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Case Study – How hidden issues are Threatening your Transformers

Power transformers are the workhorses of the industries, silently stepping down high voltage electricity for our businesses and homes. However, undetected internal damage can lead to catastrophic failures, causing power outages and equipment destruction. Routine along with diagnostic testing is essential to unlock the secrets within your transformers and prevent such disasters.

Background

A critical Generating facility and one of our long-standing customers, supplying a stable power supply to Grid, wanted to go for Regular testing of transformers, we advised them to go for diagnostic tests also along with routine. They agreed and during their annual shutdown, our team went and below were the results and some curious findings.

Findings- at Site:

Details of Transformer under Test: UT **Rating: 45 MVA, Voltage: 20/11 kV,** Tap Changer: OLTC, Year of Mfg.: 2009

- Transformer was required to carry out the routine along with Diagnostic testing.
- Various testing including Diagnostic testing of equipments was carried out.
- All Results were showing satisfactory results except one test.
- Tan Delta results HV – LV, HV – EARTH found Normal but LV – EARTH value shows abnormal.

Below are the TAN DELTA results

Winding Checks :

OTI: 24°C **WTI: 23°C** **AMBIENT: 25°C** **RH: 48 %**

Winding	Test mode	f (Hz)	U (kV)	I (mA)	C (nF)	%Tan δ
HV – LV	UST	50	2	8.6336	13.7397	0.1751
		50	5	21.582	13.7391	0.1753
		50	10	48.164	13.7393	0.1751
HV – E LV Guard	GST – g	50	2	1.6377	2.6026	0.1899
		50	5	4.0931	2.6025	0.1899
		50	10	8.1870	2.6027	0.1899
HV – E	GST	50	2	10.275	16.3428	0.1766
		50	5	25.673	16.3421	0.1768
		50	10	51.357	16.3424	0.1769
LV – HV	UST	50	2	8.6395	13.7937	0.1740
		50	5	21.584	13.7389	0.1750
		50	7	30.214	13.7389	0.1750
LV – E HV Guard	GST – g	50	2	7.5141	11.9543	**0.2644**
		50	5	18.794	11.9605	**0.3382**
		50	7	26.337	11.9735	**0.4644**

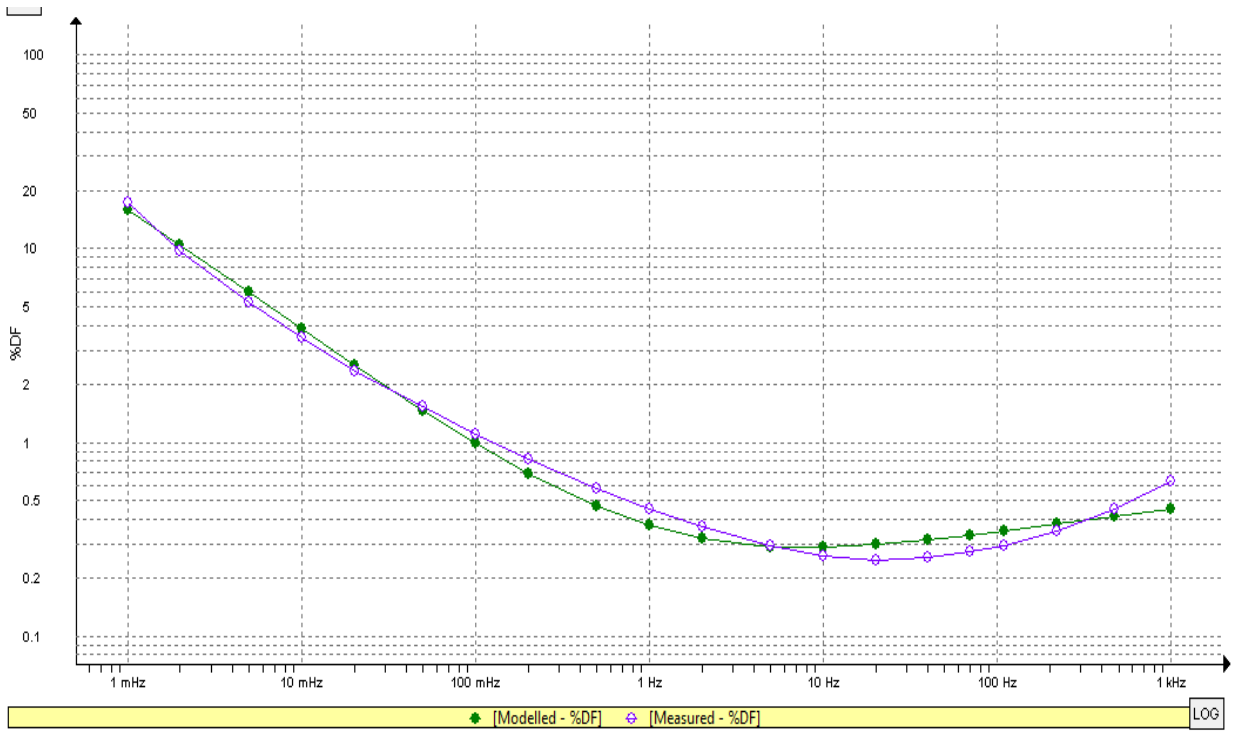
LV – E	**GST**	50	2	16.155	25.6940	0.2127
		50	5	40.372	25.6984	0.2399
		50	7	56.552	25.7115	0.2981

Tan-delta Table

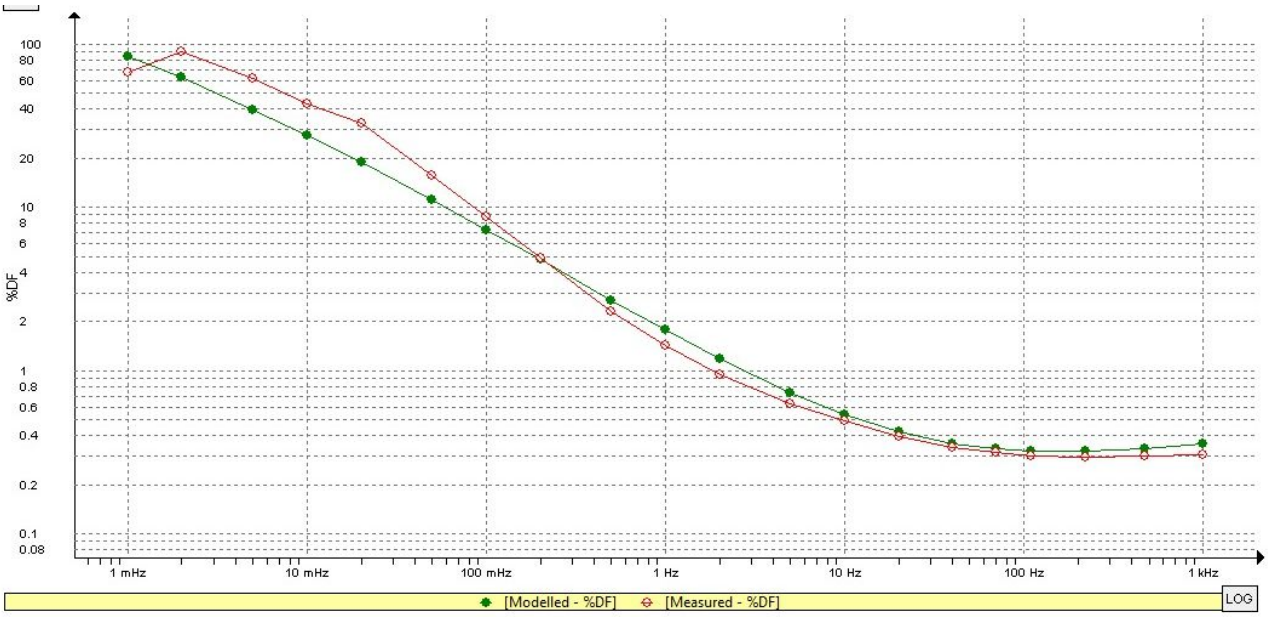
Assessment Limits					
Tan Delta : 0.311		**Moisture value : 3.0**		**Oil conductivity : 0.007**	
Moisture (%)	Value	< 1.0	1.0-2.0	2.0-3.0	> 3.0
	Assessment	As new	Dry	Moderately Wet	Wet
Oil Cond. @25 °C (pS/M)	Value	< 0.37	0.37-3.7	3.7-37	> 37
	Assessment	As New	Good	Service Aged	Deteriorated

DFRA results

The test that didn't show the proper results was **DFRA (Dielectric Frequency response analysis),** below are the graphs that show healthy and unhealthy test results :



HEALTHY DFRA GRAPH



UNHEALTHY DFRA GRAPH

- Dielectric Frequency Response Analysis (DFRA) test revealed elevated moisture levels in the transformer.
- This pattern was consistently observed in both upward and downward sweeps.
- The low-frequency (100 mHz to 1 mHz) tan delta graph deviated significantly from the standard reference curve.
- This deviation indicated potential moisture contamination in the transformer oil and pressboard insulation.
- Upon inspection, our team examined the CFT (Core frame tank) connections and overall condition.

RUSTED CFT CONNECTIONS

- From the above image you can see that the CFT components were found to be heavily rusted and moisture-affected.
- The rusted CFT connections were carefully removed, and both the contacts and plates were thoroughly cleaned.
- A subsequent DFRA test was conducted after the cleaning process.
- This time, the transformer's moisture levels were well within the acceptable limits.

AFTER CFT TERMINAL CLEANING

This is how a CFT before Opening Looks like on top of Transformer

Assessment Limits					
Tan Delta : 0.279		**Moisture value: 1.0**		**Oil conductivity : 0.001**	
Moisture (%)	Value	< 1.0	1.0-2.0	2.0-3.0	> 3.0
	Assessment	As new	Dry	Moderately Wet	Wet
Oil Cond. @25 °C (pS/M)	Value	< 0.37	0.37-3.7	3.7-37	> 37
	Assessment	As New	Good	Service Aged	Deteriorated

DFRA RESULTS AFTER CFT TERMINAL CLEANING

Root Cause :

Below are some of the potential root causes for the observed issue:

- **Moisture Accumulation in the CFT Box:** Over time, repeated heating cycles of the transformer, especially during monsoon and winter seasons, can lead to vaporization within the CFT terminal box, causing moisture buildup.
- **Improper Sealing:** The absence or inadequate use of proper sealant in the CFT box can allow moisture ingress, further contributing to insulation degradation.
- **Additional Factors:** Other contributing factors may vary on a case-to-case basis and require further investigation to confirm.

Precautionary measures to be taken to prevent such incidents:

To ensure the reliability and longevity of **Critical Transformers**, the following steps should be taken:

- **Pre-Monsoon Preventive Maintenance:** Conduct thorough inspections and maintenance before the monsoon season to prevent moisture-related issues.
- **Proper Sealing:** Ensure effective sealing of critical components, including the CFT terminal box, marshalling box, CT terminal box, and both HV & LV terminal boxes, to prevent moisture ingress.
- **Regular Inspection & Cleaning:** Every six months or whenever shutdown permits, open the CFT terminal box for proper cleaning and perform an IR test to assess insulation health.
- **Diagnostic Testing:** Periodic diagnostic testing of critical transformers with state-of-the-art technology should be conducted, including but not limited to :
  - **Online PD Measurement** – Detects insulation degradation and localized defects.
  - **SFRA)** – Assesses mechanical integrity of windings and core.
  - **DFRA** – Identifies moisture content in insulation and oil degradation.
  - **DRM of OLTC** – Evaluates the condition of the OLTC and contact integrity.

Regular monitoring and proactive maintenance of **Transformers** can significantly enhance reliability, reduce unplanned outages, and extend service life.

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Conclusion that can be drawn from this incident:

This case study demonstrates the power of Diagnostic testing in safeguarding transformers or any other MV / EHV equipments. This specialized test unlocks the secrets within Equipment before they escalate into costly failures. By incorporating diagnostics along with your routine testing, you gain valuable insights into the health of your Equipment allowing for informed decisions and a reliable power supply.

We, as an Electrical asset consultant and service provider always suggest what is best to run your industries smoothly and without hiccups of maloperation and breakdown.

And if you are looking for a dedicated agency that understands the direct link between your assets and your revenue, call/write to us, we will be happy to assist you.

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