What does new mean?

Megger

CASE STUDY

Dielectric Assessment for field commissioning

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Background:

- A new Dyn1, 16 MVA, 138/13.09 kV transformer manufactured in 2019 arrived at its service destination where a specialized testing crew carried out a complete set of acceptance tests including a 10kV line-frequency (LF) power factor (PF) test. Results were analyzed to determine the transformer's commissioning condition before startup.

Summary:

- The recently-arrived transformer was tested in the field using Megger's DELTA4000. All LF PF (dissipation factor) values were within acceptable limits, and low losses were observed at 10 kV. These results are presented in Figure 1.

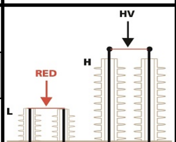
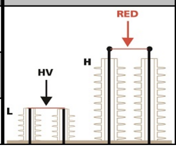
25°C				Connections	60Hz						
Test No.	NB DFR	Insulation Tested	Test Mode	Click image for detailed connection information	TEST kV	Cap (pF)	Equivalent @ 10 kV		POWER FACTOR %		
							mA	Watts	Measured	@ 20°C	IR
1		$C_{HG} + C_{HL}$	GST-GND		10.0	6,587.9	24.8	0.5383	0.22	0.22	G
2	✖	C_{HG}	GSTg-RB		10.0	2,421.1	9.09	0.2081	0.23	0.23	G
3	✖	C_{HL}	UST-R		10.0	4,146.5	15.6	0.3302	0.21	0.21	G
4		C_{HL}'		Test 1 Minus Test 2		4,166.8	15.7	0.3302			Valid
5		$C_{LG} + C_{HL}$	GST-GND		7.00	13,793.7	36.4	0.5496	0.22	0.22	G
6	✖	C_{LG}	GSTg-RB		7.00	9,646.7	25.4	0.3888	0.22	0.24	G
7		C_{HL}	UST-R		7.00	4,147.6	10.9	0.1637	0.22	0.22	G

Figure 1: Overall Transformer LF PF test results

- In addition to the overall transformer winding insulation, all bushings were LF PF tested. These results were within acceptable limits, as shown in Figure 2.

			25.5°C		60Hz							
Test No.	NB DFR	Dsg.	Test Mode	TEST kV	Capacitance		Equivalent @ 10 kV		POWER FACTOR %			Δ %PF @ 20°C
					C (pF)	Δ pF	mA	Watts	Measured	@ 20°C	IR	
11	✖	H1	UST-R	10.0	386.2		1.20	0.0283	0.23	0.24	G	
12	✖	H2	UST-R	10.0	392.7		1.23	0.0308	0.25	0.25	G	
13	✖	H3	UST-R	10.0	389.2		1.22	0.0285	0.23	0.24	G	
14	✖	N/A	UST-R	10.0								
15	✖	X1	UST-R	7.00	539.9		1.18	0.0186	0.22	0.22	G	
16	✖	X2	UST-R	7.00	540.7		1.18	0.0184	0.22	0.23	G	
17	✖	X3	UST-R	7.00	541.7		1.19	0.0184	0.22	0.22	G	
18	✖	X0	UST-R	7.00	539.4		1.18	0.0184	0.22	0.23	G	

Figure 2: C1 LF PF test results of all bushings

- Overall, the HV LF PF values are excellent and show no trace of damage, degradation, or contamination. Since these tests were performed at a top oil temperature of 25°C, the individual temperature correction (ITC) capability of the DELTA 4000 PF test set was used to obtain an accurate reference of LF PF at 20°C. The obtained values would have closed the insulation assessment with an A+ grade.

- Nevertheless, in addition to these line frequency PF tests, the end-user utilized their DELTA 4000 to acquire a baseline PF reference at 1 Hz for the windings (Figure 3) and bushings (Figure 4), corrected to 20°C by ITC, for later comparative analysis.

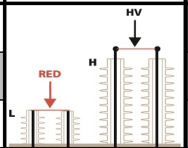
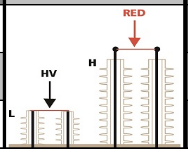
25°C				Connections	1Hz		
					POWER FACTOR %		
Test No.	NB DFR	Insulation Tested	Test Mode	Click image for detailed connection information	Measured	@ 20°C	IR
1		C_{HG} + C_{HL}	GST-GND				
2	✖	C_{HG}	GSTg-RB		1.03	0.69	G
3	✖	C_{HL}	UST-R		1.55	0.96	G
4		C_{HL}'		Test 1 Minus Test 2			
5		C_{LG} + C_{HL}	GST-GND				
6	✖	C_{LG}	GSTg-RB		1.23	0.77	G
7		C_{HL}	UST-R				

Figure 3: Overall Transformer 1 Hz PF test results - ITC corrected to 20 °C

			25.5°C 1Hz		
			POWER FACTOR %		
Test No.	NB DFR	Dsg.	Measured	@ 20°C	IR
11	✖	H1	0.26	0.23	G
12	✖	H2	0.21	0.20	G
13	✖	H3	0.21	0.19	G
14	✖	N/A			
15	✖	X1	0.40	0.31	G
16	✖	X2	0.34	0.27	G
17	✖	X3	0.34	0.28	G
18	✖	X0	0.33	0.28	G

Figure 4: All bushings 1 Hz PF test results - ITC corrected to 20 °C

- The test results revealed that the overall CHL 1 Hz PF value was elevated when compared to those observed in other new transformers that had just shipped from the factory.
- Given the 1 Hz PF information, the customer performed additional testing, including NB DFR for the overall winding insulation (Figure 5).

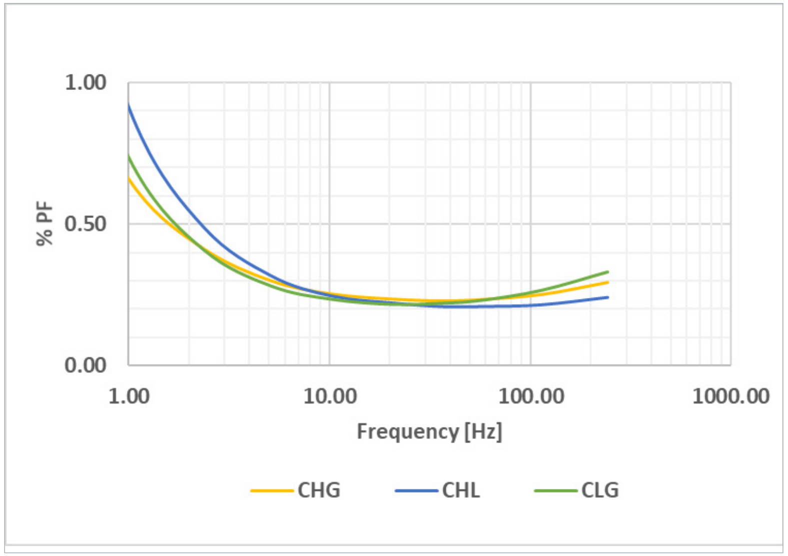


Figure 5: NB DFR winding Insulation corrected to 20 °C by ITC algorithm

- The NB DFR response of the transformer, despite having good PF values at LF and 10 Hz, revealed a significant increase at 1 Hz, which is not expected for a new transformer just shipped from the factory. When the customer submitted the information to us for advice, our suggestion was to run a test that assesses both moisture in the solid insulation and conductivity of the liquid insulation. A full dielectric frequency response test with the Megger IDAX 300 was used.

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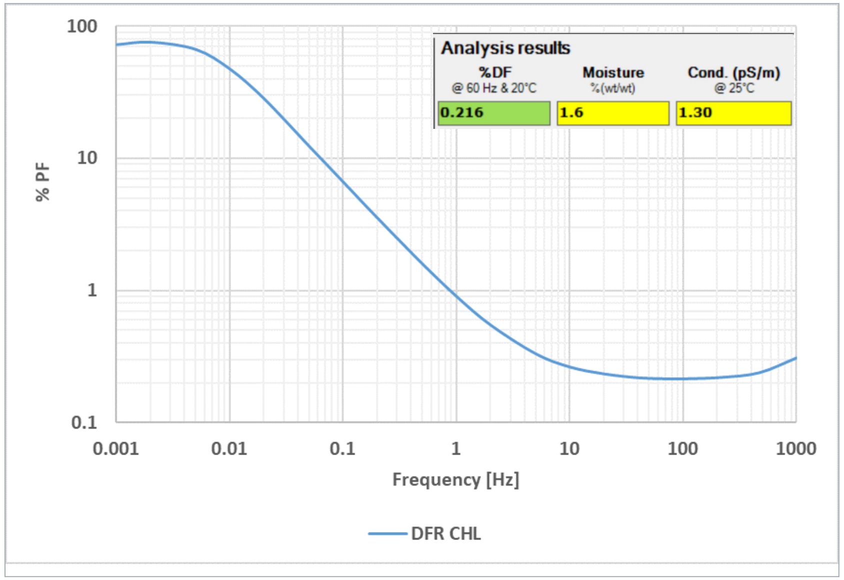

Figure 6: DFR test results obtained with IDAX 300

- The Dielectric Frequency Response (DFR) testing carried out on CHL with IDAX 300 (Figure 6) confirmed a good condition of the overall insulation but not as good as expected for a new transformer during commissioning. For a new unit, it is suggested that the percentage moisture concentration in the solid insulation not exceed 1 % and the conductivity of the liquid insulation (σ) be below 0.37 pS/m.

- As described in CIGRE TB 445 section 5.6.2, moisture in insulation represents a risk to transformers in three ways. It accelerates the aging of paper, reduces the breakdown voltage of oil, and increases the risk of bubbling during a sudden overload or thermal stress. Laboratory experiments reported in CIGRE TB 445 are presented in Figure 7.

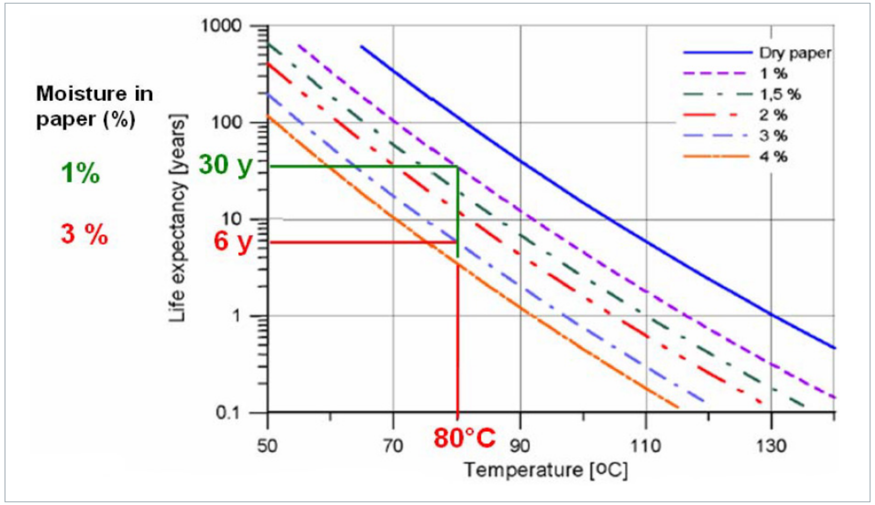

Figure 7: CIGRE TB 445 - Influence of Temperature Combined with Water on Solid Insulation Life Time

- The transformer's owner scheduled a dedicated dry-out process for this unit aiming to reach less than 1 % moisture in the solid insulation following recommendations made by Megger's specialists and CIGRE TB 445.

Takeaways:

- Line-frequency power factor, 1 Hz power factor (DF), and NB DFR testing as parts of field commissioning procedures are effective mechanisms to:
    - Record a benchmark signature of the dielectric condition of a power transformer.
    - Identify deviations from practical references that supplement those that have historically only been given for LF PF. 1 Hz complements and enhances the information obtained by LF PF.
- For a new power transformer with mineral oil, the typical 1Hz PF (20 °C) value is between 0.2 and 0.5 % and for a new HV OIP bushing, the typical 1 Hz PF (20 °C) is between 0.2 and 0.4 %.
- A full spectrum analysis (DFR) with IDAX 300S or IDAX 322 is the definitive method to determine the condition of solid and liquid insulations.
- For a new transformer, the limit of moisture is recommended to be < 1 % and the limit for liquid insulation conductivity is recommended to be < 0.37 pS/m.
- Low moisture at the beginning of the transformer’s service is critical to its longevity, reliability, and safe operation in the field.

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Product Reference:

DELTA:

- Dedicated capacitance and PF/DF test instrument (also exciting current):
- Narrowband DFR (NB DFR: 1 - 505 Hz)
- Individual Temperature Correction (ITC)
- Voltage Dependence Detection (VDD)

TRAX + TDX

- A multi-functional tester for transformer and substation equipment.
- Narrowband DFR (NB DFR: 1 - 505 Hz)
- Individual Temperature Correction (ITC)
- Voltage Dependence Detection (VDD)

IDAX + VAX

- Megger's DFR test instrument (IDAX) and voltage amplifier (VAX)
- Provides analysis of moisture content, oil conductivity, and PF/DF; also performs NB DFR
- When coupled with the VAX or by upgrading to the IDAX 322, an HV 1.4 kV rms output assures speed and reliability in high-interference environments.
- A culmination of >20 years' experience in the design of DFR test equipment and expertise in the subject area

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Dielectric-commissioning-CaseStudy4-EN-V04