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Early Detection and Replacement Saves Two 69 kV Bushings for APAC Utility

CASE STUDY

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CHALLENGE

Hidden Risk in Critical Transformer Bushings

Transformer bushings are critical components, yet their deterioration is often hard to detect before failure. Variations in load demand, environmental conditions, and the increasing impact of distributed energy resources (DERs) impose sustained thermal stress on insulation systems, which over time can result in rising Power Factor (PF), increased Partial Discharge (PD) activity, and progressive insulation degradation.

If left unaddressed, these conditions may escalate into:

- Bushing failure
- Forced outages
- Catastrophic failure

The utility's challenge was to know when and how to intervene, without unnecessary disruption or risk to the transformer.

EVENT

Continuous Monitoring Reveals Early Warning Signs

In 2019, a leading Asia Pacific utility installed TOTUS on a 100 MVA autotransformer to continuously monitor:

- 9-gas DGA
- Bushing capacitance & Power Factor
- Partial Discharge (PD) activity

In March 2021, the transformer went through a sustained high-load period lasting almost a week, driving oil temperatures significantly higher. During this period, TOTUS recorded rising CO and CO_2 levels that tracked with temperature but remained within safe limits. At the same time, bushings A2 and C2 on the 69 kV side showed a gradual increase in Power Factor and a clear step-change in partial discharge activity.

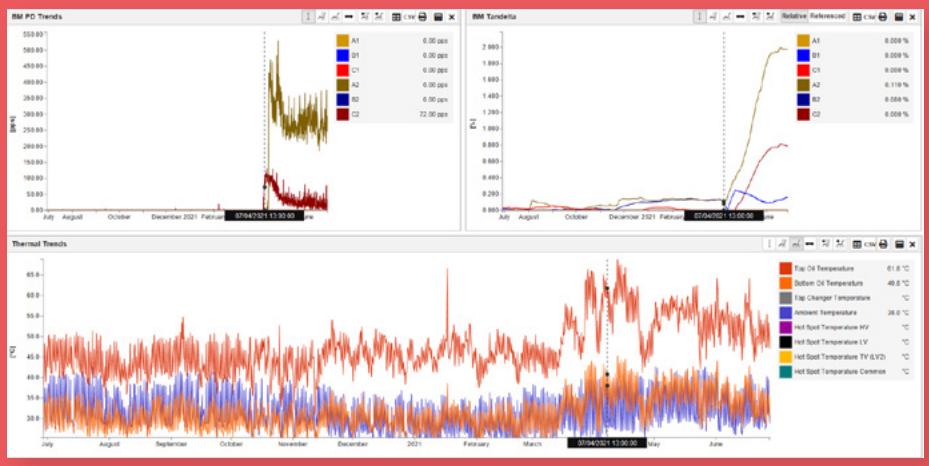
Even when the load was temporarily reduced, the degradation trend did not stabilise, and Power Factor continued to rise, a clear indication of persistent deterioration. Crucially, TOTUS was able to accurately localise the PD activity to the bushings rather than the main tank, pinpointing the source of risk and enabling precise, targeted intervention.

Figure 1:

Camlin bushing sensor installed at the bushing test tap to detect both Partial Discharges and changes in Capacitance and Power Factor.

Figure 2:

PD trend in all bushings (Top left) showing a step increase only in bushings A2 and C2 together with the slow Tandelta increase (Top right) in the same bushings. Both phenomena are correlated to the Top Oil increase (Bottom)

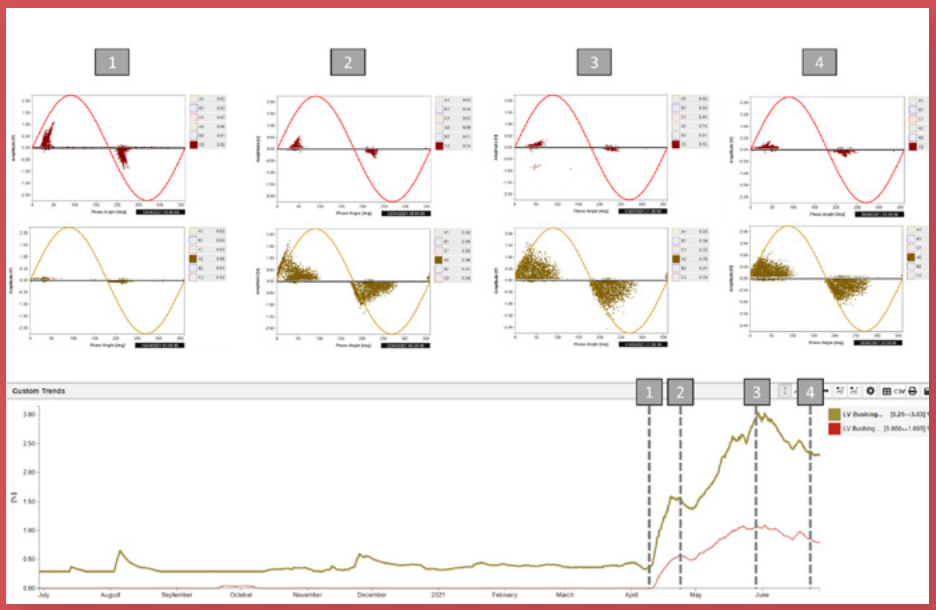


69 kV bushing Offline 30/06/2021

	Capacitance pF	Power Factor %
A1	350.8	0.241
B1	343.5	0.266
C1	345.8	0.272
A2	313.8	**3.085**
B2	331.4	0.269
C2	331.9	**1.793**

Figure 3:

Hourly PD evolution in bushings A2 and C2 on LV side, correlated with Tandelta Increase and Decrease over the time, before switching the transformer off.



ACTION

Proactive Intervention

With the visibility of data provided by TOTUS, the utility de-energised the transformer and carried out targeted offline testing. This confirmed abnormal Power Factor readings on two bushings, 3.0% on A2 and 1.8% on C2, indicating emerging insulation deterioration. Based on this evidence, the utility prioritised proactive replacement of both bushings before an in-service failure could occur.

By acting on validated risk rather than waiting for a fault, the utility was able to take planned, controlled action instead of responding to an emergency event.

OUTCOME

Prevented Failure with Measurable Business Impact

Technical outcome:

- Early detection of bushing deterioration via PD and Power Factor trends
- Accurate localisation of risk to A2 and C2 bushings
- Planned replacement before critical failure

Commercial & Operational Impact:

- **Maintained asset integrity:** avoided potential transformer damage
- **Reduced operational risk:** prevented a potential catastrophic failure
- **Prevented unplanned outage costs:** transformer remained operational until controlled intervention
- **Optimised resource planning:** replacement was executed under planned conditions