Condition Assessment on Transmission Cables using OWTS HV Technology

Goal of PD On-site Testing / Diagnosis:

new installed Power Cables

- ***during after-laying test (in combination with voltage withstand test)***
- ***to recognize poor workmanship in cable accessories,***
- ***by checking up to $1.7U_0$ $2.0U_0$ the PD-free condition of cable accessories,***
- ***and in the case of PD presence an evaluation of the PD level preferably in [pC] and repair of the particular accessory.***

Goal of PD On-site Testing / Diagnosis:

service aged Power Cables

- ***during service life (as a part of on-site condition assessment)***
- ***to support the maintenance- and operation decisions,***
- ***by detecting and localising PD's in cable insulation and cable accessories,***
- ***and in the case of PD presence an evaluation of the PD occurrence (PDIV, PD-levels, PD patterns) and comparison to the acceptance norms for particular types of cable insulation and accessories.***

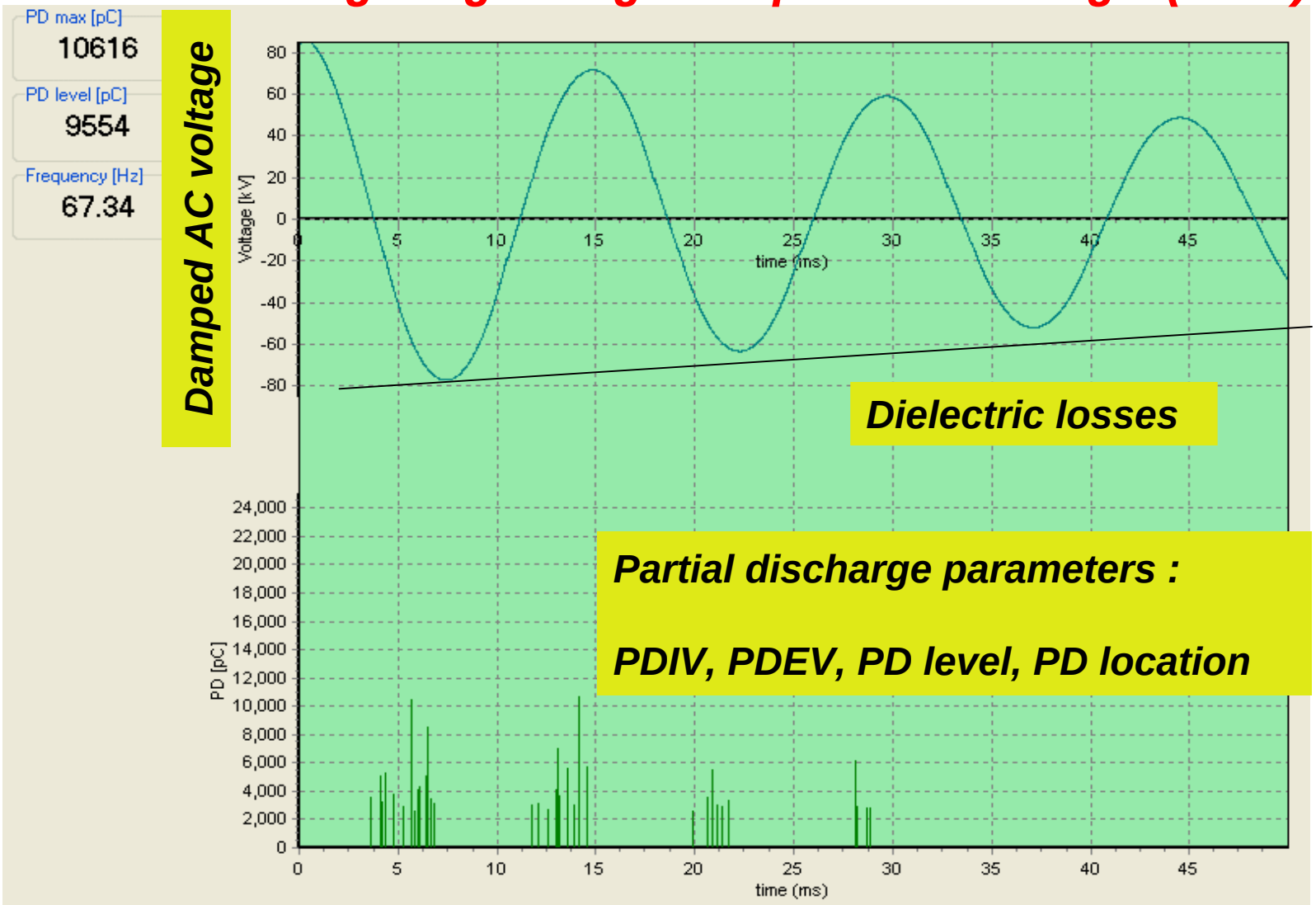
On-site PD Diagnostic Methodologies

OWTS® methodology

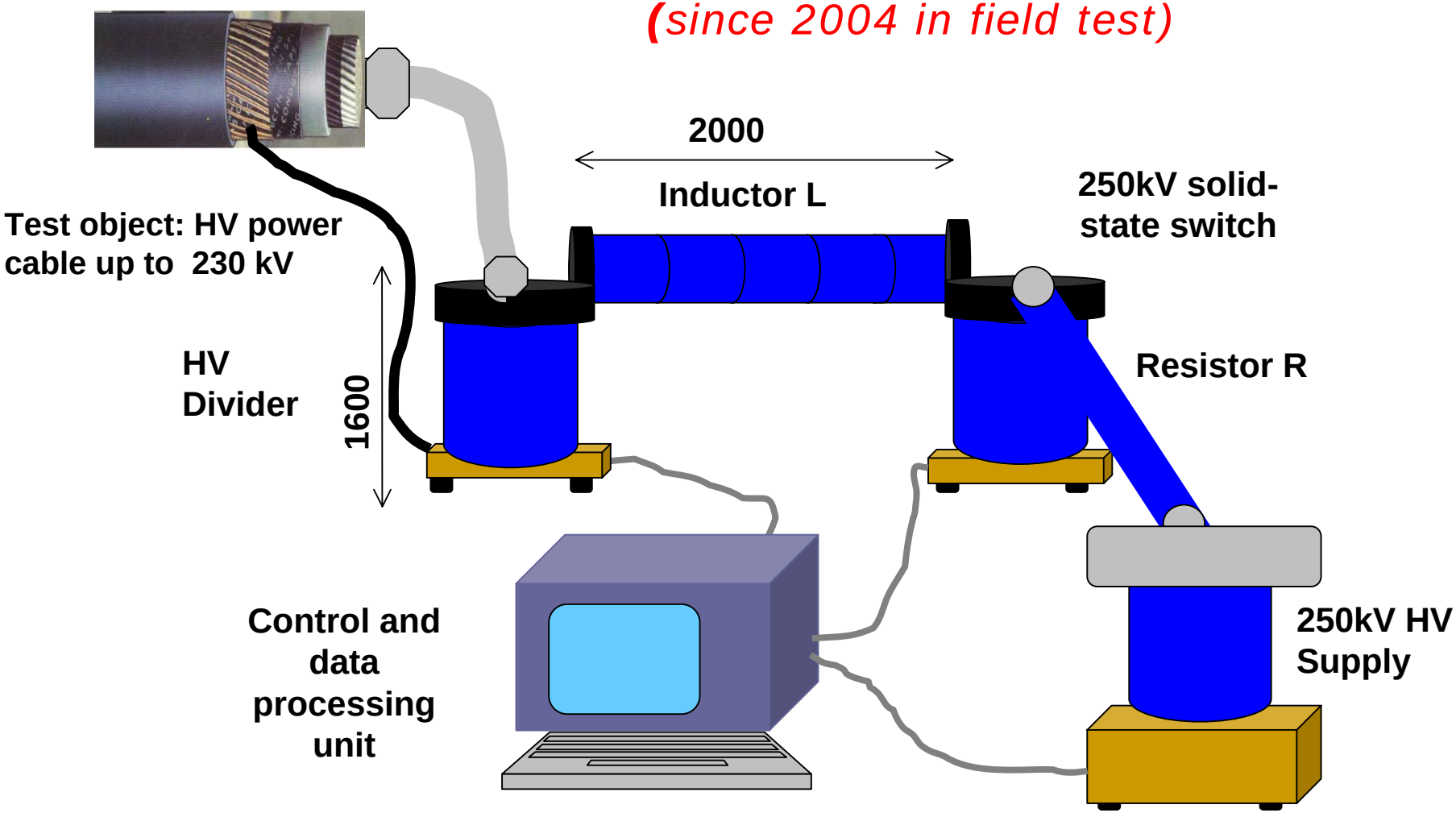
on-site PD detection and localisation as well as dielectric losses measurement in cable insulation and accessories using

Damped AC voltages up to 250kV

On-site Energizing using Damped AC Voltage (DAC)



Test Setup OWTS type 250 kV_{peak} (since 2004 in field test)

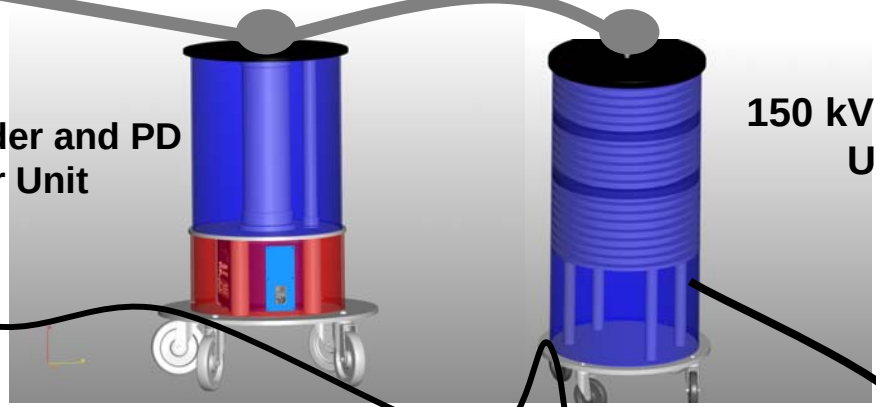


(Out-door) On-site testing using damped AC 250kV: PD and dielectric losses

Weight: 300kg
Supply voltage: 220V
Max. load at 250kV: 8μF
Output: DAC voltage 250kV (50 Hz - 500 Hz)

Test object: power cables: 100m -20km

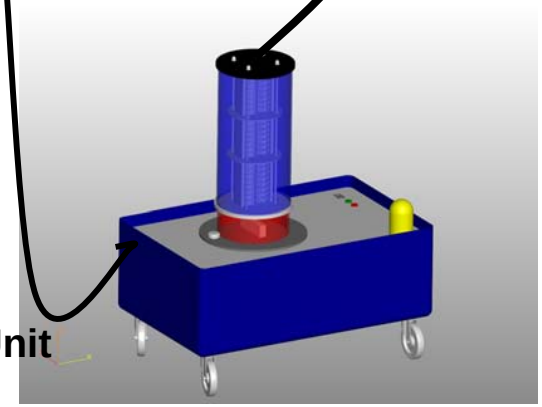
Test Setup OWTS type 150 kV_{peak}



HV Divider and PD analyser Unit

150 kV_{peak} Coil Unit

Computer Control Unit



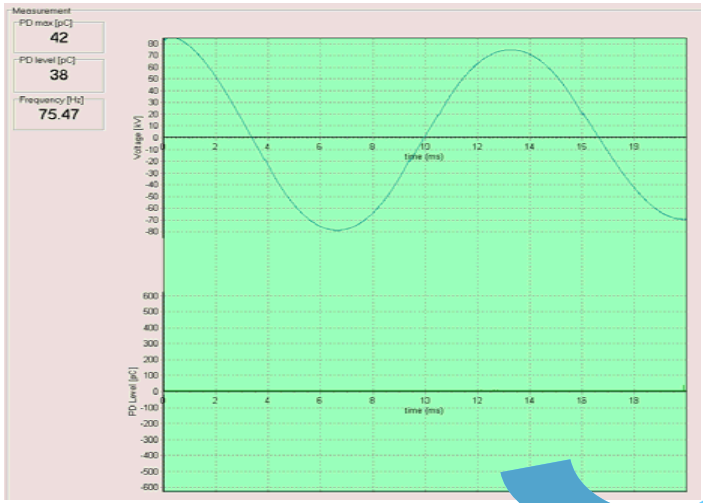
150 kV_{peak} HV Unit

Example 1:

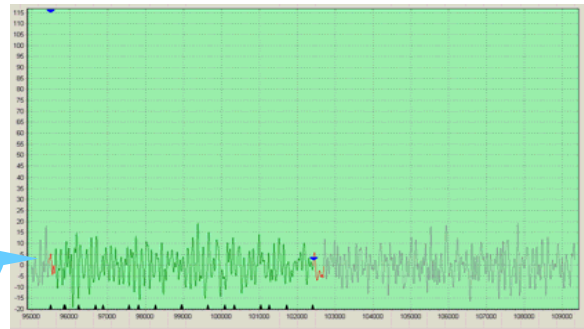
After-laying test and PD inspection of a 50kV XLPE cable section

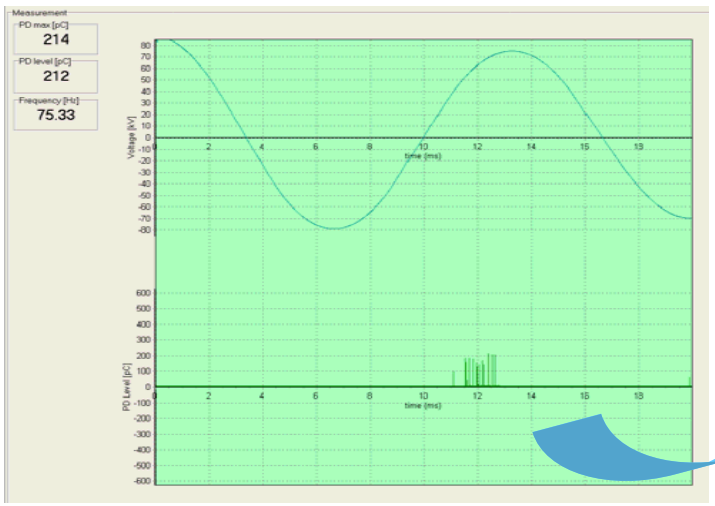
Substation of Railway Power supply

Example 1:
PD on-site diagnosis up to 2 x U_0 (6km /50kV; XLPE)



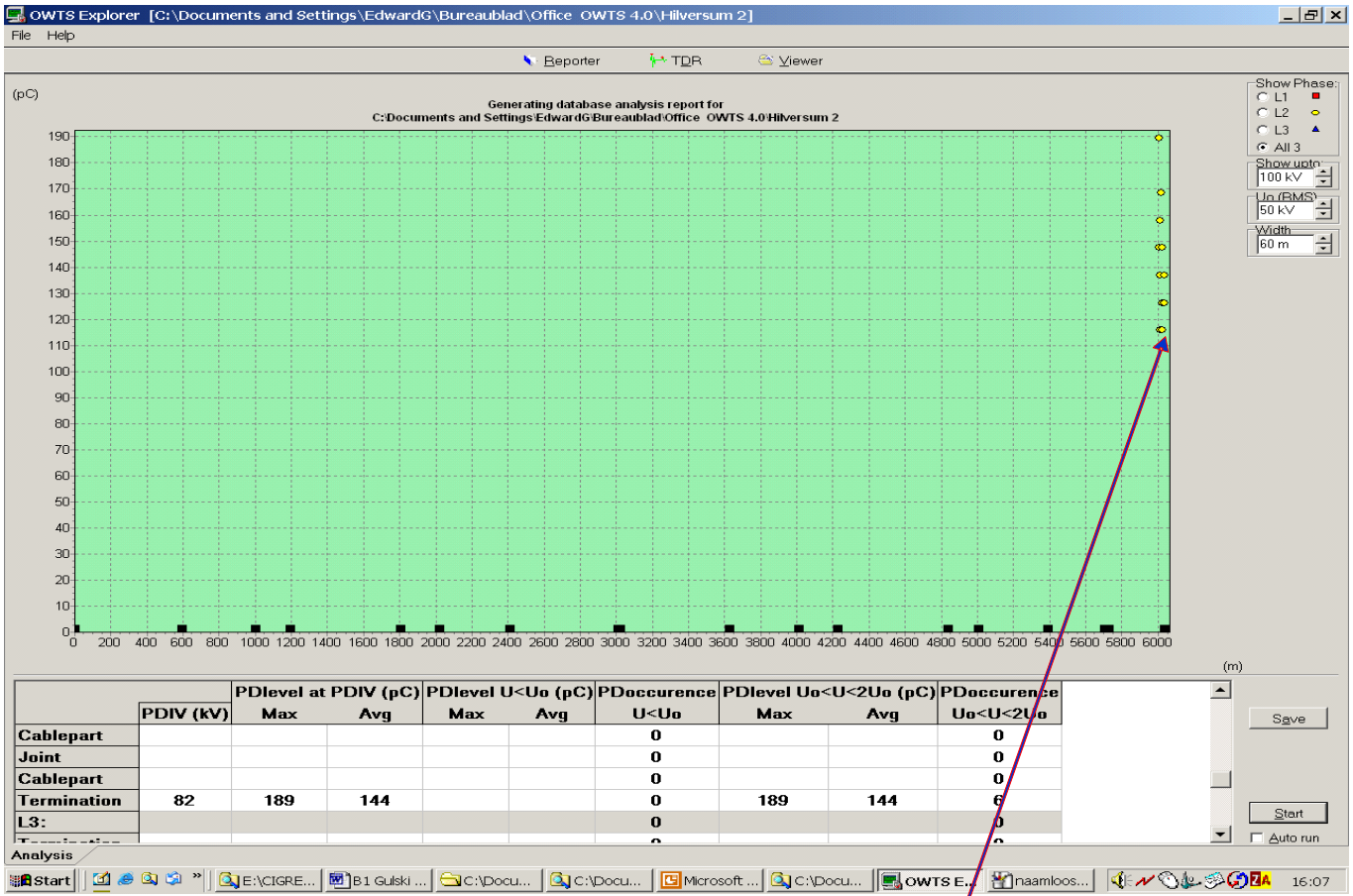
L1, L2 : up to 2xUo PD free
Noise level < 10 pC





L3: PDIV @ 82kV
PD~180 pC

Example 1:
PD on-site diagnosis up to 2 x U_0 (6km /50kV; XLPE)



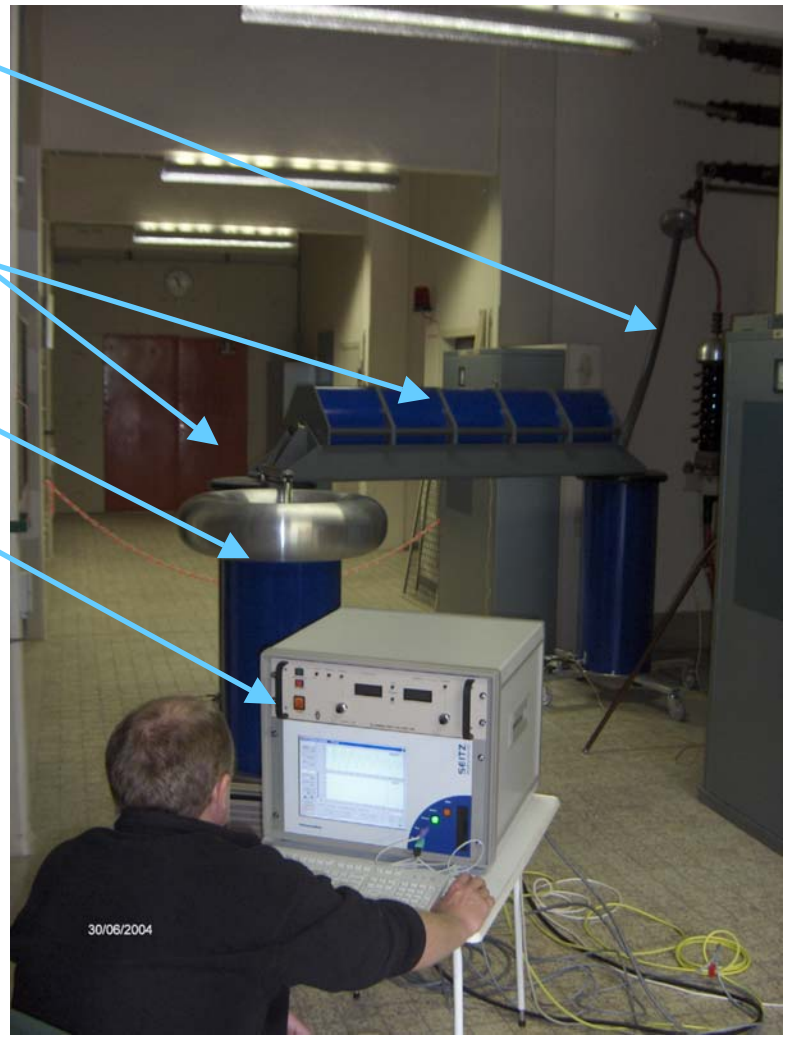
	PDIV (kV)	PDIevel at PDIV (pC) Max	PDIevel at PDIV (pC) Avg	PDIevel U<Uo (pC) Max	PDIevel U<Uo (pC) Avg	PDoccurence U<Uo	PDIevel Uo<U<2Uo (pC) Max	PDIevel Uo<U<2Uo (pC) Avg	PDoccurence Uo<U<2Uo
Cablepart						0			0
Joint						0			0
Cablepart						0			0
Termination	82	189	144			0	189	144	6
L3:						0			0

L1, L2 : up to 2xUo PD free (PD < 10 pC)

L3 : PDIV @ 82kV; PD level ~ 180 pC located in the termination

(In-door) On-site testing using damped AC 250kV: PD and dielectric losses

- 50kV Power Cable
- 250kV HV Switch
- 3.5 H Inductor
- 250kV HV Supply
- HV Control Unit
  PD Analyzer

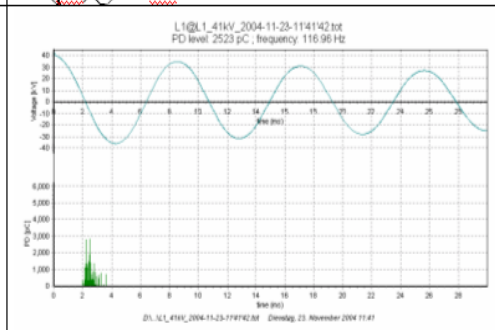
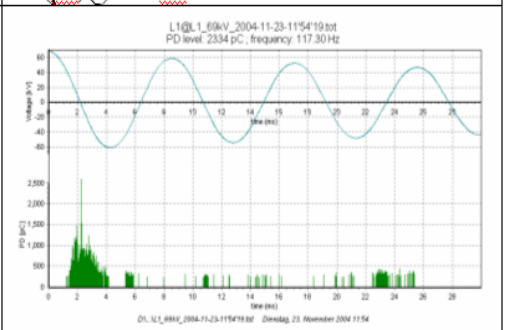


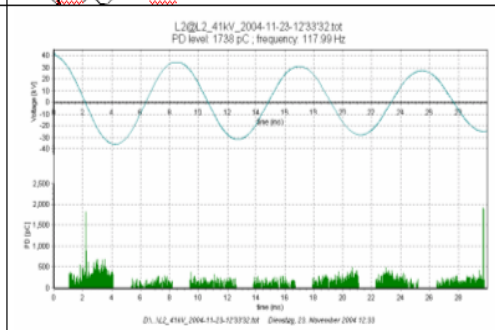
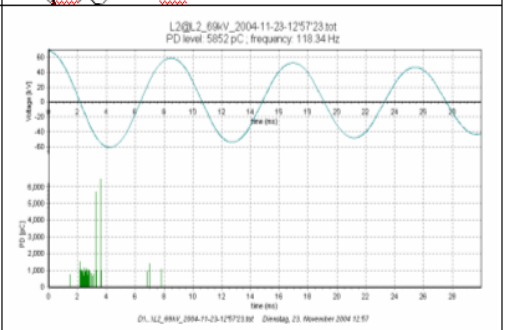
Example 2: PD diagnosis of a service aged 50kV-paper-oil-cable

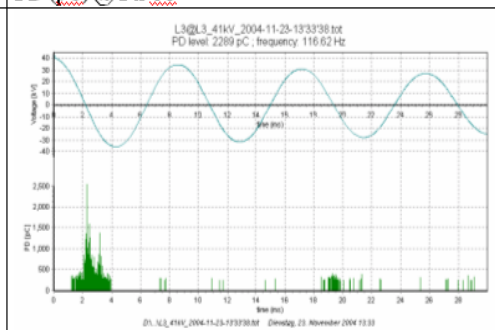
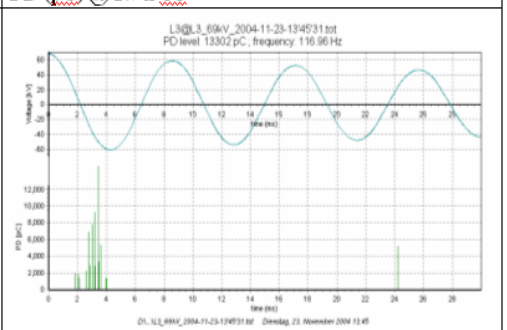
PDIV L1, L2, L3: $0.7xU_0$

@ $1.0xU_0$

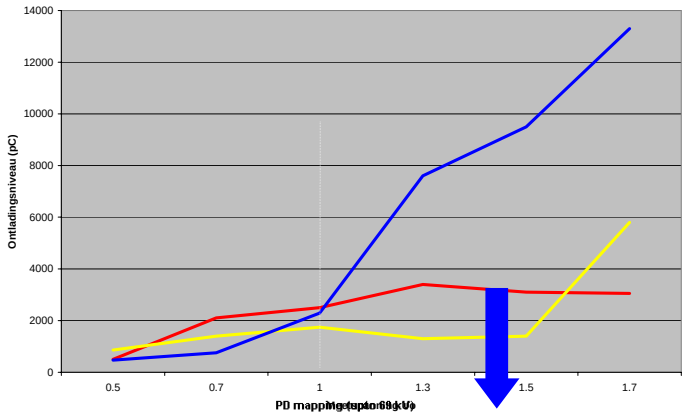
PD L1:	**2500pC**
PD L2:	**1780pC**
PD L3:	**2300pC**

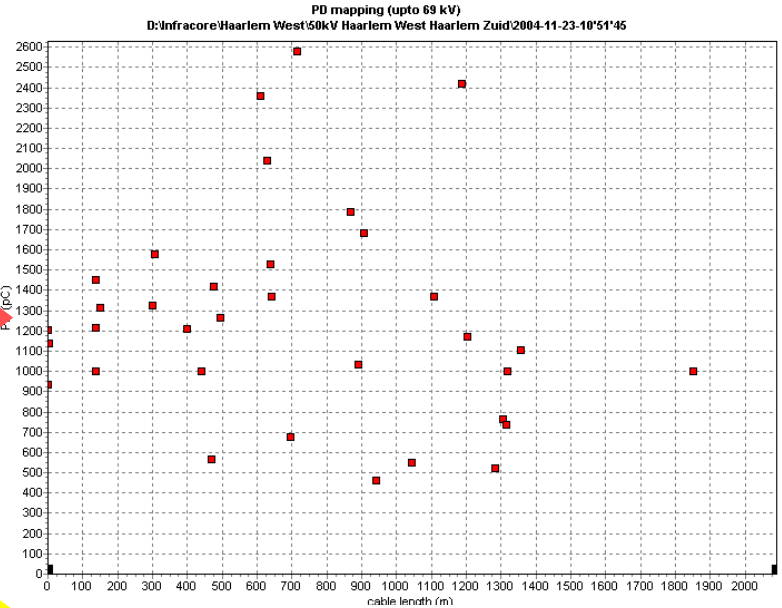
Fase L1	Results	
Date	PD (pC) @ 1 x Uo	PD (pC) @ 1.7 x Uo
23-11-04		

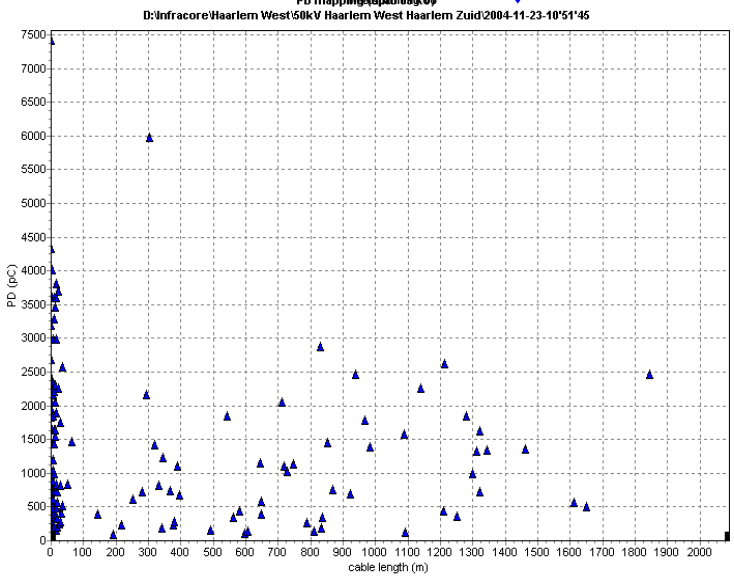
Fase L2	Results	
Date	PD (pC) @ 1 x Uo	PD (pC) @ 1.7 x Uo
23-11-04		

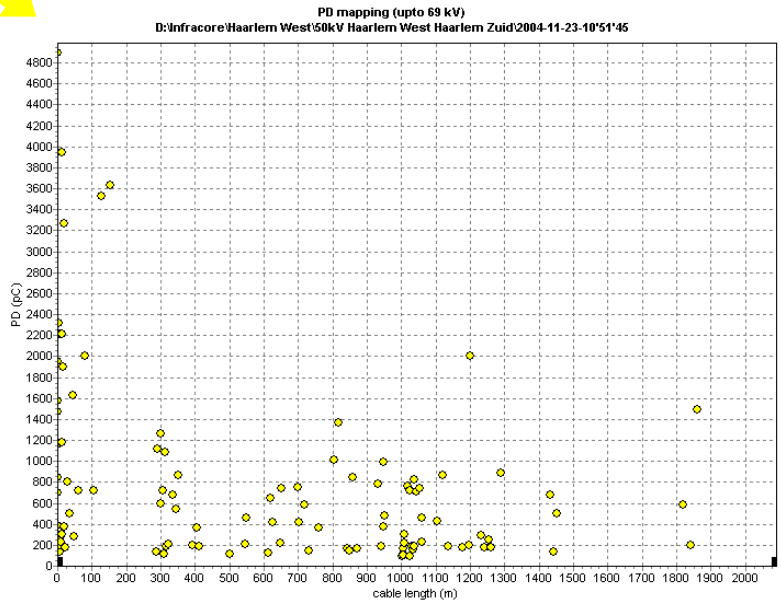
Fase L3	Results	
Date	PD (pC) @ 1 x Uo	PD (pC) @ 1.7 x Uo
23-11-04		

Example 2: PD diagnosis of a service aged 50kV-paper-oil-cable





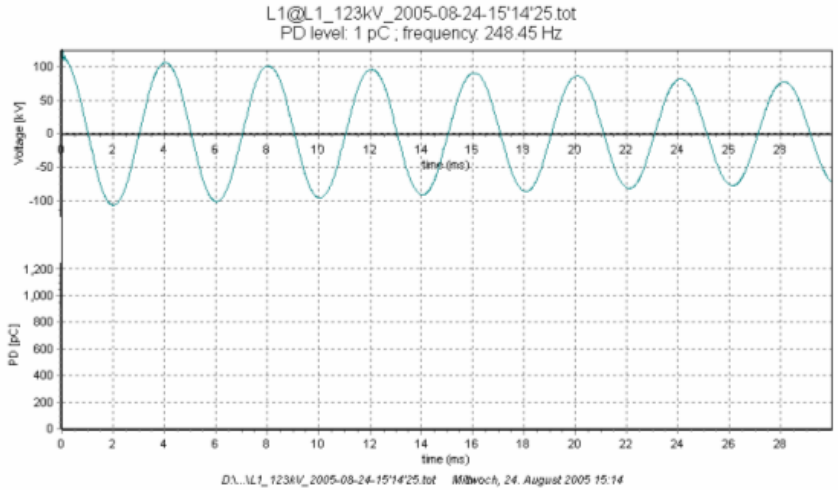
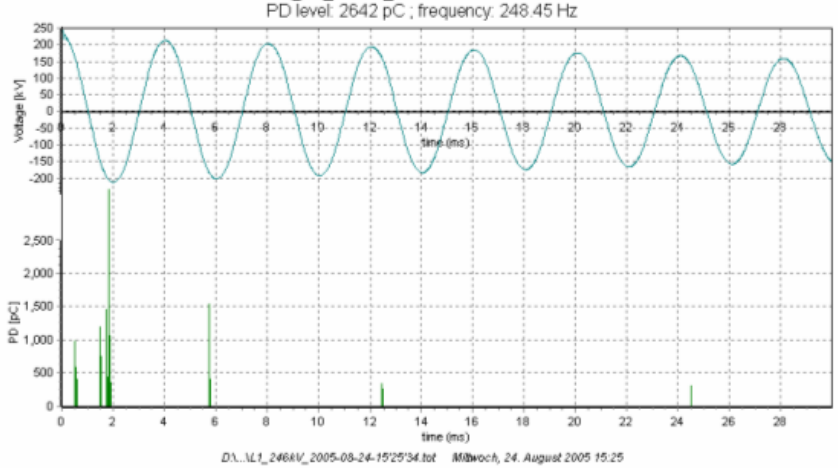




Example 3:
PD diagnosis of a service aged 150kV XLPE cable

Example 3: PD diagnosis of a service aged 150kV XLPE -insulated power cable

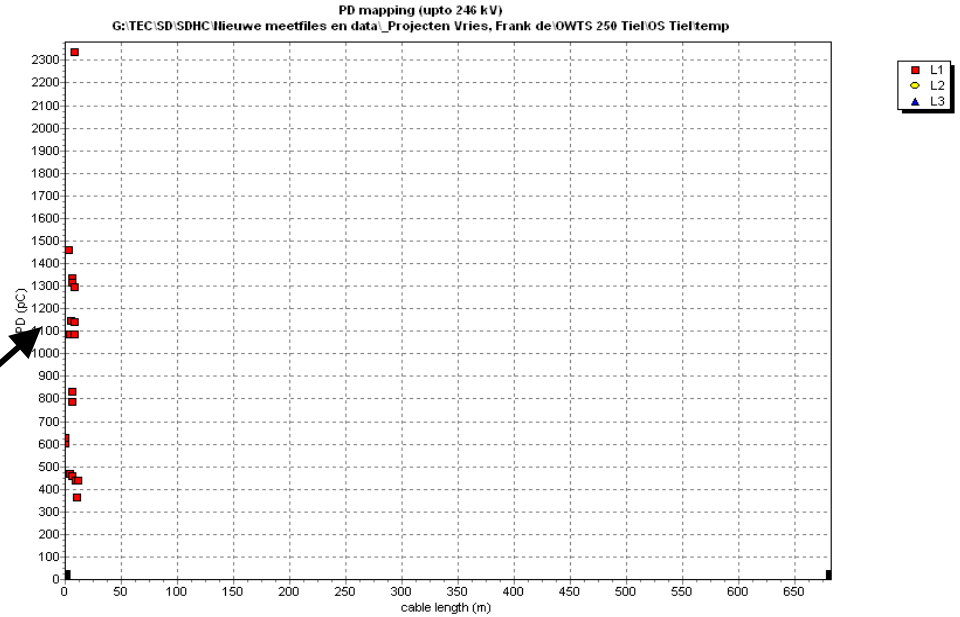
Bedrijf: Continuon	Kabelnr: -	Van: OS Tiel BR2	Naar: OS Tiel Oost TR2
Type: 150kV XLPE	Uo (V): 87.000	Kabeldoorsnede (mm²): -	Kabellengte (m): 682

Fase L1	Results
Date	**PD (pC) @ 1 x Uo**
24-08-05	
Date	**PD (pC) @ 2 x Uo**
24-08-05	

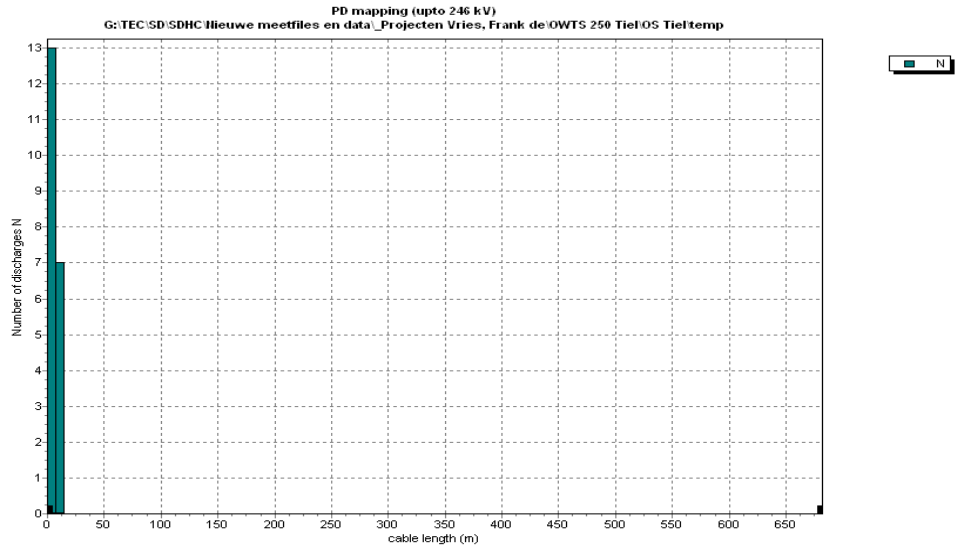
Phase L1: PDIV 1.7xUo

Phase L2, L3: PD free up to 2xUo

Example 3: PD diagnosis of a service aged 150kV XLPE -insulated power cable



Phase L1: PDIV 1.7xUo Termination problem



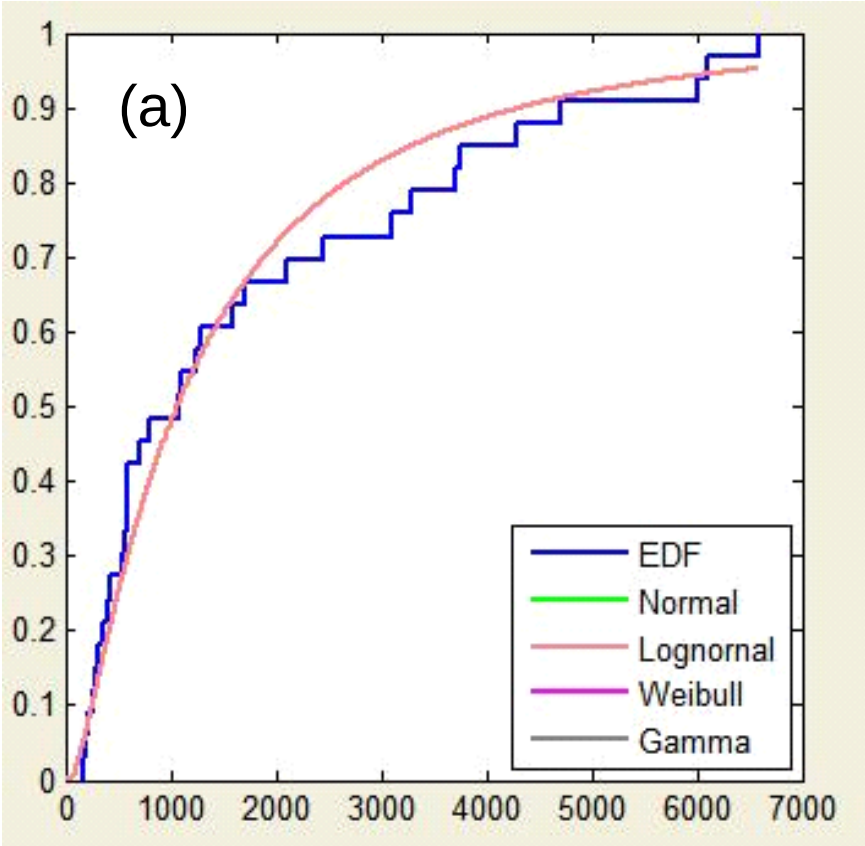
Phase L2, L3: PD free up to 2xUo

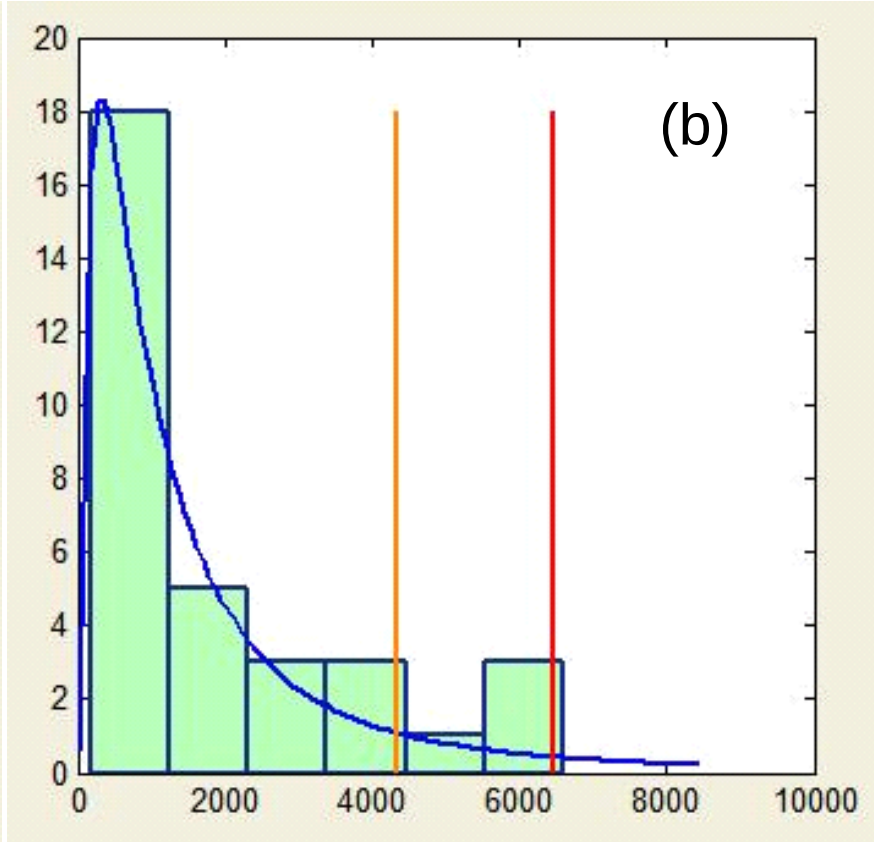
PD parameters are useful to generate PD norms

	PD parameters		Weight factor
Cable system	PD inception voltage (PDIV)		*4*
	PD source location (cable/accessories)		*2*
	PD mapping (interpretation)		*1*
Individual cable components	PD inception voltage PDIV		*8*
	PD level	Average at U_0	*4*
		Maximum at U_0	*3*
		Average at $2U_0$	*2*
		Maximum at $2U_0$	*1*
	PD occurrence frequency	At U_0	*4*
		At $2U_0$	*2*
	Phase resolved PD pattern	*Interpretation*	*2*

Example:

Norm Generation (PD level @ $1.0U_0$) for Mass-insulated Cable Terminations Type with Interfacial Discharges on the HV Connectors





the best fitting: ***lognormal distribution population***

boundaries: ***4.3nC (90%); 6.5nC (95%)***

Summary

I. Based on technologies as available non-destructive PD diagnosis can be done by :

   i. VHF/UHF PD detection in combination with mobile resonate AC voltage sources;
   ii. IEC60270 detection at damped AC voltages as available with OWTS 250;

II. With regard to HV power cables and PD on-site diagnosis the following can be concluded:

   i. → Quality issue; during after-laying test of new cables PD detection may provides valuable information about discharging defects in cable accessories;

   ii. → Maintenance and operation issue; during condition inspections of service aged cable systems PD diagnosis may provide information about insulation defects in cable insulation and cable accessories;

III. Based on field application statistical norms can be developed to support the condition evaluation for maintenance purposes.