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HV AND EHV BUSHING CONDITION ASSESSMENT – FIELD EXPERIENCE

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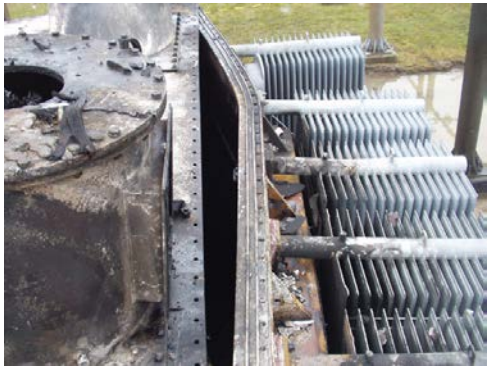
Cigré-057

Statement of the problem (Background)

- Utility commitment for reliability and availability of HV and EHV equipment, safety of personnel and environment protection.
- CIGRE TB 642 reported 17% transformer breakdown to be caused by bushing failure followed by explosion



Source : http://tdworld.com/substations/risk-equals-probability-times-consequences

Asset management point of view

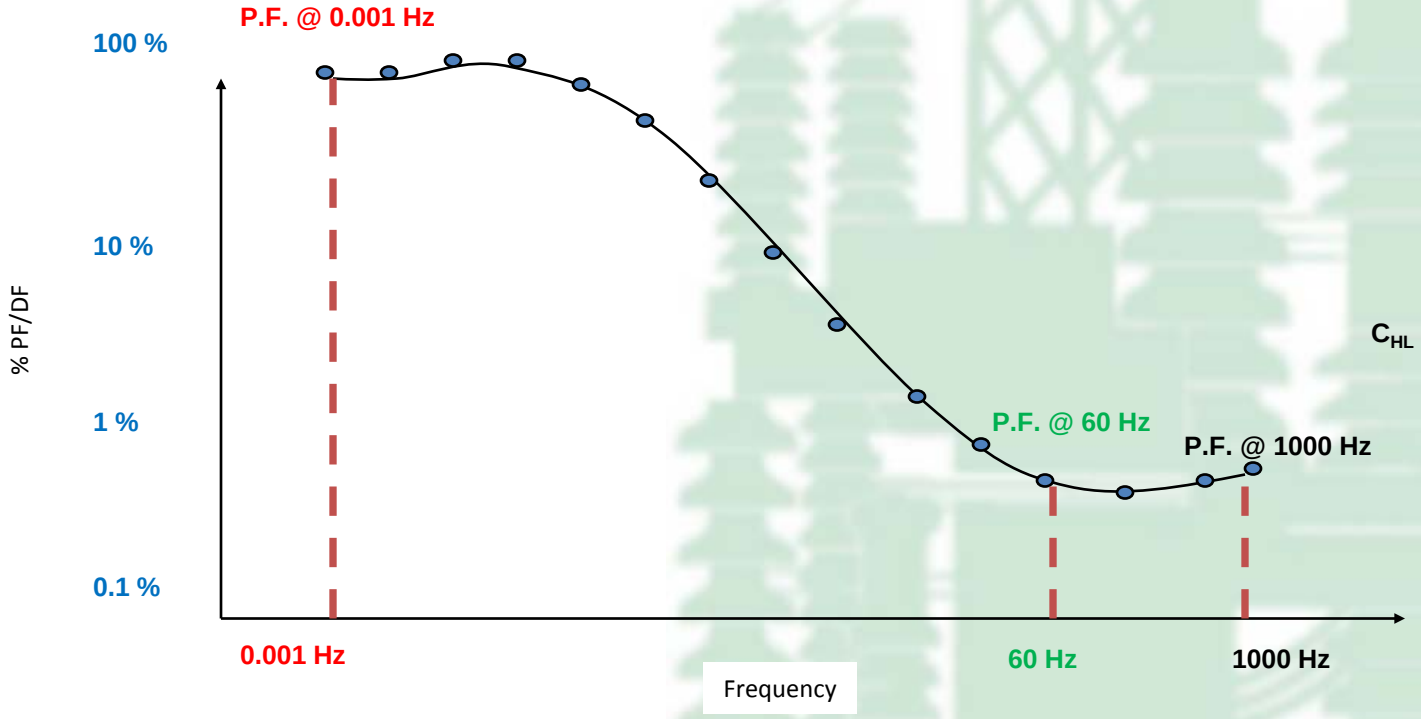
- Ensure the safety of workers by implementing restricted areas around the bushings of common characteristics as the failed bushing until the root cause is determined
- Recognition of failure pattern
- Identifying a reliable testing methodology to determine potential symptoms before recurrence of catastrophic failures is crucial
- Condition assessment and proactive actions

Condition assessment

- Post fault data collection and review
  - Maintenance history of the failed unit(s), prior dielectric testing, **DGA**, Visual inspections
  - Field testing on similar unit(s) : Capacitance (C) and power/dissipation factor (PF/DF %)
- Need of effective bushing diagnostic techniques to better prioritize maintenance activities and/or replacement of unit(s) with increased risk of failure
  - Physical and chemical analysis of insulating oil
  - Advanced offline dielectric testing (**DFR**)

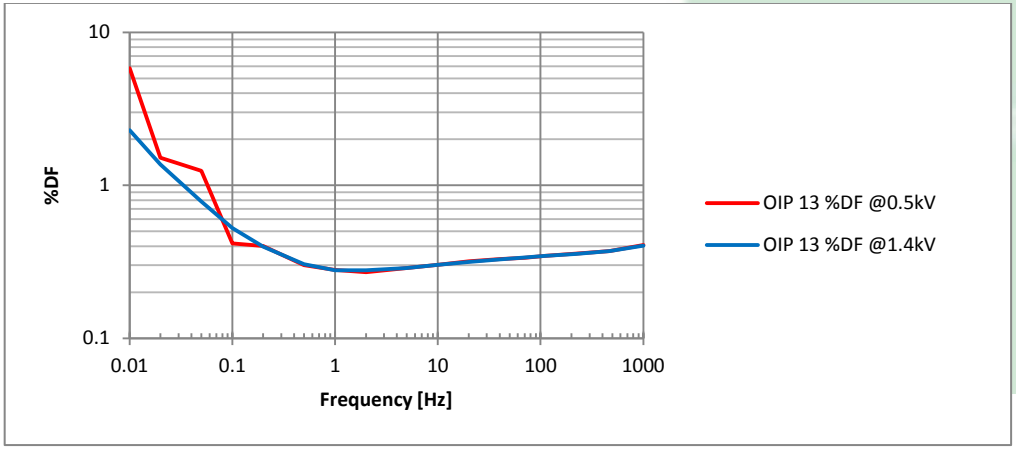
Dielectric Frequency Response (DFR) Analysis

- Measurement of capacitance, C, and power factor/dissipation factor as function of frequency, from about 1000 Hz down to 1 Hz, 0,1 Hz, 0.01 Hz or lower.

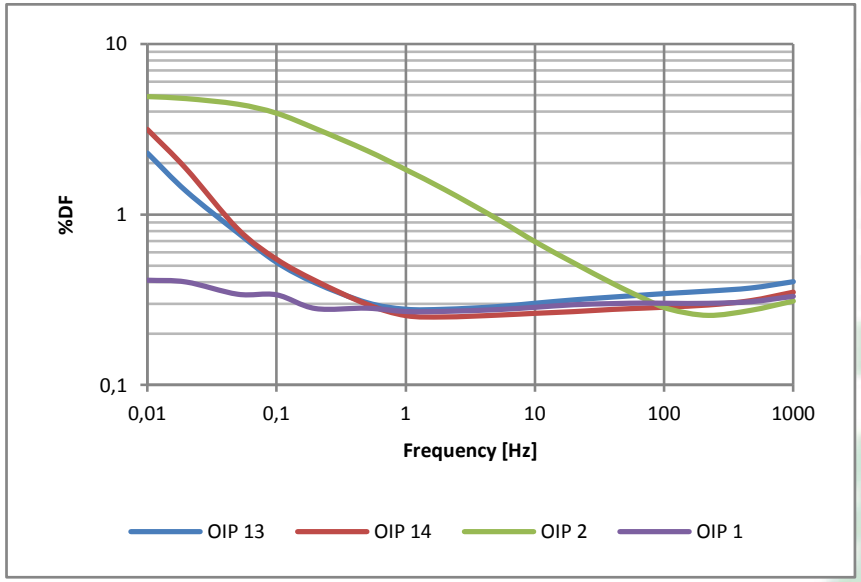


DFR applied to EHV bushings - field experience

- Disadvantages :
  - Time consumed to isolate the test object
  - Susceptibility to EMI in EHV substations
- Best practices:
  - Quality of test connections and grounding
  - Stability of test object temperature during the test and correction to a normalized value
  - In warehouse or laboratory conditions, vertical position is preferable
  - Increase signal to noise ratio by applying higher voltages



Assessment based on DFR

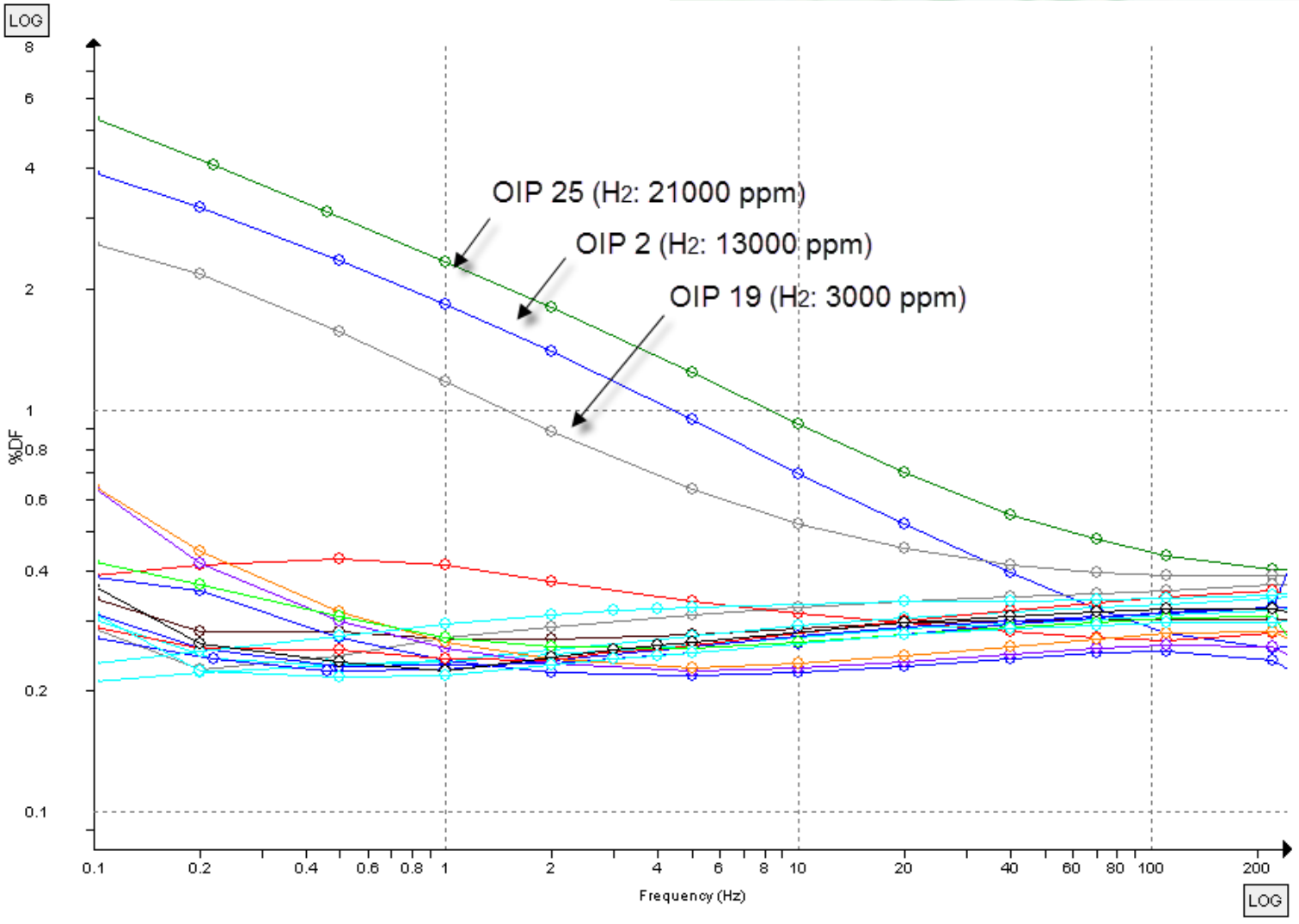
DFR	Specimen	Condition	%DF @ 20C			
			60 Hz	10 Hz	1 Hz	0.1 Hz
	OIP 13	good	0.32	0.29	0.28	0.57
	OIP 14	good	0.28	0.26	0.25	0.73
	OIP 2	bad	0.31	0.61	1.58	3.57
	OIP 1	good	0.30	0.29	0.27	0.32

Correlation between DGA and DFR

Sample	Indicator DFR				Indicator DGA						
	60Hz	10Hz	1Hz	0.1Hz	H_2	CO	CO_2	C_2H_2	CH_4	C_2H_6	C_2H_4
OIP 2		a	X	X	X			X	X	X	
OIP 5				X							
OIP 6				X							
OIP 7				X							
OIP 8				X							
OIP 11				X							
OIP 17								X			
OIP 19		a	X	X	X			X	X	X	
OIP 21				X							
OIP 22				X							
OIP 25		a	X	X	X			X	X	X	

- None of the investigated bushings had power factor above 0.5% at 60Hz.
- Bushings OIP 2, OIP19 and OIP 25 had DGA indicators and DFR indicator at 1 Hz (and 0.1 Hz)
- OPI 2, 19 and 25 showed elevated hydrogen concentration.

Correlation between H2 and DFR response



Conclusions

- DFR and HV DFR offer an effective diagnostic technique that provides very useful information to end-users
- Traditional dielectric testing at the line frequency was not sufficient to detect insulation degradation in EHV bushings
- DFR response at 20°C and below 1 Hz correlated well with DGA results
- DFR technique can be used to detect presence of solid particles of carbon and hydrocarbon polymers (X-wax)
- Asset management engineers can implement proactive condition-based maintenance or replacement programs based on DGA and DFR analysis
- Further research must be conducted to provide utilities with guidelines for selection, procurement, maintenance and diagnostic of HV and EHV bushings

Questions?

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