TOTUS save two 130 kV bushings in Canada

Evidence: Increase of Power Factor and Partial Discharges in the bushing
Action: Both bushings replaced after offline tests confirmed the online results

Background

Due to federal PCB regulations in Canada, the utility has a targeted transformer bushing replacement program to meet end of use dates in 2025. Typical practice at the company is to install bushing monitors on new transformer HV oil filled bushings and to target older suspect bushings as a retrofit. In this instance the utility was applying a new approach, by adopting a more advance online monitor, TOTUS, that could measure DGA in main tank as well as Partial Discharge (PD) in both main tank and bushings. The unit was installed to investigate a suspected source of PD in the transformer with the transformer bushings replaced at the same time.

The choice of TOTUS was driven by the unique capabilities to separate the PD in the tank from those in the bushings, as well as automatically rejecting the noise.

132 kV Bushing DGA and Oil Quality Offline 28/08/2018	
Hydrogen, H2 (ppm)	9780
Methane, CH4 (ppm)	278
Ethane, C2H6 (ppm)	154
Ethylene, C2H4 (ppm)	10
Acetylene, C2H2 (ppm)	5
Carbon Monoxide, CO (ppm)	458
Carbon Dioxide, CO2 (ppm)	1671
Moisture, H2O (ppm)	10
Interfacial Tension (mN/m)	23.6
Acid Number (mg KOH, g)	0.008
Dielectric BV (kV)	26
Power Factor @25°C (%)	0.03
Power Factor @100°C (%)	1.1

Event

After about 2 years from the new bushing installation, an alarm was notified by the monitoring system for increased Power Factor (Tan Delta) indicating two of the three 130 kV bushings have deteriorated.

Figure 1 shows the increasing trend of the relative Power Factor, estimated from the variation of the angles of the currents (red trend line). The Power Factor started to raise in March showing an increment of around 0.7%, thus justifying further investigation. It is interesting to note the black trendline which shows the number of PD per second detected in the same bushing (X3): after some sporadic discharge between October and April, PD started to be more repetitive, correlated with a simultaneous increase of the Power Factor in the same bushing.

The TOTUS system identified the source of PD to be located in the bushing and by analysing the Phase-Resolved Partial Discharge (PRPD) pattern it was possible to speculate that the PD was likely due to the presence of particles in oil.

An alarm was triggered and sent to the utility, for high Power Factor on 2 bushings.

Action

The utility decided to de-energise the transformer and perform the offline test including DGA and oil quality. The results confirmed the abnormal condition of the bushings, showing poor oil quality values and high DGA readings for Hydrogen, exceeding 9000 ppm. The bushings were planned for immediate replacement and visual inspection.

The inspection showed presence of metallic contamination. DGA was planned on all the bushings of the same batch that were not equipped with online monitoring highlighting that 3 other bushings had abnormal H2 values which led to the replacement of a total of 5 bushings.

By implementing the standard program of electrical measurements every six years, it would not have been possible to detect the problem in time and prevent a possible unexpected failure.

Diagnosis

Due to por manufacturing, metallic particles were trapped in the bushing and free to move when, at higher temperature, the oil viscosity higher. This was generating Partial Discharges and increase of bushing losses, thus resulting in a Power Factor increase.

Figure 1: Kelvatek bushing sensor installed at the bushing test tap to detect both Partial Discharges and changes in Capacitance and Power Factor.

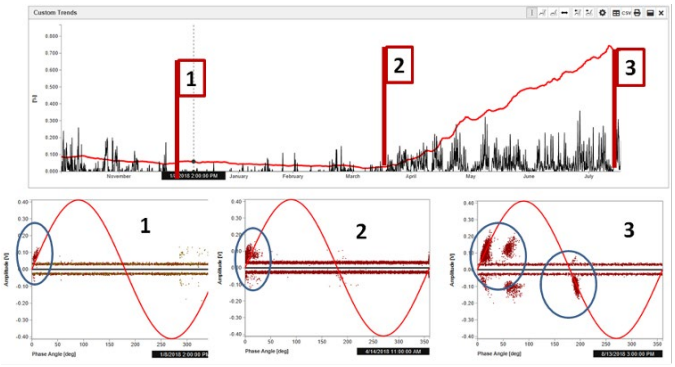

Figure 2: Hourly PD evolution in bushings X3 on LV 130kV side, correlated with Tandelta Increase over the time, before switching the transformer off.

Figure 3: Findings of metallic particles in the bushing during visual inspection.

"Thanks to the monitoring system, a total of 5 new bushings have been replaced. A failure would have possibly led to a potentially catastrophic failure" by Utility Asset Manager.

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