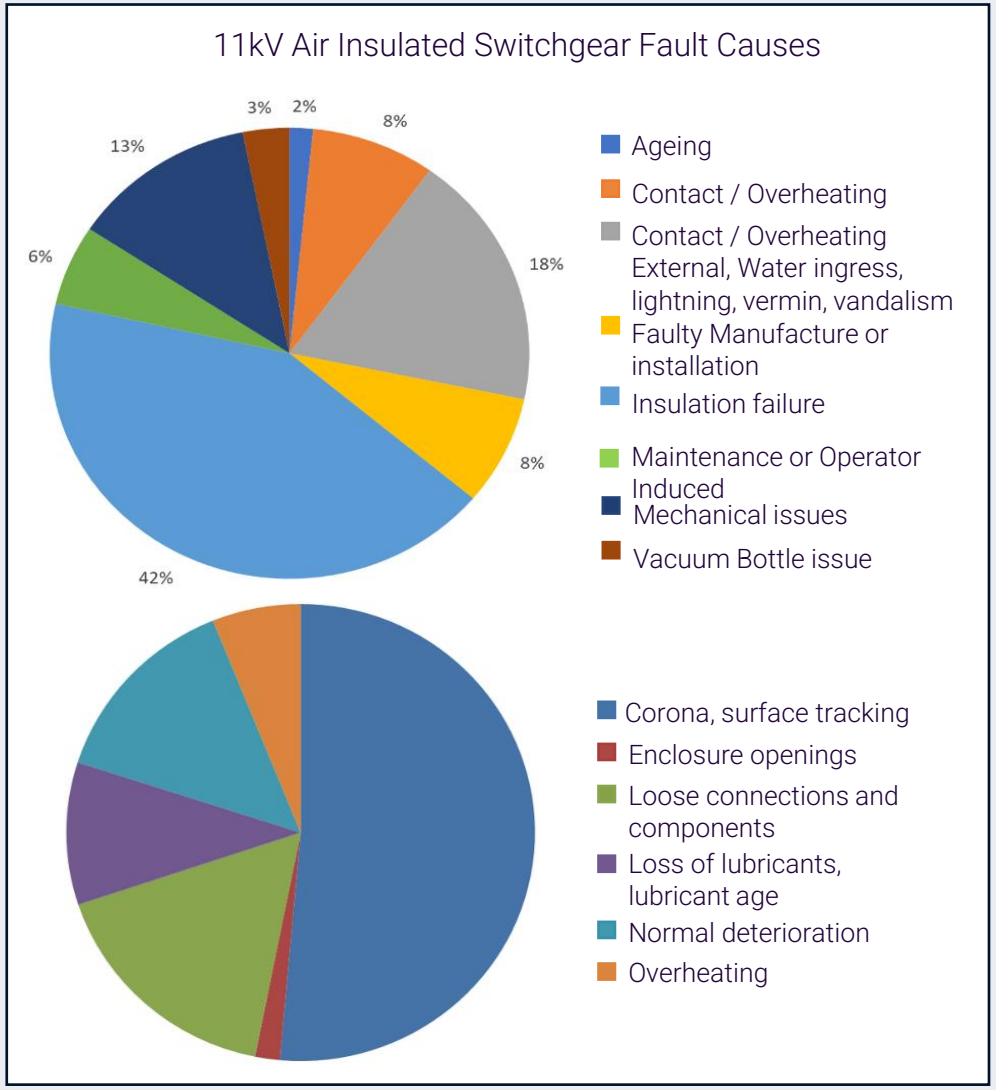
Reduce Capital Expenditure

HV Switchgear Fault Causes

PD is the primary cause of faults on MV/HV switchgear

40 – 50% of all faults on switchgear are associated with insulation failure and PD

80 – 85% of all **disruptive failures** are associated with insulation failure



References

ENA Neders database, UK failure statistics on 11kV AIS switchgear 1989 – 2016

After Paoletti et al. Failure contributors of MV Electrical Equipment and Condition Assessment Program Development. IEEE Transactions on Industry Applications,(Volume:38 , Issue: 6 2002)

What is Partial Discharge?

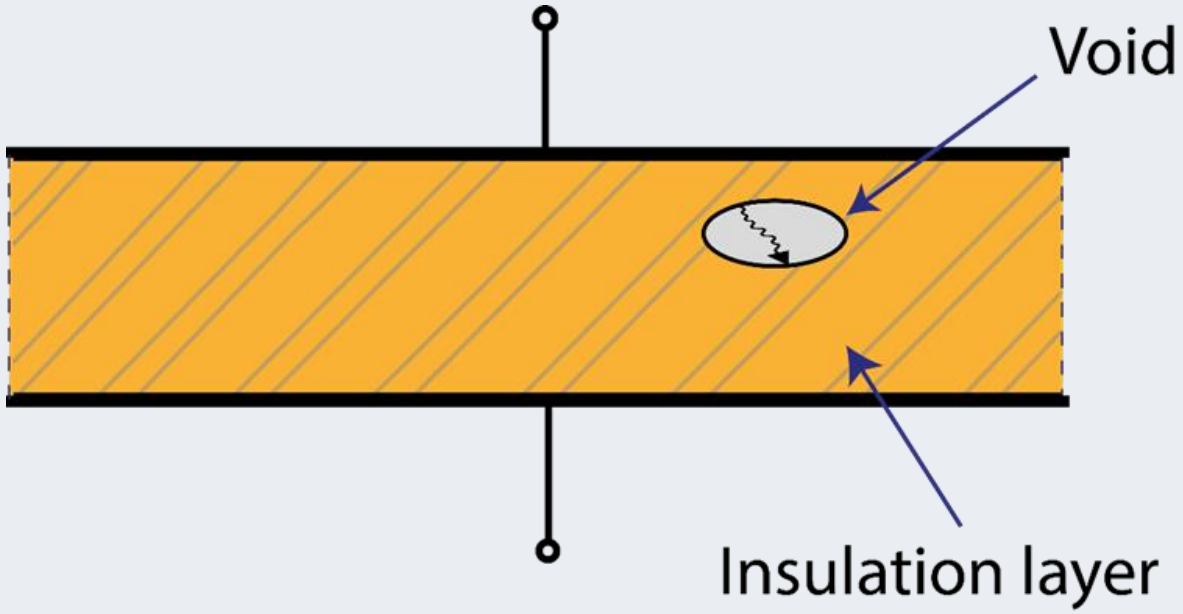
Partial discharge is a localized electrical discharge within or along insulation that causes progressive deterioration over time.

> Partial discharge: Localized electrical discharges that only partially bridge the insulation between conductors and which can or cannot occur adjacent to a conductor. Partial discharges are in general a consequence of local electrical stress concentrations usually caused by defects within the insulation or alternatively on the surface of the insulation. Generally such discharges appear as small electrical discharges with durations of less than 1µs

Definition: IEC 60270

Partial Discharge Activity

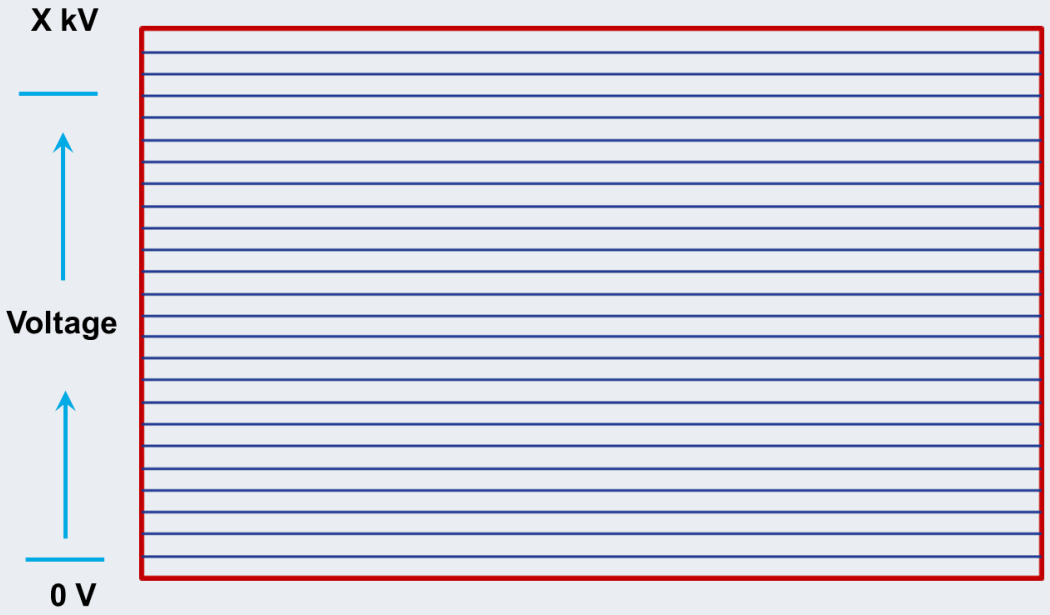
- Electrical discharges that do not completely bridge the electrodes
- Cause deterioration and eventual failure of the insulation layer
- Partial discharge breakdown of insulation produces:



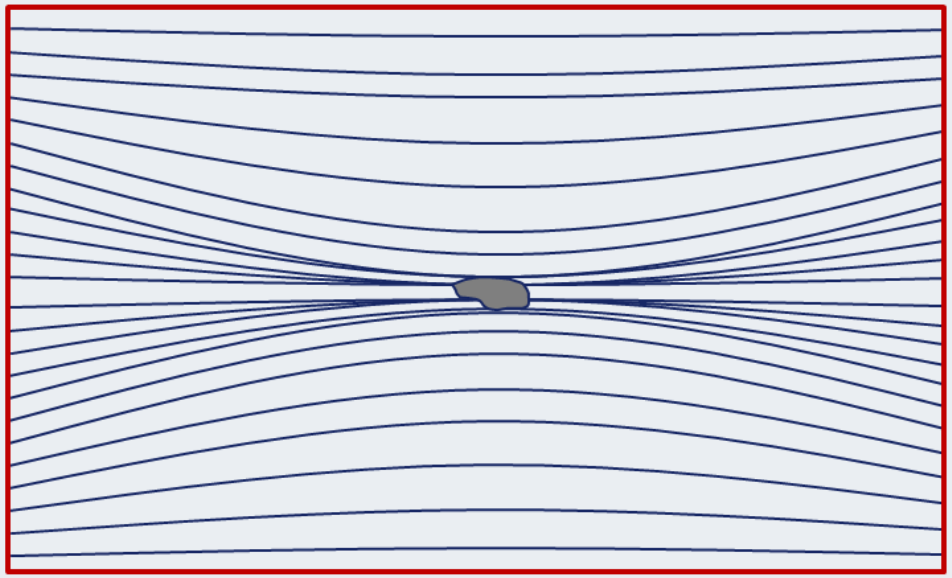
Light
Heat
Smell
Sound
Electromagnetic waves

Electromagnetic Stress Concentration

A defect within insulation distorts the electrical field — concentrating stress to the point of breakdown at normal operating voltages.



Healthy insulation — uniform field, 3× voltage drop

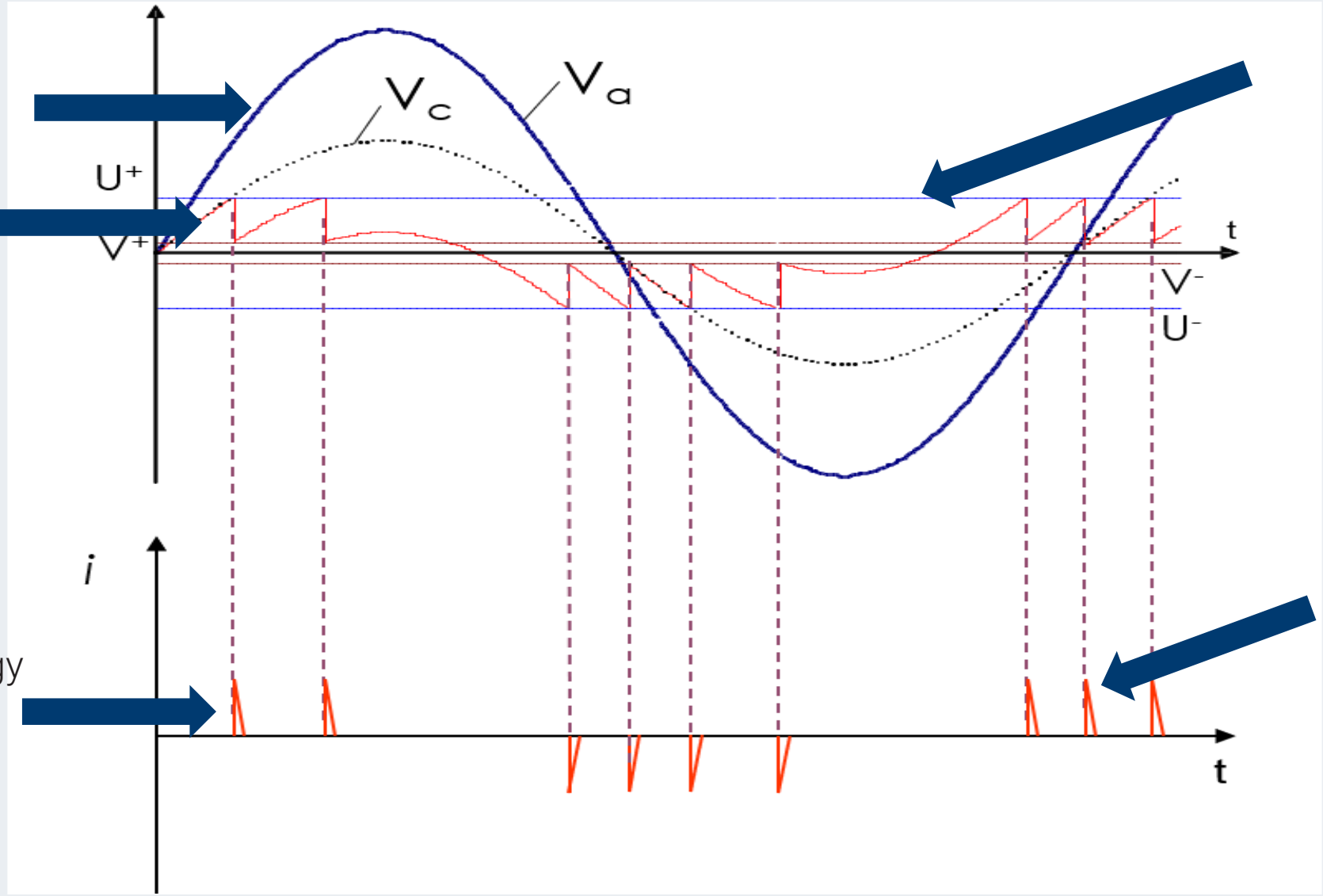


Void present — field concentrates through defect, 10× voltage drop → breakdown

The void has a lower dielectric constant than the surrounding insulation — the field concentrates through it, causing breakdown at working voltages. This is the mechanism that initiates Partial Discharge.

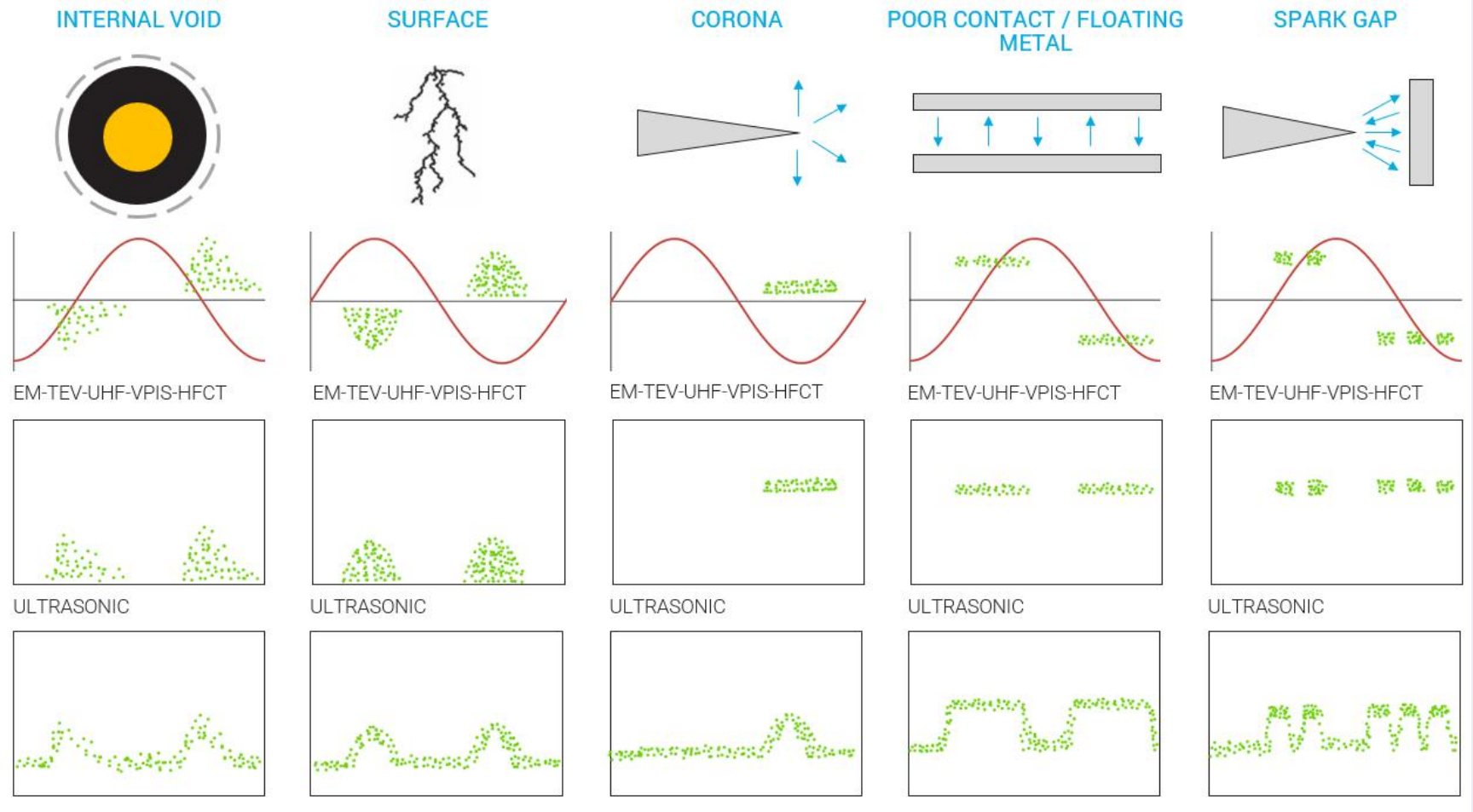
Recurrence of Discharges over time

- Line Voltage
- Voltage level across the PD defect
- Pulse of energy occurs with each PD



- Breakdown voltage of the PD site (not always at a set level)
- PRPD: Pulses are measured and plotted over time against mains frequency – usually 50Hz or 60Hz

Defect Types and Phase resolve patterns



Each defect Type has a Unique Phase Resolve Pattern

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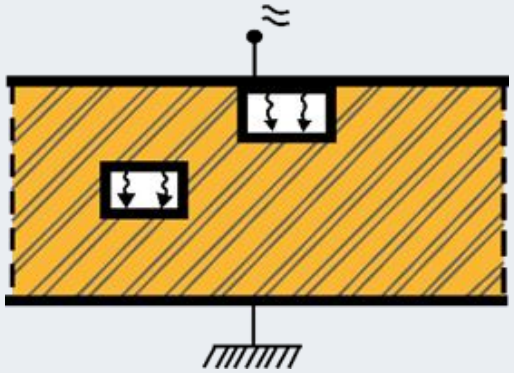
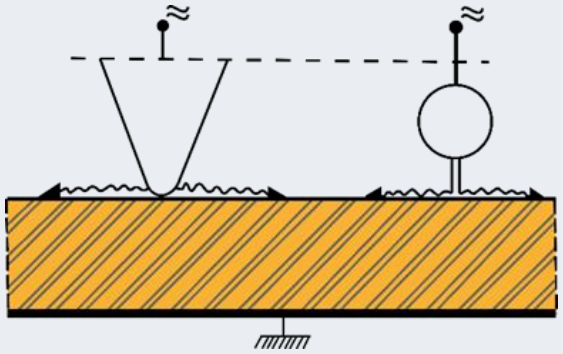
Types of Partial Discharge

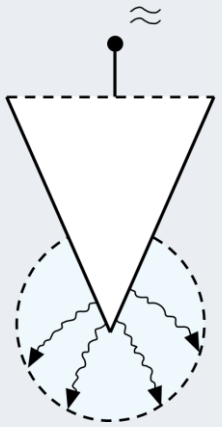
The 3 main classifications of PD:ns



Internal Discharge

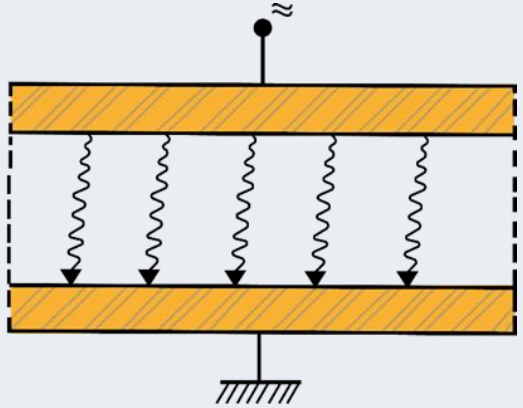


Surface Discharge



Corona Discharge

Also another cause:

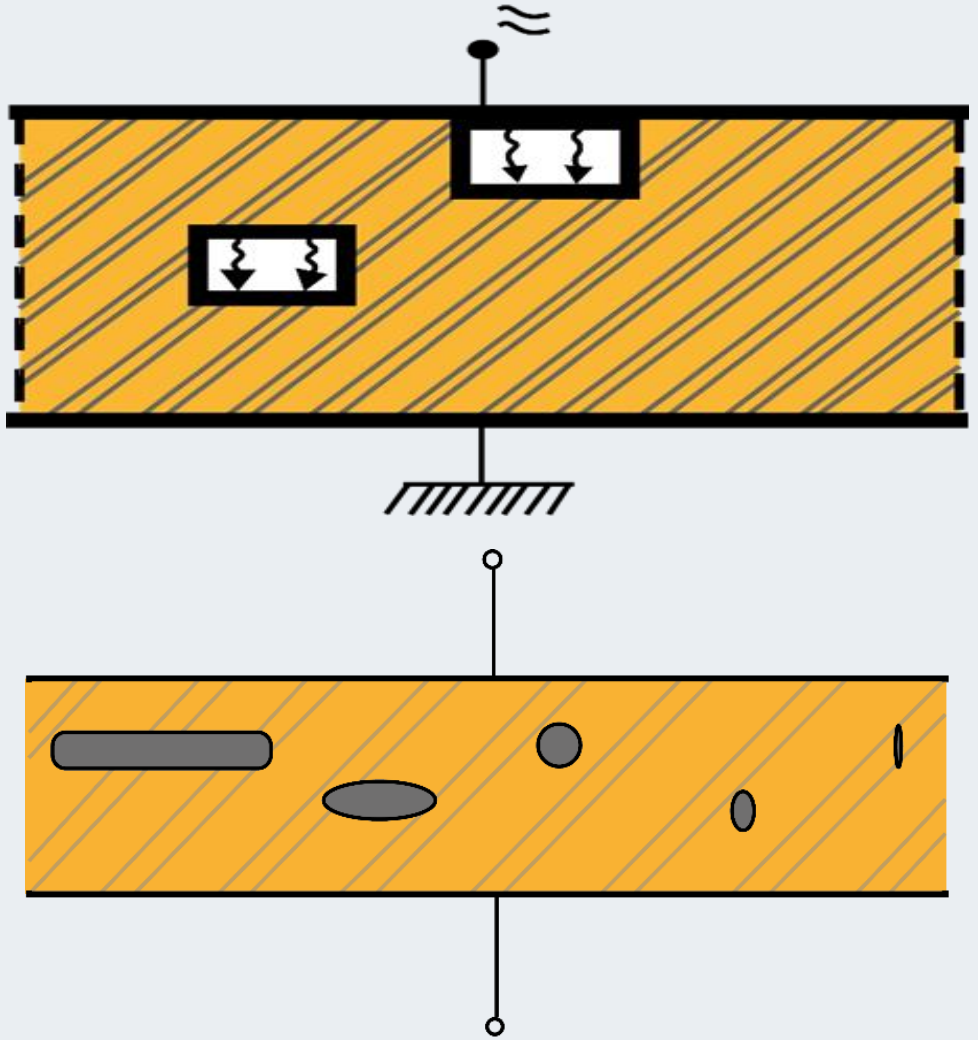


Contact / Gap / Floating Metalwork

20

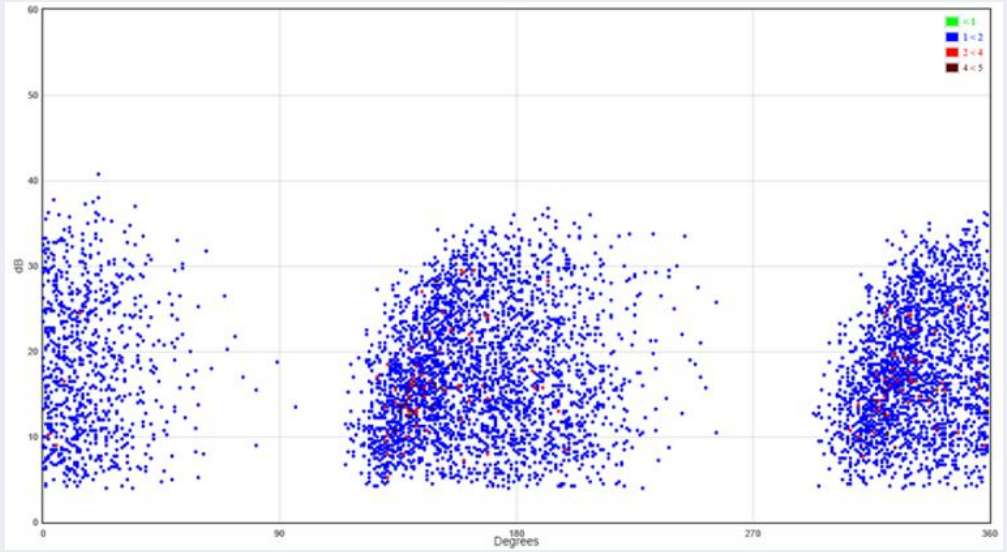
Internal Discharges

- Occurs within the insulation system, often in voids or cavities
- Usually produces strong electromagnetic emissions, making it well suited to TEV, HFCT and UHF detection
- The amplitude and nature of the detected signals is highly dependent on the location, size and shape of the void
- Will likely not be detectable ultrasonically because the acoustic energy is often absorbed by the surrounding insulation and enclosure
- Due to its nature, internal void defects are not visible during inspections

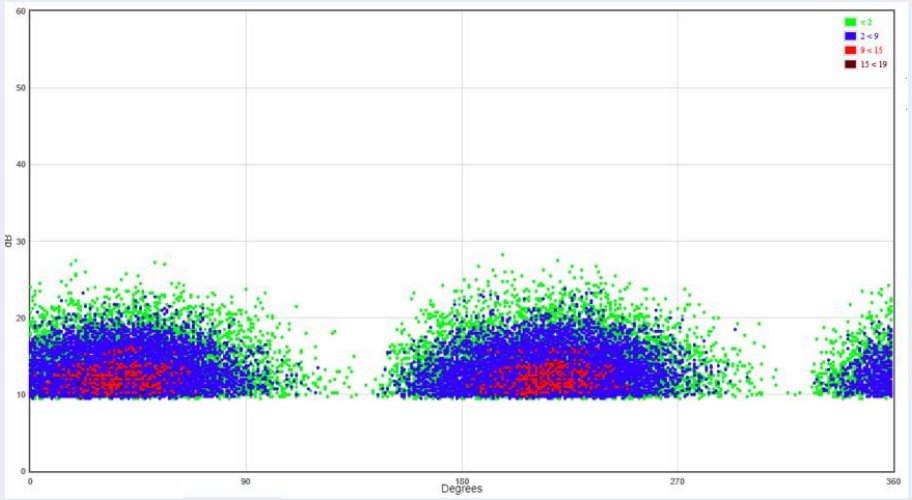


Differences In Internal Voids

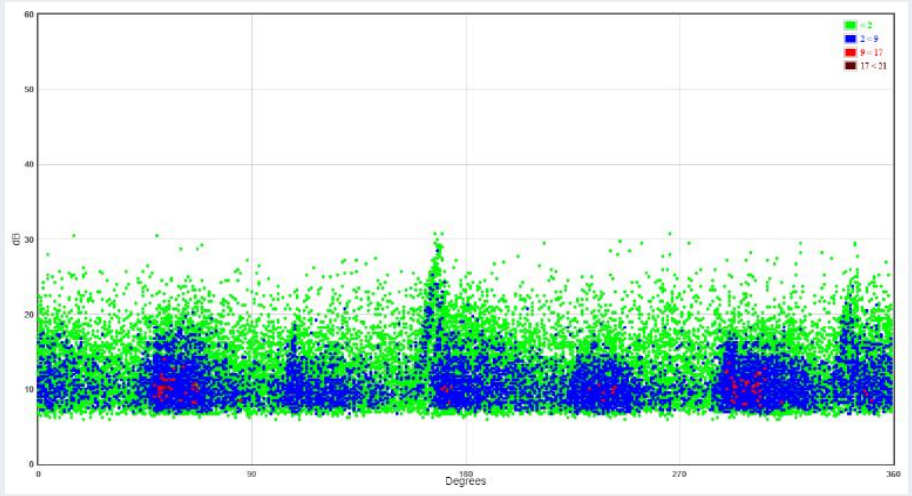
Internal Void – Phase Resolve Plots



Internal Void - single phase



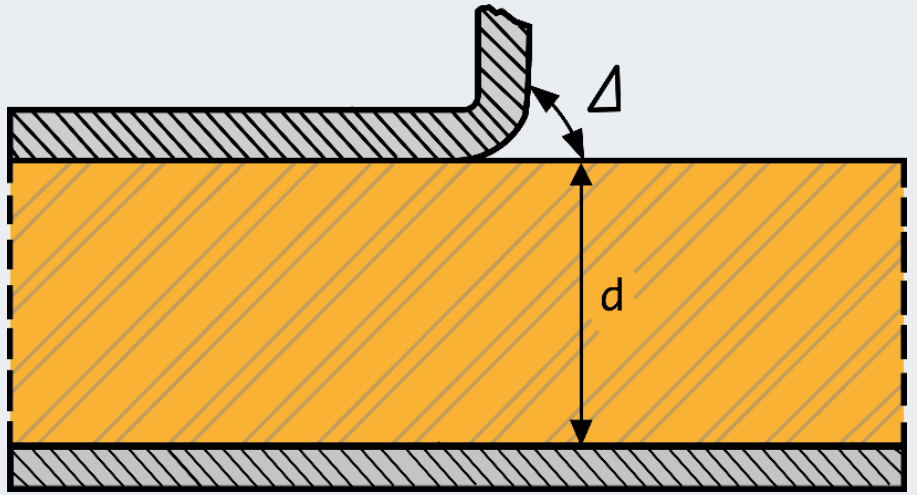
PD inside oil filled Tx - single phase

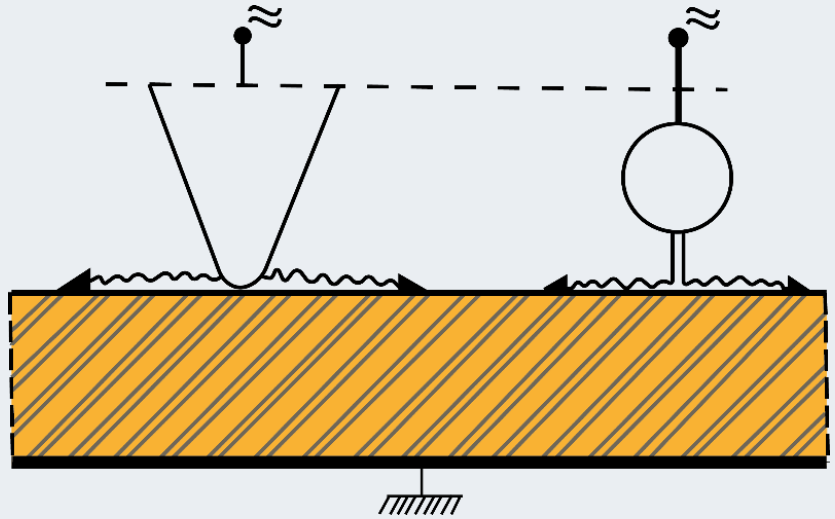


Internal Void - three phase

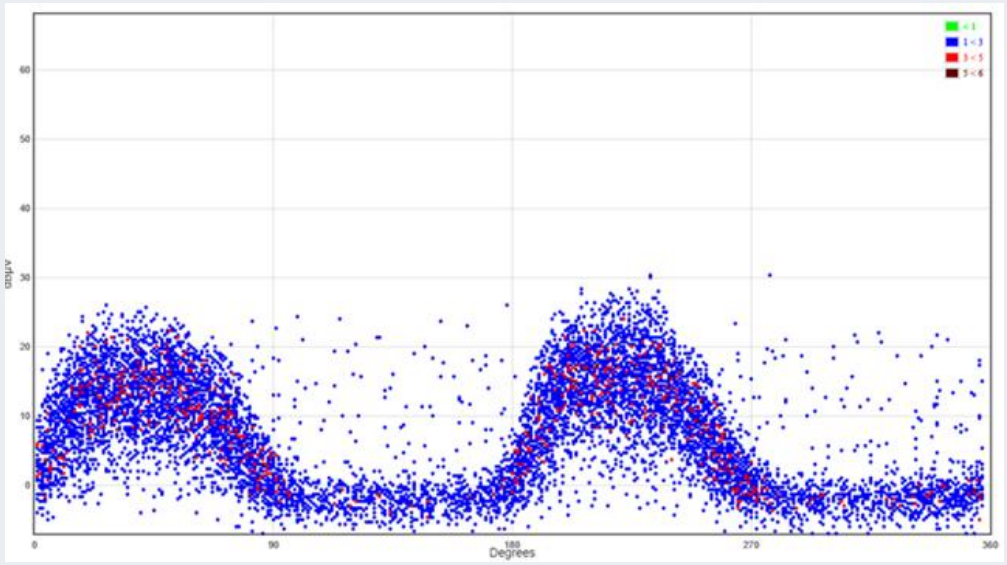
Surface Discharges

- Occurs along the surface of insulation rather than within it
- Commonly associated with contamination, moisture and reduced clearances
- Often found on cable terminations, bushings and insulation interfaces
- Frequently produces strong ultrasonic emissions, making it easier to locate
- Can often be identified by tracking, carbonisation or visible insulation damage
- Due to their location, surface discharge is often identified through a visual inspections

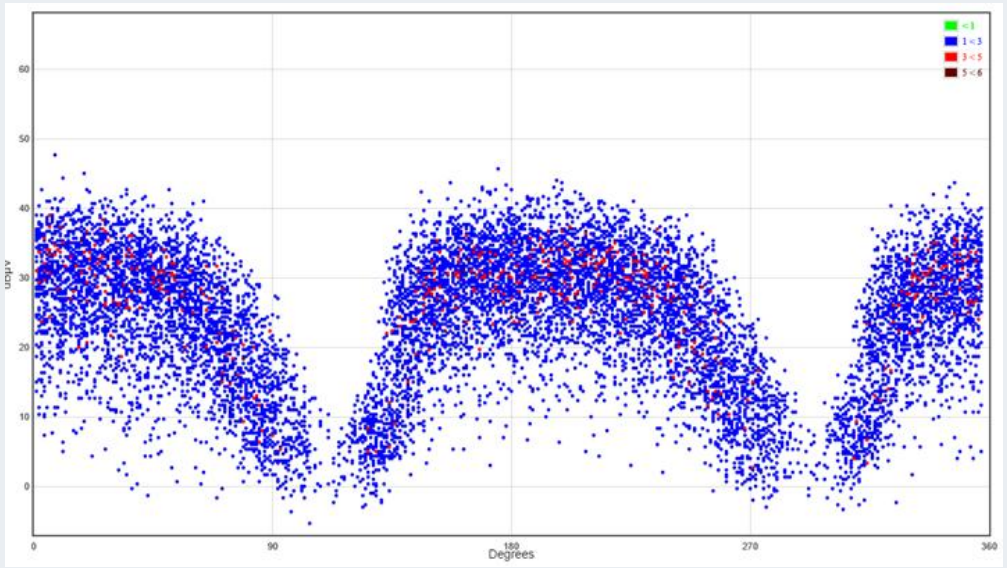




Surface Discharge – Phase Resole Plot



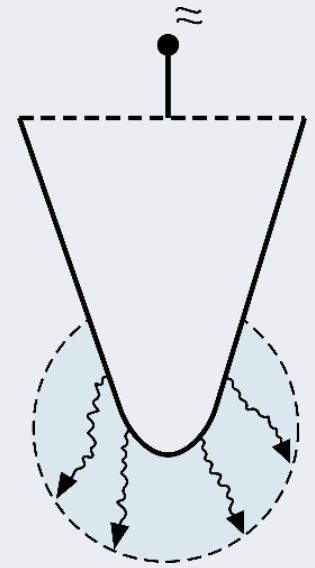
Surface Discharge – single phase

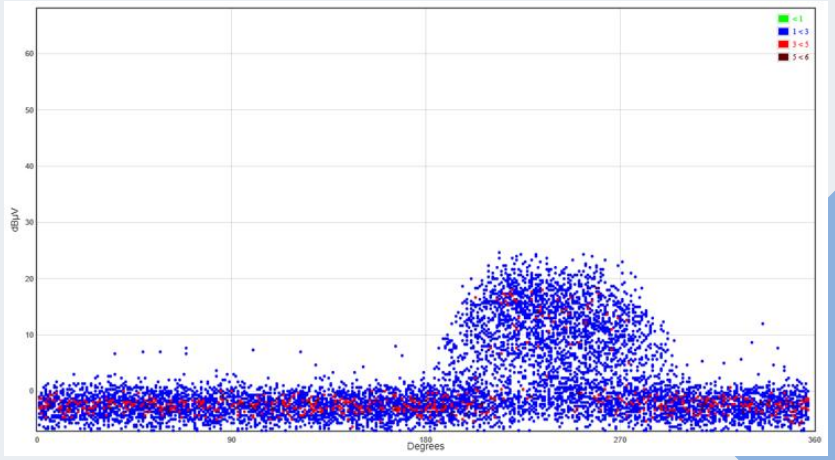


Surface Discharge - multi phase

Corona Discharges

- Occurs around sharp points or edges where electric field stress is concentrated
- Commonly found on outdoor switchgear, overhead lines and exposed conductors
- Often active on one half of the AC cycle, creating a distinctive PD pattern
- Typically produces strong ultrasonic emissions and can often be heard from a distance
- May be relatively benign outdoors, but can become damaging if present inside enclosed equipment

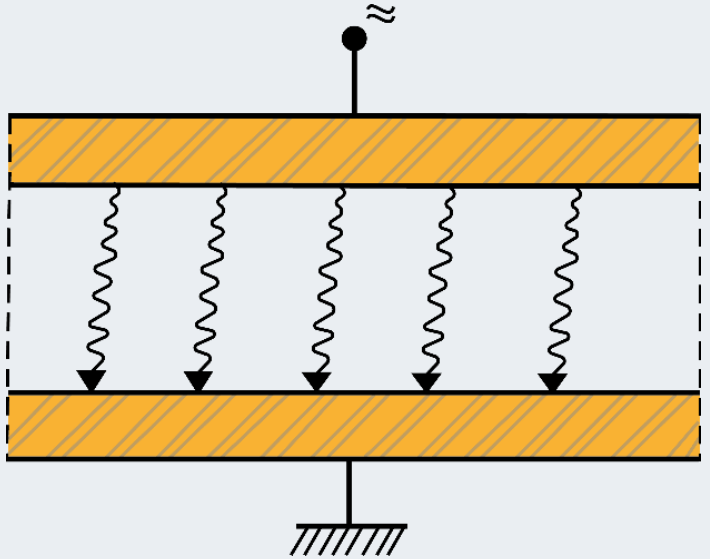


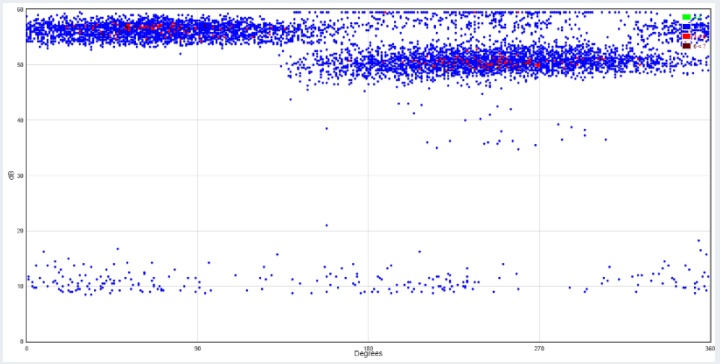


Corona Discharge - single phase

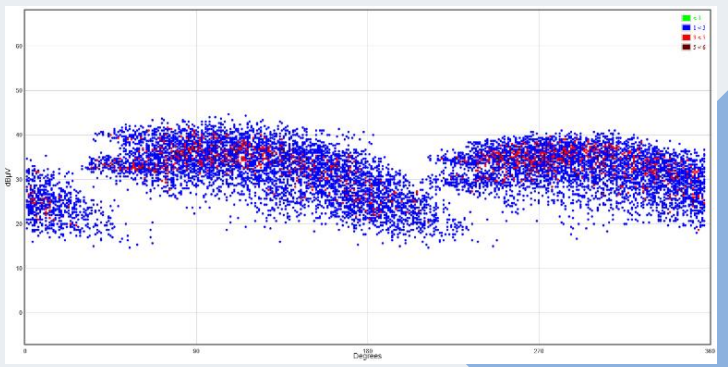
Discharge Across a Gap

- Can have aspects of both internal and surface type PD
- Often characterised by relatively higher than typical magnitude for surface PD
- Higher repetition rate compared with internal discharge
- Floating metalwork, contact problem
- Laminated materials





Contact Type Discharge - TEV



Contact Type Discharge - Ultrasonic

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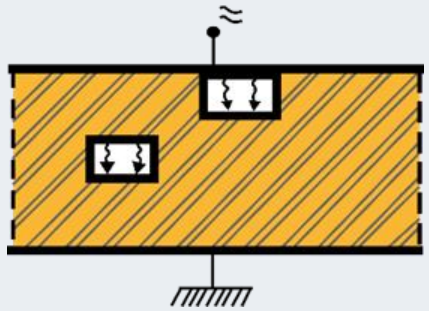
Sensing Technologies and Detection Methods

Matching The Detection Method To The Defect

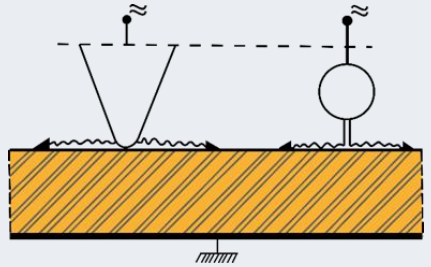
Internal Discharge

- TEV
- HFCT



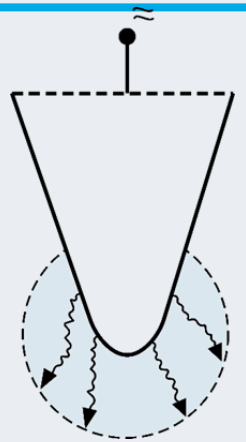
Surface Discharge

- Ultrasonic
- TEV (High level Only)
- HFCT (High level Only)



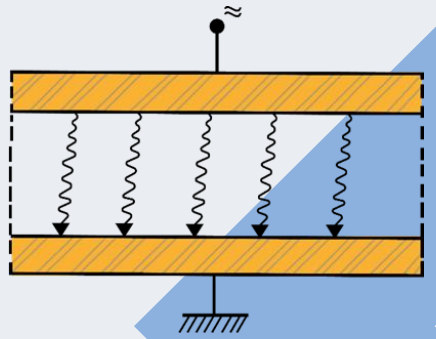
Corona Discharge

- Ultrasonic



Contact Discharge

- Ultrasonic
- TEV
- HFCT



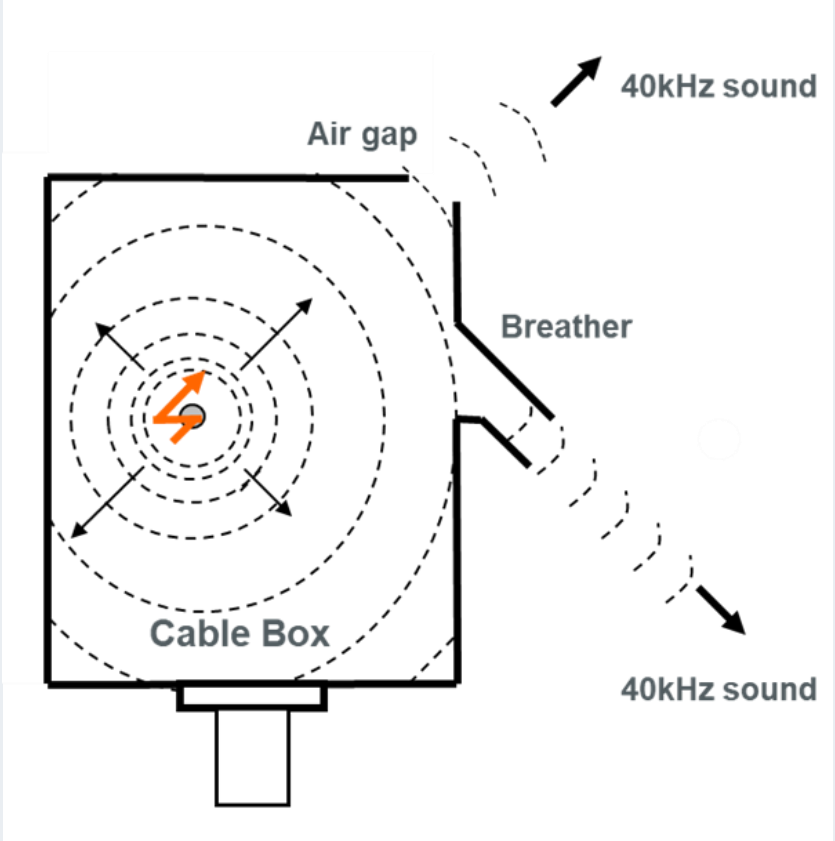
Each defect type is detectable by a specific set of tests

TEV Detection

- Detects electromagnetic emissions generated by internal partial discharge within high-voltage equipment
- Best suited to metal-clad switchgear, RMUs and cable boxes, where PD signals couple onto the enclosure
- Particularly effective for identifying **Internal Void** defects that may not be visible during an inspection
- Completely non-intrusive, allowing assets to be tested safely while remaining in normal service – uses capacitive sensors
- Provides a fast and efficient method for surveying large populations of assets and establishing condition baselines

Ultrasonic Detection

- Detects acoustic emissions generated by partial discharge, typically in the ultrasonic frequency range
- Particularly effective for identifying surface discharge, corona and contact-type defects
- Often allows defects to be located accurately due to the directional nature of ultrasonic signals
- Can be used on switchgear, cable terminations, transformer cable boxes and outdoor HV assets
- Complements TEV testing by detecting defects that may produce little or no measurable electromagnetic activity
- Provides a safe, non-intrusive method of assessing asset condition while equipment remains in service



HFCT Detection

- HFCTs (High Frequency Current Transformers) detect the high-frequency current pulses generated by HV cable partial discharge
- Particularly effective for identifying PD associated with cable joints, terminations and cable insulation defects
- Installed around cable earth screens, allowing testing without disconnecting or disturbing the cable system
- Can detect PD activity over long cable lengths, making it suitable for both individual circuits and network surveys
- Provides valuable information on the presence, severity and trend of cable insulation defects
- Often used alongside TEV and Ultrasonic testing to help distinguish cable PD from switchgear PD

UHF Detection

Switchyards and overhead assets

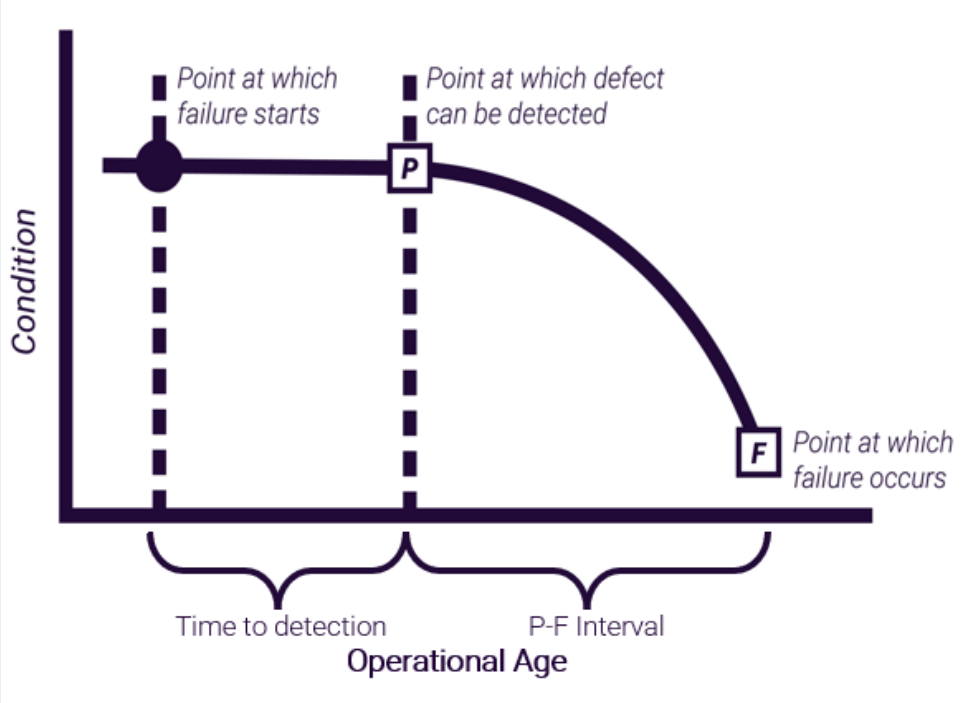
Best Suited To

- Open terminal switchyards
- Outdoor HV assets
- GIS and enclosed equipment with UHF sensors
- Situations where TEV measurement is not possible

- Detects high-frequency electromagnetic emissions generated by PD
- Particularly useful for locating defects on outdoor assets from a safe distance
- Less susceptible to corona interference than lower-frequency techniques
- Signals attenuate rapidly, helping pinpoint the source of discharge
- Complements TEV, Ultrasonic and HFCT as part of a multi-technology approach

Time to Failure - P-F Interval

- The P-F Interval is the time between the point where the potential failure become detectable and the point at which failure occurs
- Every Partial Discharge Defect has a unique P-F curve that is dependent on;
    - Type of Partial Discharge
    - Type of HV Asset
    - Discharge amplitude
    - Insulation type
    - Environmental conditions
    - Physical position of discharge
- Identifying problem early gives the most amount of time for planning and action



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Applying PD Testing Across Asset Types

Applying PD Testing Across Different Asset Types

There is no single "PD test" that suits every asset

- Different HV assets present different Partial Discharge failure modes.
- No single sensing technology is suitable for every asset or application.
- Effective condition assessment matches the right test method to the asset being assessed.

HV Equipment	Applicable Detection Method
Metal clad switchgear, including circuit breakers, ring main units, isolators and fused switches	TEV, Ultrasonic and VPIS HFCT as Secondary
Open terminal switchgear, busbars, insulators, isolators, disconnectors, OHL equipment, CT's, VT's Bushings	UHF, TEV, Ultrasonic
Cable terminations	TEV, Ultrasonic, online, UHF (where applicable) and VPIS
Cable circuits	TEV and HFCT

Metal-Clad Switchgear

Primary Test Points

- Circuit breaker compartments
- Cable boxes and cable terminations
- Busbar chambers
- CT and VT compartments
- Panel joints, vents and inspection covers

Recommended Test Methods

- TEV for internal insulation defects
- Ultrasonic for surface discharge and air-gap defects
- HFCT on accessible cable earth screens

Key Takeaway

- Combining multiple sensing technologies provides the highest confidence assessment of switchgear condition.

Transformers and Outdoor HV Assets

Primary Test Points

- HV and LV cable terminations
- Bushings
- Tank and accessible metalwork
- Tap changer compartments
- Cable boxes and marshalling kiosks

Recommended Test Methods

- TEV on accessible metalwork and cable boxes
- Ultrasonic on bushings, cable boxes
- UHF for internal defects and outdoor transformer assessments

Key Takeaway

- Multiple test techniques are often required to distinguish between transformer, bushing and cable termination defects, allowing the true PD source to be identified.

HV Cable Systems

Primary Test Points

- Cable earth screens and earth straps
- Cable terminations and cable boxes
- Cable joints and link boxes (where accessible)
- Cable pits and transition points

Recommended Test Methods

- HFCT – Primary technique for assessing cable insulation, joints and terminations by measuring PD currents on the cable earth screen.
- TEV – Detects PD propagating along short cable runs and helps identify defects close to switchgear and cable terminations.
- Ultrasonic – Used primarily to detect surface discharge at cable terminations and cable boxes.

Key Takeaway

- Cable PD assessment relies on combining HFCT, TEV and Ultrasonic, with each technique providing different information about the cable system and its terminations.

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Designing for Long term Condition Monitoring

The Gap: When Foresight Determines What's Possible

Ultrasonic

- Modern switchgear is increasingly well sealed, reducing natural air paths for airborne ultrasonic testing.
- Technologies such as **UltraBolt** place the sensor inside the switchgear, providing a permanent measurement point with improved sensitivity.
- Best incorporated during design, but can also be retrofitted to existing assets.

HFCT

- Effective cable PD testing relies on access to cable earth screens.
- Earth screen accessibility should be considered during switchgear design and cable installation.
- Where access is limited, permanently installed HFCTs with external test points provide an effective retrofit solution.

TEV

- TEV testing is less affected by enclosure design and remains applicable to most metal-clad switchgear.
- Can be combined with VPIS phase reference to improve measurement confidence and repeatability.
- Provides a robust foundation for routine condition assessment throughout the asset's life.

The way we design today's assets determines how well we can monitor them tomorrow

Catch is at the IDC HV Conference

Clayton Ross

Engineer | EA Technology

"Designing for Insight at the Outset"

HV Conference, Brisbane

21–22 July 2026

Key Themes

1. Asset management begins at the acquire phase — decisions made early determine whether monitoring is possible at all.
2. Leading vs lagging indicators: design-stage choices determine which you can access across the asset's lifetime.
3. HV cables: long circuits and sealed earth screens create monitoring blind spots when foresight is absent.
4. Designing and commissioning with monitoring in mind transforms high-risk, opaque assets into manageable ones.

13th Australian High Voltage Conference

Australia & New Zealand Attendees!

Join Australia's 13th High Voltage Conference

21–22 July 2026 | Brisbane

If you're based in Australia or New Zealand and work with high voltage systems, don't miss this leading industry conference featuring:

- 17 expert speakers from Australia and overseas
- Practical case studies and technical workshops
- The latest developments in HV asset management, testing, maintenance and safety
- Valuable networking with industry peers

Learn more and register:

https://events.idc-online.com/upcoming-conferences/high-voltage-conference-3

If you are looking to refresh your knowledge or continue building your understanding of PD, these resources are a great next step:

Try EA Technology's quick 10-question PD quiz and put your knowledge to the test! A fun way to recap key concepts from the webinar and see how much you know.

PD Quiz: https://app.quizitri.com/render/170edd0a-dae9-40dc-bec7-17cc50f4643d

You can also sign up to EA Technology's newsletter to receive future educational materials, technical insights, and practical resources on partial discharge testing and condition assessment.

Newsletter: https://eatechnology.com/australia/newsletter-sign-up/

Partial Discharge Quiz

How well do you know Partial Discharge?

Take our 10-question quiz and find out!

With you today

Thomas Whyte

Thomas.Whyte@eatechnology.com

LinkedIn: @Thomas Whyte

EIT Engineering Institute of Technology. | ECT Engineering College of Technology. | ECST Engineering College of Science and Technology. | IDC Technologies

Thank You!

Upcoming Courses

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) *Australian Accredited Qualifications & Short Courses*	Start Date
Professional Certificate of Competency in Power Distribution	3 November 2026
52888WA Advanced Diploma of Applied Electrical Engineering (Power Industry)	1 September 2026
52892WA Advanced Diploma of Electrical and Instrumentation (E&I) Engineering in Mining	1 September 2026
52910WA Graduate Certificate in Hydrogen Engineering and Management	6 October 2026
Bachelor of Science (Electrical Engineering)	17 July 2027
Graduate Certificate in Power System Analysis and Design	4 January 2027
Associate Degree in Electrical Engineering	8 February 2026
Master of Engineering (Electrical Systems)	4 January 2026
Master of Engineering – Applied Research (Electrical Systems)	4 January 2027

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) *UK qualifications*	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) *South African accredited qualification & ECSA-endorsed*	Start Date
Bachelor of Engineering Technology in Electrical Engineering	3 August 2026

Q&A

EIT
Engineering Institute of Technology.

ECT
Engineering College of Technology.

ECST
Engineering College of Science and Technology.

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Programmes
www.ecst.ac.za/course-types/bachelor-of-engineering/