

The Risks of Contamination

The risks and consequences for transformer safety and reliability.



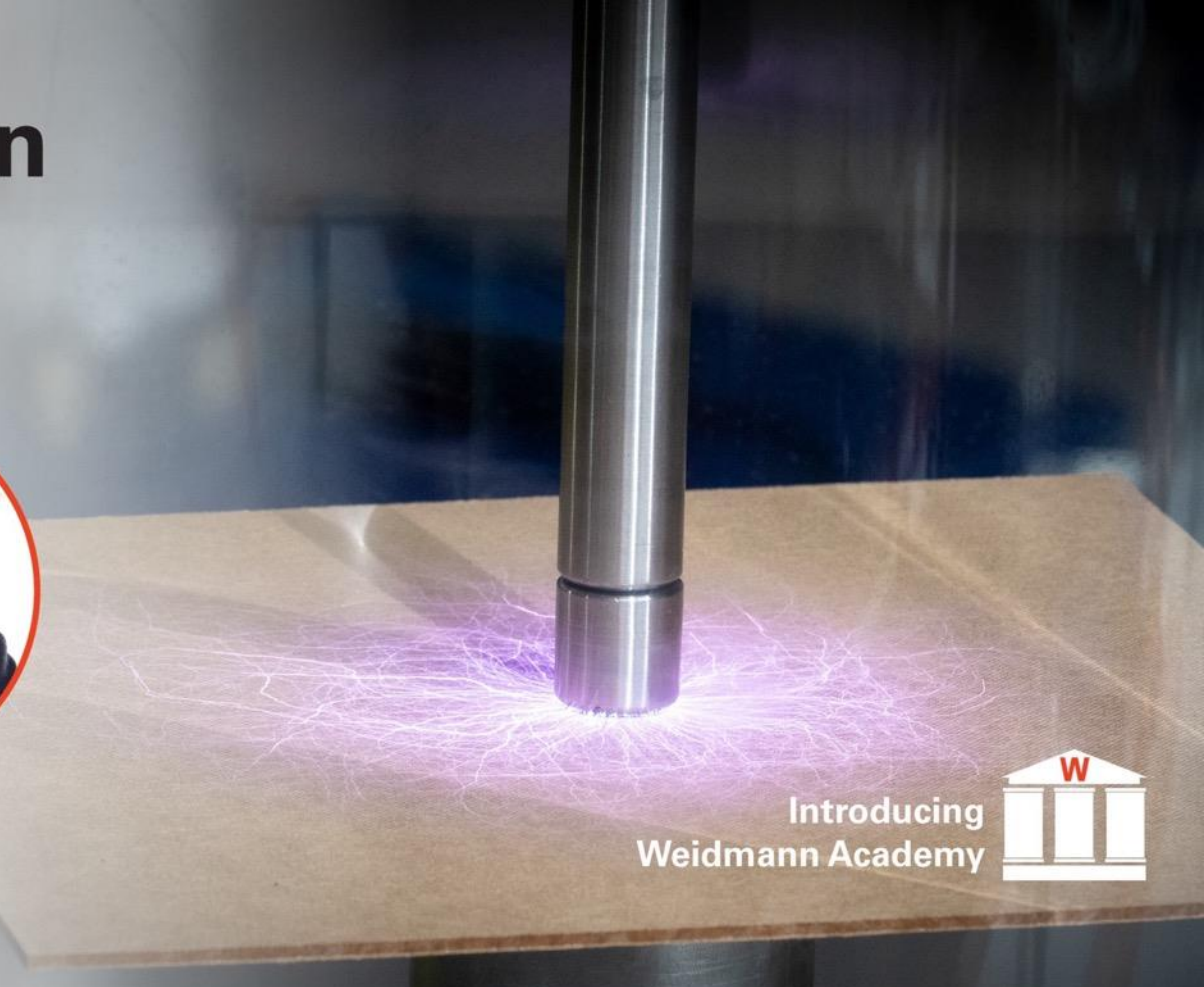
Brad Greaves
Laboratory
Services Manager



Yurii Shypilov
Head of
Weidmann Academy



Francis Fisher
Moderator



Introducing
Weidmann Academy



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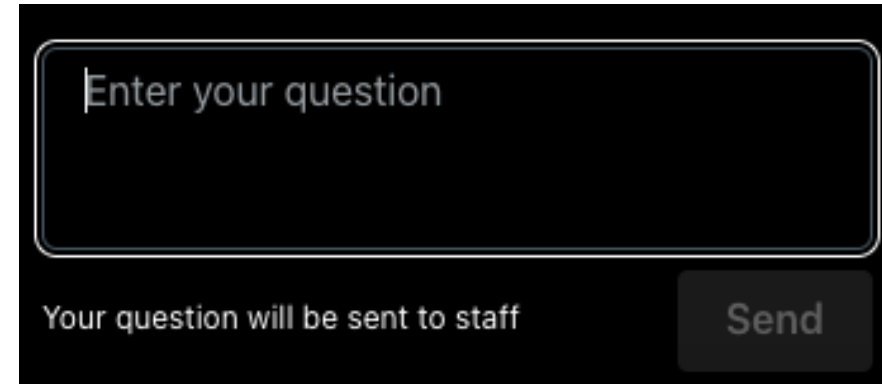
THE RISKS OF CONTAMINATION

THE RISKS OF CONTAMINATION WEBINAR

HOW TO ASK A QUESTION



Click the question mark icon in the top right panel.

A dark gray question submission form. It features a large text input field with the placeholder text "Enter your question". Below the input field, there is a line of text that reads "Your question will be sent to staff". To the right of this text is a button labeled "Send".

Type your question. This will only be seen by the event organizers.



THE RISKS OF CONTAMINATION

The Risks of Contamination

Partial Discharge

Contaminants in a Controlled Environment

Conclusions

Questions?

THE RISKS OF CONTAMINATION

MAIN FUNCTIONS OF INSULATION

Electrical Insulation

- Oil is five times a better insulator than air
- Dried and oil-impregnated paper is an excellent insulator

Mechanical Support

- Cellulose is a strong insulator
- Pressboard has good mechanical stability

Heat Transfer

- Oil is a good heat transfer fluid
- Paper and pressboard are porous... Oil can flow through the material
- Oil can be used to remove heat from windings

BEST INSULATION SYSTEM FOR TRANSFORMERS IS OIL/PAPER



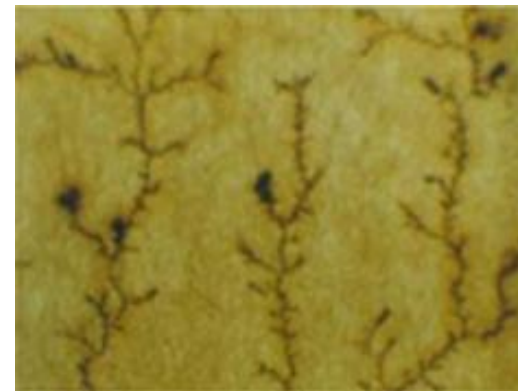
THE RISKS OF CONTAMINATION

INSULATION FAULT

What happens **when a metal particle is** in an insulation material?

- Local overheating, becomes larger
- Possible explosion of the transformer
- Danger to life for persons in the vicinity

An insulation fault in a transformer is similar to a lightning strike



THE RISKS OF CONTAMINATION

CLEANLINESS OF RAW MATERIALS – PULP AND WATER

UKP E-Grade

=

Unbleached Kraft Pulp Electrical Grade



Source: Conifers (pines and spruce) are from the Northern Hemisphere → renewable resource. Electrical Grade – extremely clean pulp.

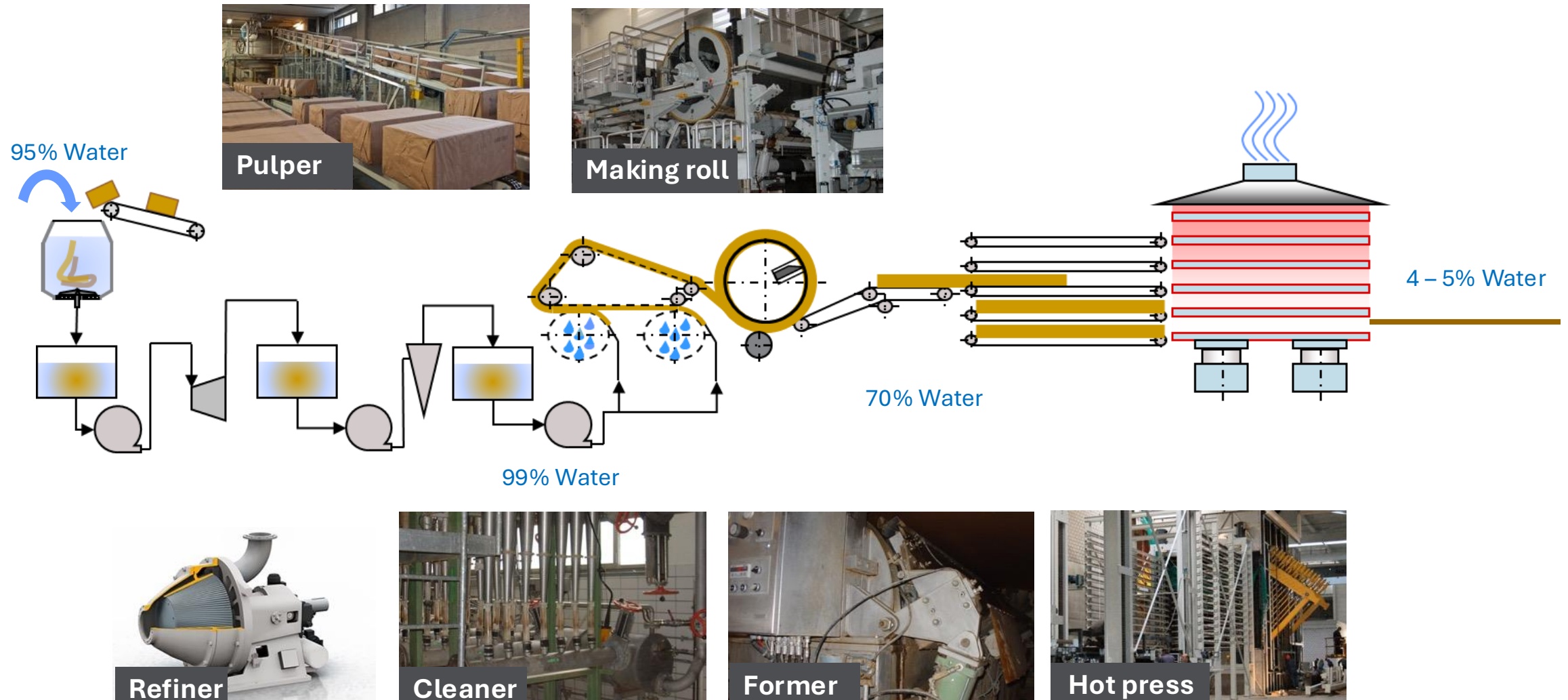
Water quality: pH value, conductivity, floating particles, water hardness, and contents of chloride

- Coagulation
- Filtering
- Flocculation



THE RISK OF CONTAMINATION

CLEANLINESS IN PRODUCTION OF TRANSFORMERBOARD



THE RISKS OF CONTAMINATION

RULES IN PRODUCTION AREAS



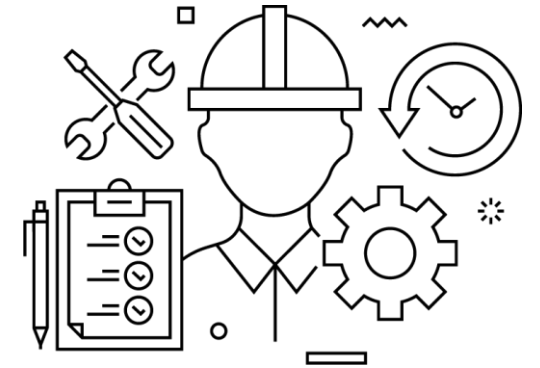
THE RISKS OF CONTAMINATION

RULES IN PRODUCTION AREAS



THE RISKS OF CONTAMINATION

RULES ALSO FOR MAINTENANCE, CONSTRUCTION WORK, AND REPAIR PERSONNEL



Do not forget
external
craftsmen!

THE RISKS OF CONTAMINATION

GENERAL RULES FOR REDUCING THE RISK OF PRODUCT CONTAMINATION

- Before starting work on production sites, make sure work clothes and work shoes are clean and that there are no metal chips/particles on them.
- Don't carry metal parts (such as nuts, paper clips, drills, etc.) in the pockets of work clothes.
- Store small items (e.g., screws and nuts) in suitable containers.
- Use only serviceable equipment and tools.
- **You should never touch manufactured products with your shoes.**



THE RISKS OF CONTAMINATION

SOURCES OF PRODUCT CONTAMINATION

The source of product contamination can be metal parts and tools left unattended or those that are damaged:

Friction of metal against metal

**Mechanical damage to molds
(cracks, chips, and burrs)**



Conclusion: It is necessary to conduct a periodic inspection of tools and equipment. If damage is detected, inform your manager of the need to replace or repair the damaged tools.

THE RISKS OF CONTAMINATION

SIMPLE, BUT VITAL, PREVENTIVE ACTIONS

Contaminated premises and work surfaces, repairs, cleaning, maintenance, and installation of equipment in the production area are also associated with a high risk of product contamination.



To reduce the risk of contamination, it is necessary:

Regular cleaning and checking of
work surfaces and surrounding areas



Two types of cleaning:

- **Dry cleaning** – Clean surfaces in production areas, on main and auxiliary equipment, and other objects in the premises with brushes, a vacuum cleaner, or compressed air (but be careful!)
- **Wet cleaning** – Clean surfaces in production areas, on main and auxiliary equipment, and other objects in the premises with wet wipes, mops, or a floor washer.

Regularly check the level of cleaning quality:

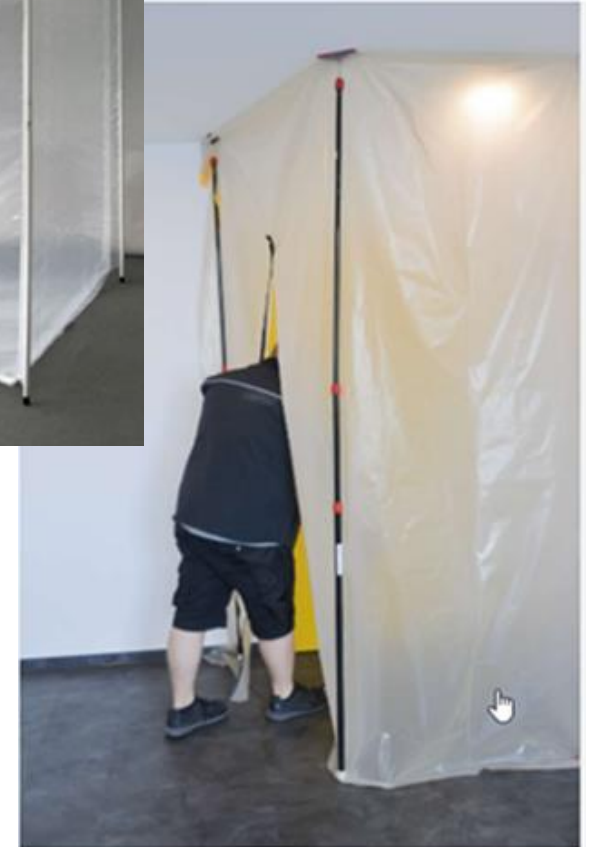
- **Metal audit** – Daily checking with magnet tools in hard-to-see places in and around the production areas.

THE RISKS OF CONTAMINATION

SIMPLE, BUT VITAL, PREVENTIVE ACTIONS

Maintenance, repair, and installation of equipment may cause increased risk of product contamination.

- Separate the workplace from the rest of the production workshop.
- Use only serviceable equipment and tools.
- At the end of the work shift, clean the workplace to make sure contamination has not affected work surfaces.



THE RISKS CONTAMINATION

SIMPLE, BUT VITAL, PREVENTIVE ACTIONS

Storage and packaging areas

- To ensure products won't be contaminated, storage and packaging areas must be kept dry and clean.
- Before beginning the packaging process, check the area for contaminants.
- Install warning signs to enclose the packaging area.

Important: Use only clean and proper film for packaging (to prevent static electricity). Any part of the film that contacts the floor must not come in contact with the product.



Important: Do not touch shoe film or parts. When placing parts inside the packaging, the worker must always use plastic overshoes.





THE RISKS OF CONTAMINATION

The Risks of Contamination

Partial Discharge

Contaminants in a Controlled Environment

Conclusions

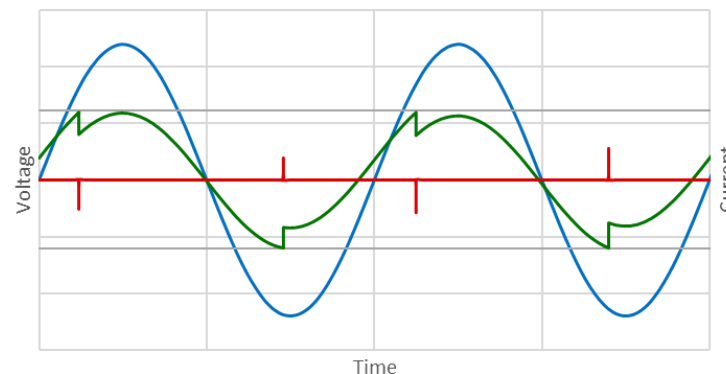
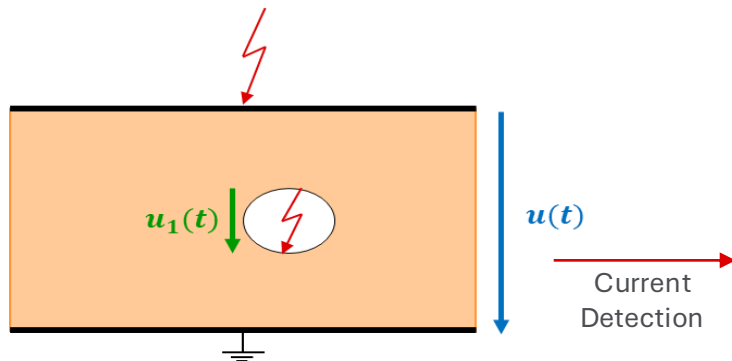
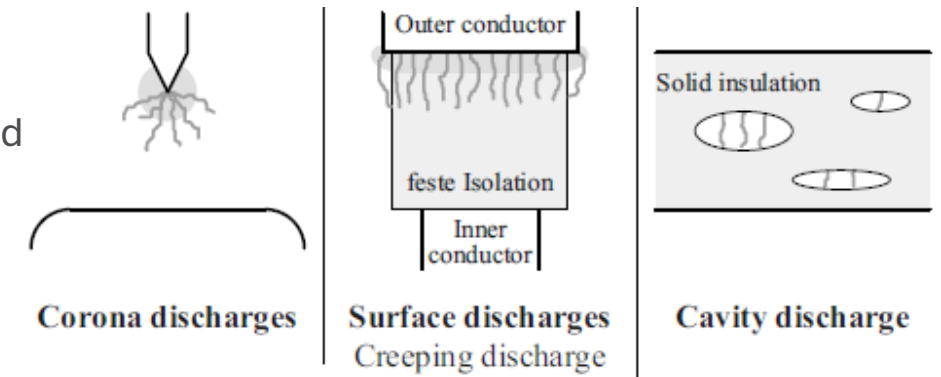
Questions?

ELECTRICAL TEST

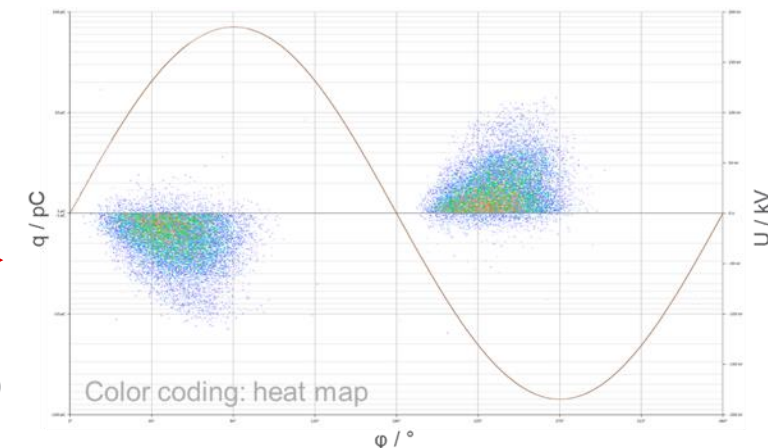
PARTIAL DISCHARGE (PD) SERVES AS A QUALITY INDICATOR FOR INSULATION SYSTEMS

- **Definition of Partial Discharge (PD):**

- Partial discharge (PD) is a **localized electrical discharge that partially bridges the insulation** between electrodes.
- It occurs due to imperfections in dielectric materials, causing local field enhancement where intrinsic field strength may be exceeded.
- PD is often a precursor of a breakdown.
- PD consists of rapid and small current pulses, typically in the nanosecond range.
- PD generates electromagnetic signals and is often accompanied by emission of sound, light, heat, and chemical reactions.
- PD signal processing enables the identification and differentiation of partial discharge sources.

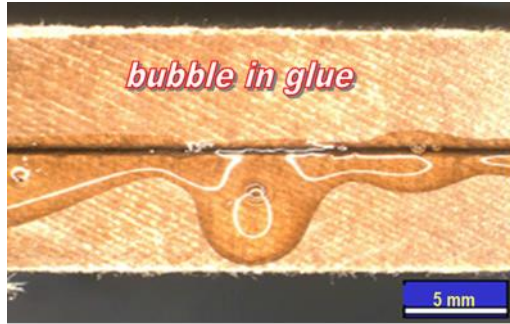


Current Signal
Processing
(PRPD Patterns)

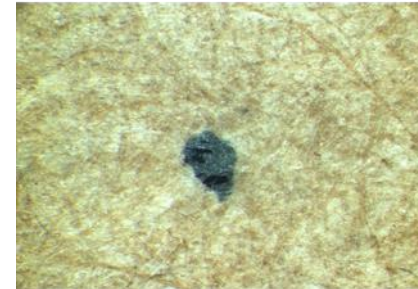
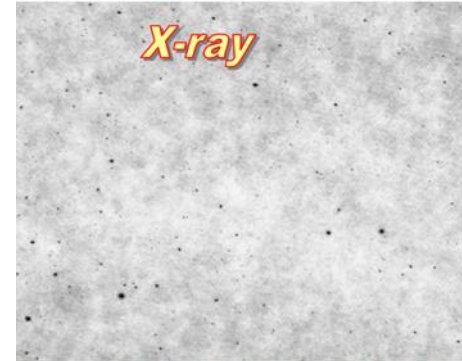


PARTIAL DISCHARGE (PD)

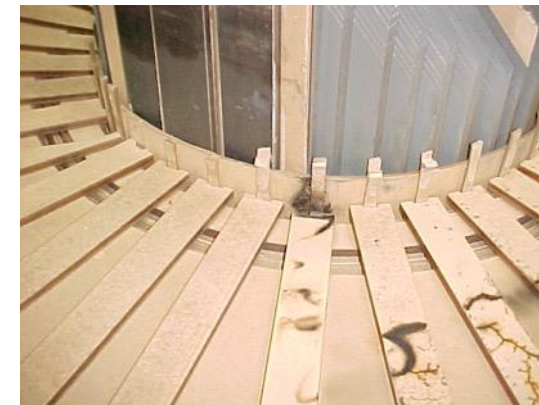
PD TESTS HELP TO UNCOVER HIDDEN ISOLATION ISSUES FOR TIMELY INTERVENTION



- Surface contamination, dirt, particles
- Hazardous glue
- Bubbles in excessive glue
- Insufficient drying
- Harsh vapour phase drying
- Particles in oil



- metallic (particles) inclusions
- voids (air bubbles)
- copper conductor deformation
- burst of paper wrapping
- defect metallization of a metalized shield (ring)
- magnetic steel oxidation



PARTIAL DISCHARGE (PD)

WHAT DOES PD LOOK LIKE?

CIGRE Technical Brochure 676, Partial Discharges in Transformers

- Type 1 – Conducting material directly connected to a metallic electrode
- Type 2 – Conducting material with no contact to a metallic electrode
- Type 3 – Conducting particles on the surface of material

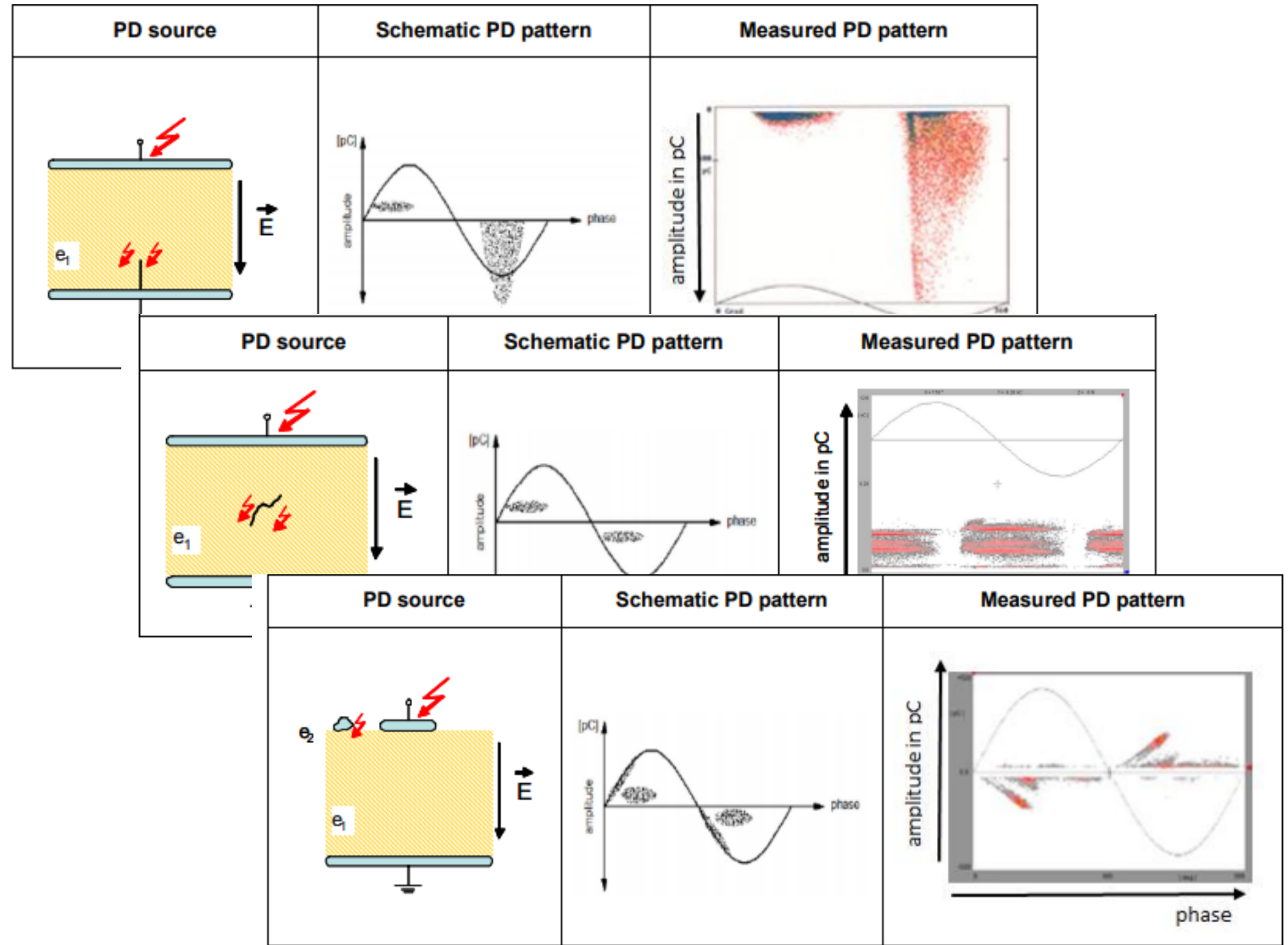
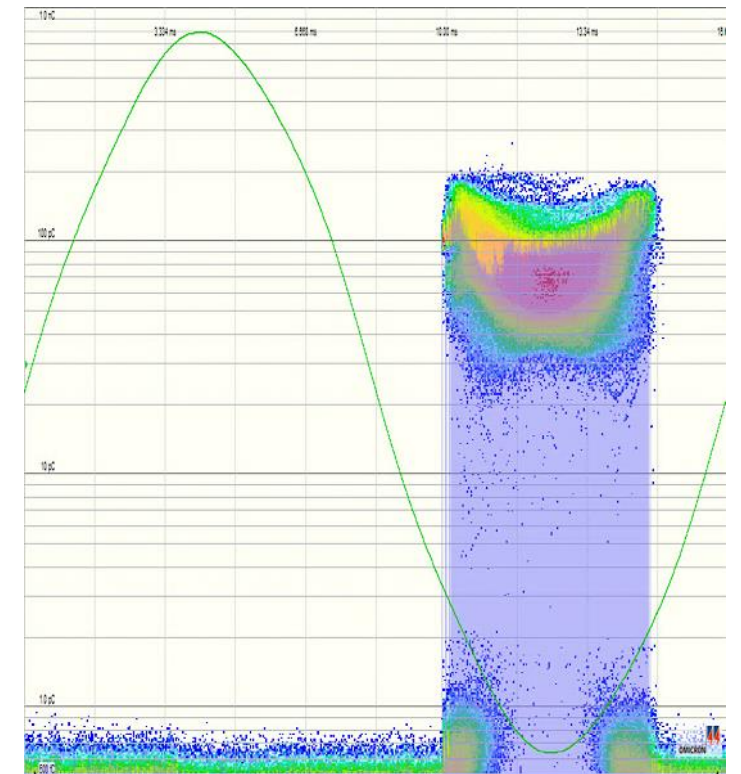
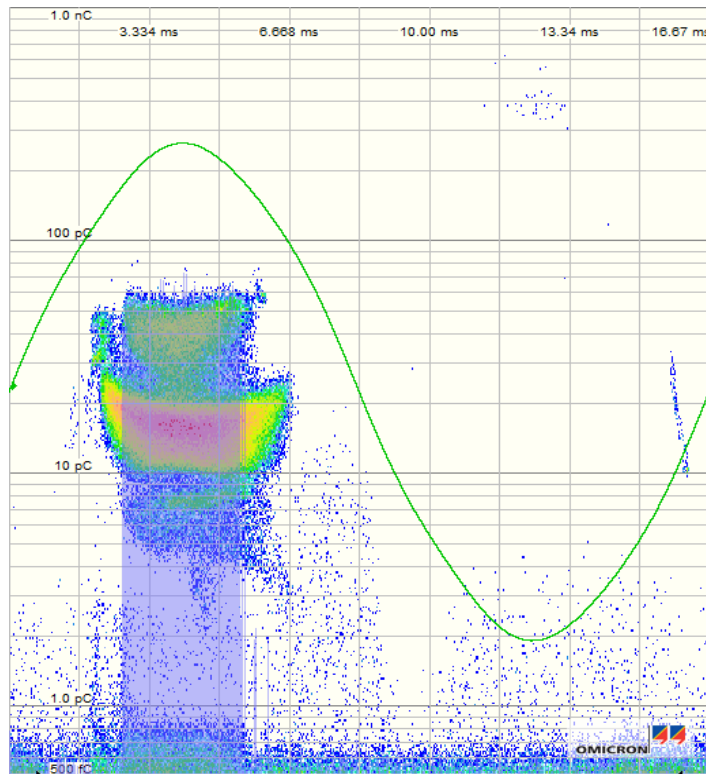


Figure 3.3 : Example of typical PD pattern type 3 [Schwarz-Siemens, Carlson-2010]

PARTIAL DISCHARGE (PD)

WHAT DOES PD LOOK LIKE?

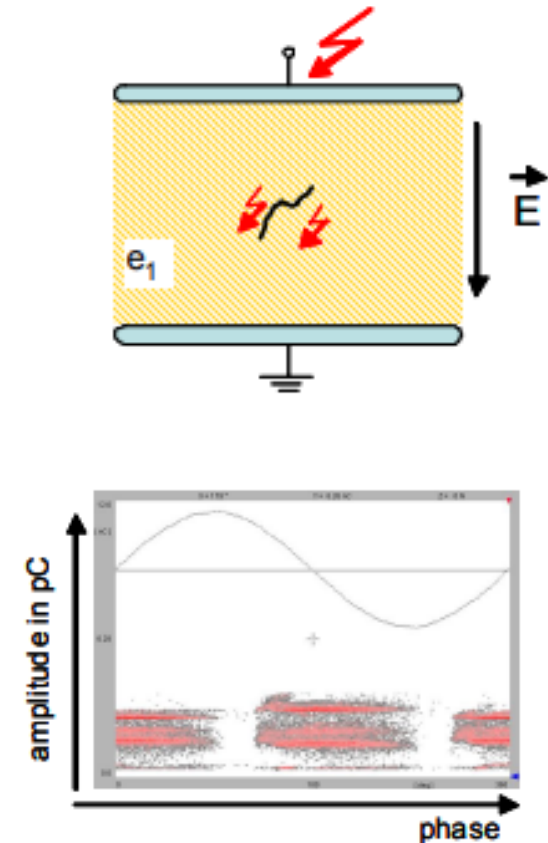
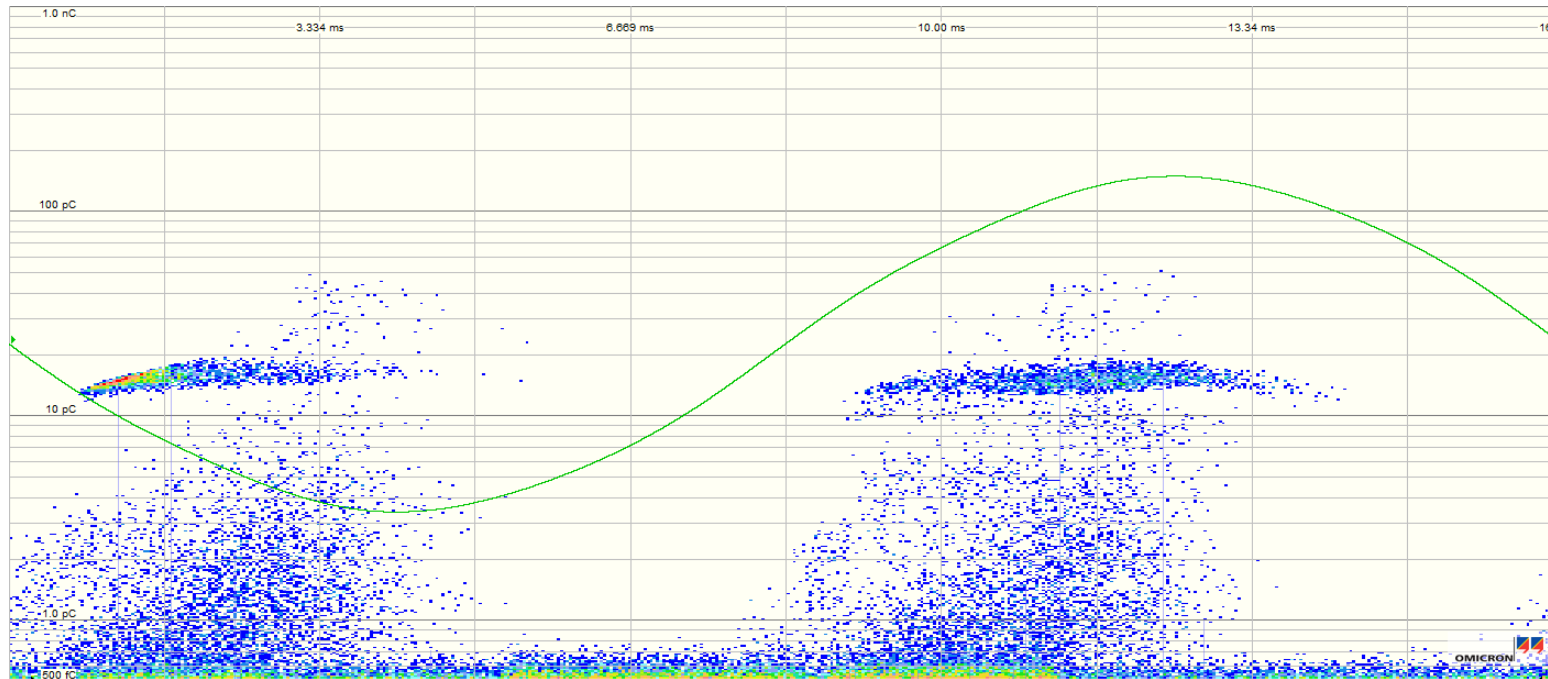
- Corona – similar to Type 1 – Conducting material directly connected to the electrode.



PARTIAL DISCHARGE (PD)

WHAT DOES PD LOOK LIKE?

- Type 2 – Conducting material with no contact to the electrode (also appears to have a type 5).



PARTIAL DISCHARGE (PD)

WHAT DOES PD LOOK LIKE?

CIGRE Technical Brochure 676, Partial Discharges in Transformers

- Type 4 – Non-conducting material with contact to an electrode
- Type 5 – Non-conducting material with no contact to a metallic electrode
- Type 6 – Non-conducting material with interaction at the surface with no electrode contact

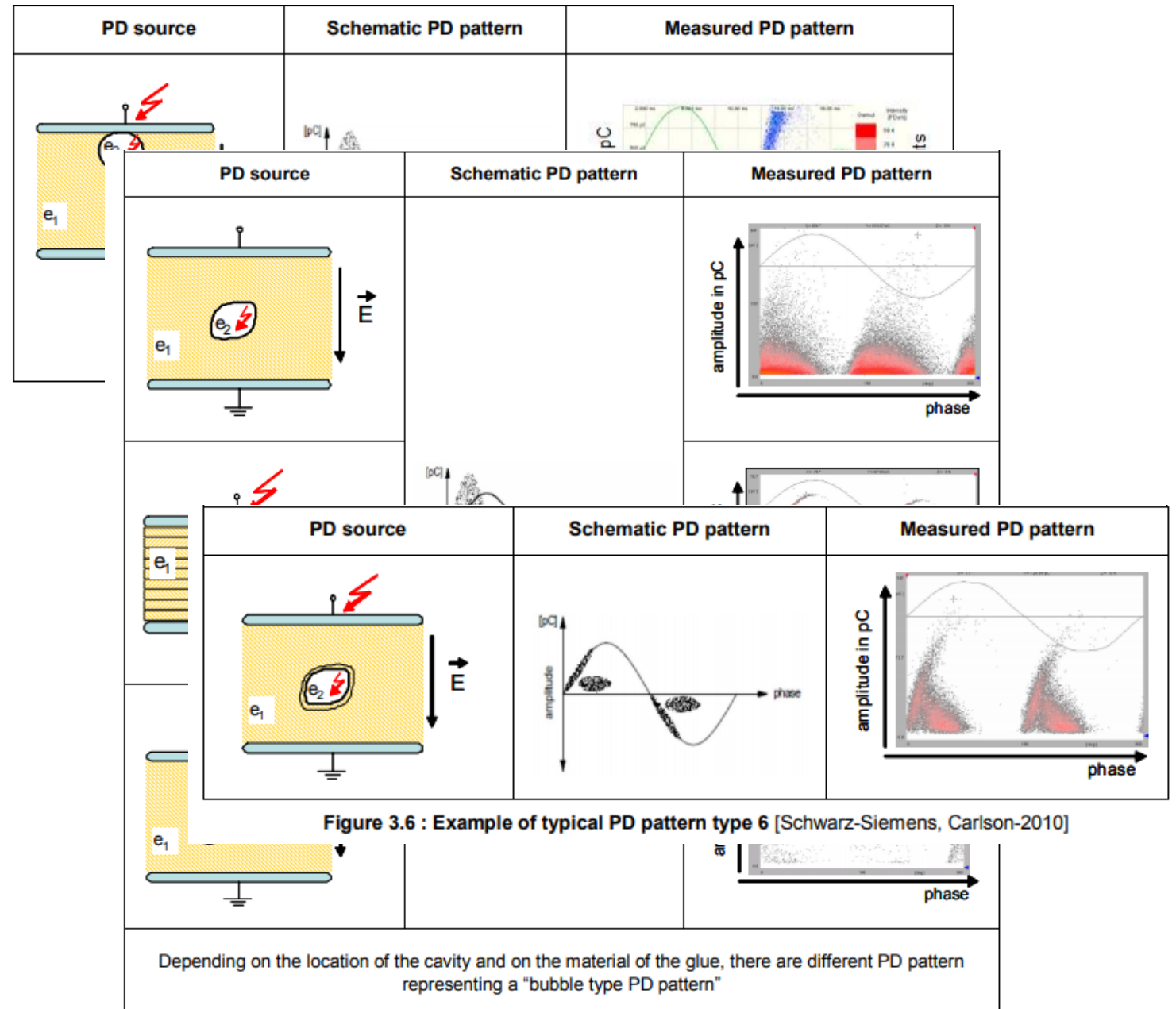
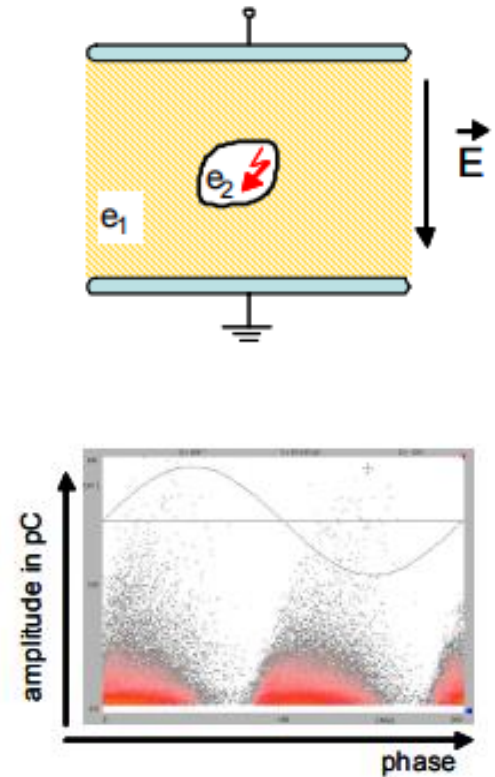
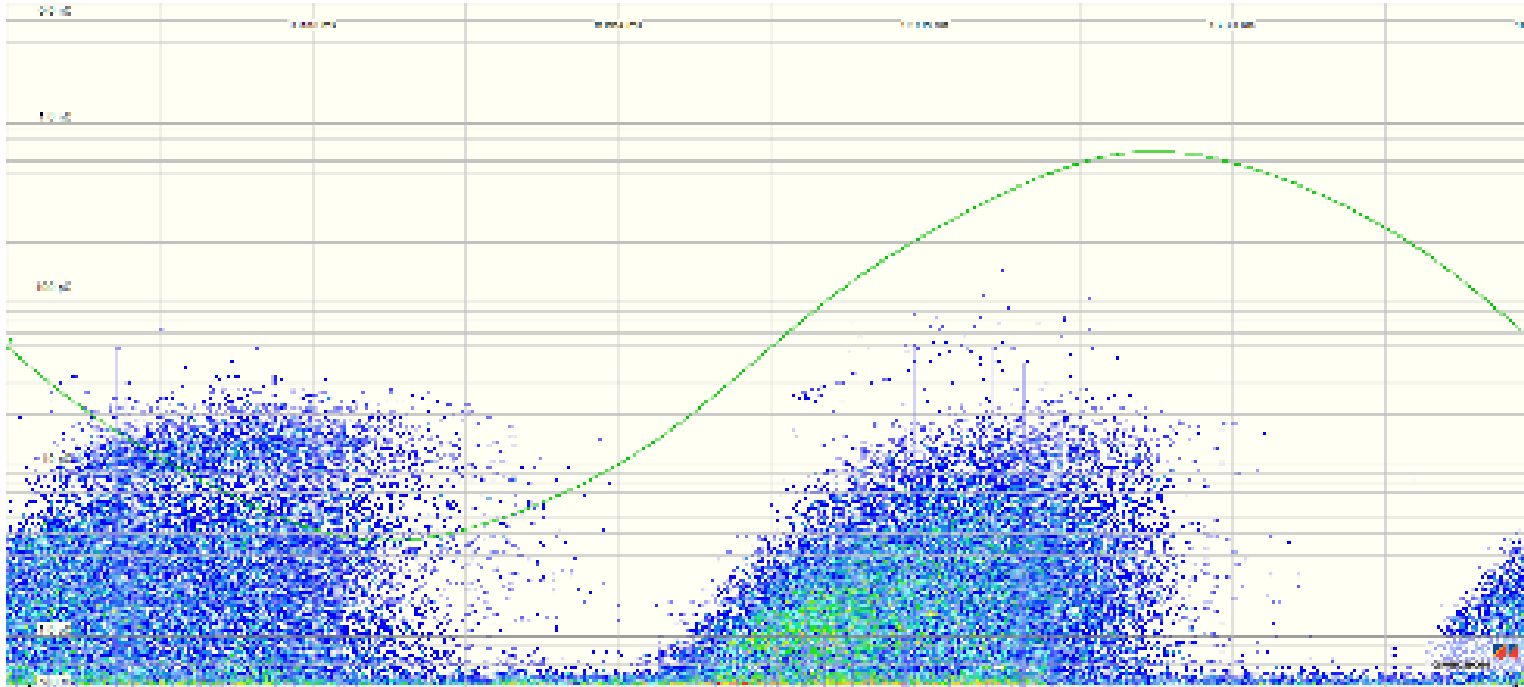


Figure 3.5 : Example of typical PD pattern type 5 [Schwarz-Siemens, Carlson-2010]

PARTIAL DISCHARGE (PD)

WHAT DOES PD LOOK LIKE?

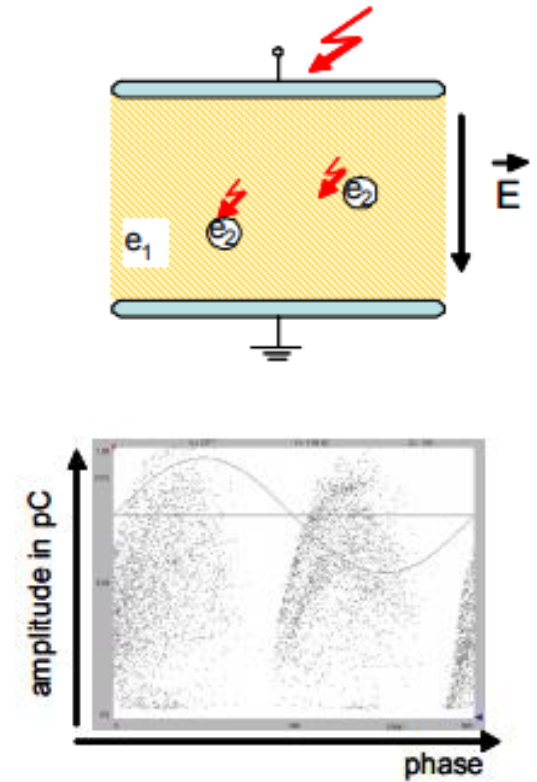
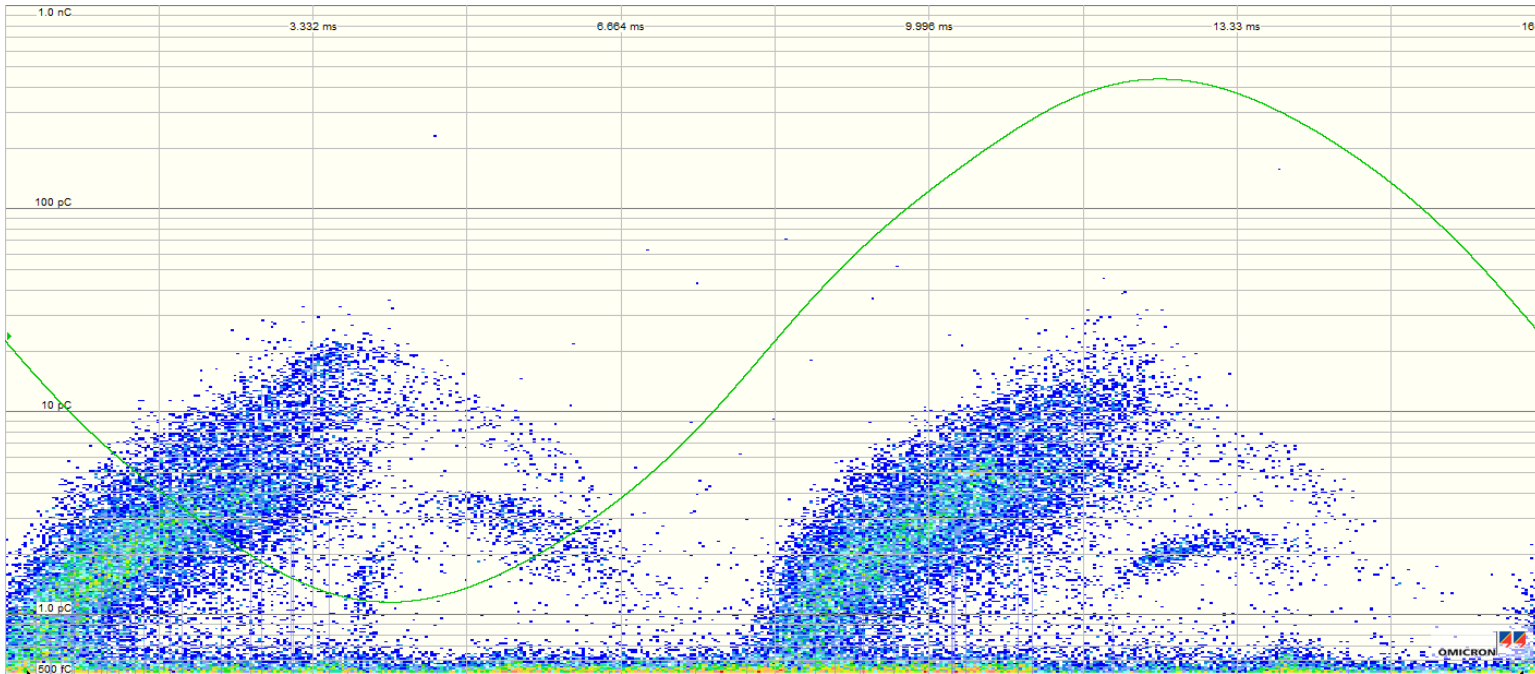
- Type 5 – Non-conducting material with no contact to an electrode (single defect).



PARTIAL DISCHARGE (PD)

WHAT DOES PD LOOK LIKE?

- Type 5 – Non-conducting material with no contact to an electrode (multiple defects).





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CONTAMINANTS IN A CONTROLLED ENVIRONMENT

WHAT DOES A BREAKDOWN LOOK LIKE?

- Surface contaminants can provide a path for discharges to occur
- Free contaminants can be moved throughout a transformer by the oil
- Attracted by the dielectric field to high-stress areas
- Multiple examples of what different contaminants look like when exposed to high dielectric stresses
 - Surface contaminate (pencil)
 - Metal filings
 - Transformerboard chips
 - Free water
- [Watch the examples here](#)



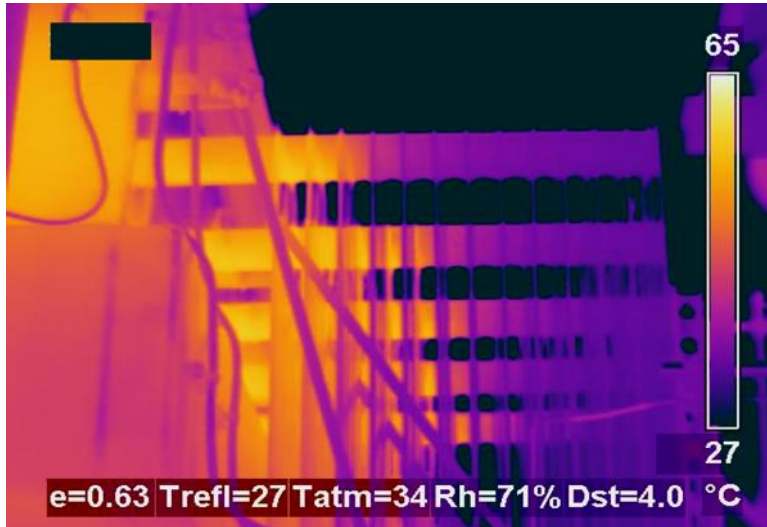
THE RISKS OF CONTAMINATION

BREAKDOWN, PARTIAL DISCHARGE, AND OVERHEATING



THE RISKS OF CONTAMINATION

FAILURE AND ACCIDENTS OF TRANSFORMERS





THE RISKS OF CONTAMINATION

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THE RISKS OF CONTAMINATION

CLEANLINESS OF PRODUCTION PROCESSES – PAY ATTENTION TO:

- Cleanliness requirements
- Memo to the employee
- Crane runways
- Metal audit regularly
- Chips on the tool = particles in the material
- Packaging materials, auxiliary materials – neatly and cleanly
- Clean dust collectors, machines, brooms, and dustpans (don't blow around)
- Places of contamination (friction, dust, air currents, ventilation, and dirty clothes/shoes)
- Repair, construction work – strict isolation from production sites (screens, or remotely)
- Metal pieces (bolts, nuts, washers) and other small parts (staples, paper clips, etc.) that may be in pockets
- Welding, cutting, any other work with metal – in isolation and outside the workshop/site





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W Weidmann Academy



Basic Courses

- 12 lessons
- One per month
- Virtual
- English
- Conducted by Weidmann trainers



Special Courses

- Special groups
- 10 – 15 lessons
- Special sessions
- Domestic language



Training Courses

- External
- 10 – 15 lessons
- Upon request, paid courses
- 1 – 2 day seminars

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THANK YOU!

Weidmann Knowledge: Rules | Tools | Publications | Books