camlin energy

Clear Visibility Supports Smarter Intervention for Latin American Utility

CASE STUDY

CAMLINENERGY.COM

CHALLENGE

Detecting Temperature-Sensitive Bushing Defects

Oil-Impregnated Paper (OIP) bushings are essential transformer components, yet certain failure mechanisms develop gradually and seasonally, making early detection challenging: moisture ingress or insulation contamination can raise Power Factor (PF) under high temperatures, seasonal thermal cycles cause PF and capacitance to fluctuate, masking early deterioration, and offline PF tests may miss faults as elevated losses dissipate when the transformer cools.

For utilities, the challenge is identifying defects early and acting before a catastrophic failure, while avoiding unnecessary outages or emergency interventions.

EVENT

Seasonal PF and Capacitance Trends Detected by TOTUS

TOTUS online bushing monitoring was installed on a 42MVA, 230kV/115kV transformer. During summer 2021, the system detected elevated Power Factor and an intermittent rise in capacitance on the Bphase bushing, both occurring during periods of high operating temperature. When cooler weather arrived in winter 2021–22, the values returned to within normal limits, but the pattern repeated the following summer: the same thermal increase once again drove PF and capacitance upward, and partial discharge activity appeared, confirming the early signs of a developing defect. By Summer 2023, the seasonal behaviour had become more pronounced, with PF rising and capacitance showing a clear progression of deterioration, indicating worsening insulation condition.

The repeating, temperaturedependent trend, combined with intermittent PD activity, provided a clear early warning of a developing bushing defect long before an in-service failure could occur.

Figure 1:

Top: trend shows seasonal variations in bushing capacitance where the B phase bushing shows the largest deviations; ~2.3% change.

Bottom: trend shows seasonal variations in the B-phase bushing power factor deviations to approximately 2.5%. The variations are directly correlated to the transformer operating temperature.

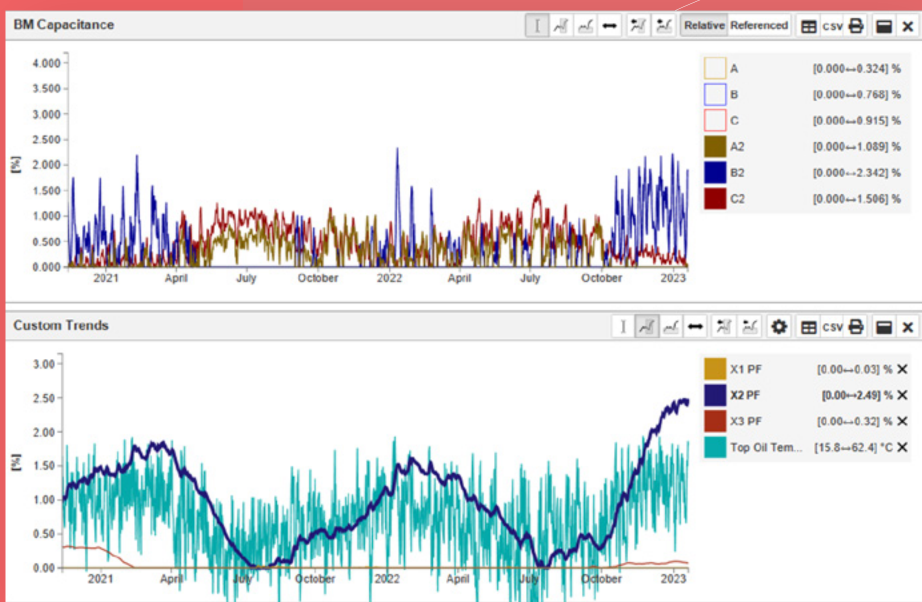
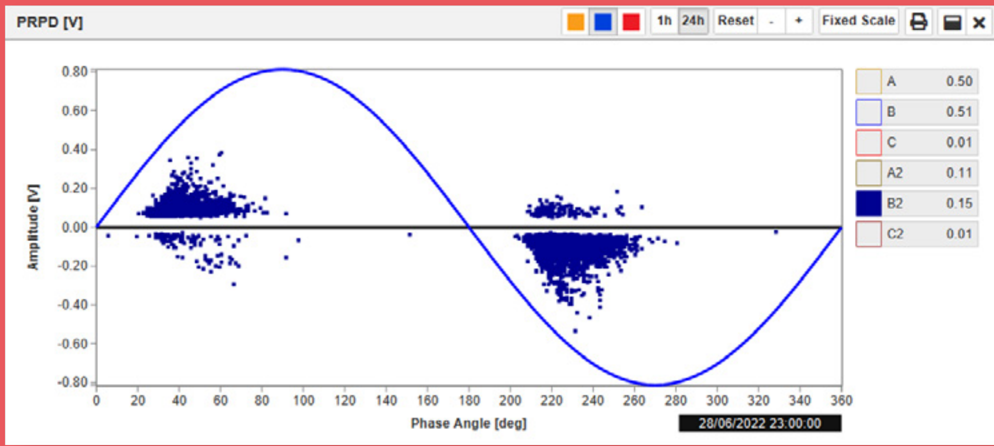


Figure 2:

Phase resolved partial discharge diagrams clearly show the presence of electrical discharges inside the B-phase bushing.



ACTION

Targeted Intervention and Proactive Replacement

Based on the trends identified through TOTUS, the utility scheduled a planned summer outage in 2023 to assess the bushing under peak operating conditions. During the outage, offline Dielectric Frequency Response (DFR) testing was performed, providing detailed Power Factor and capacitance measurements across multiple frequencies. The results confirmed a Power Factor of 5.29% on the Bphase bushing and a moisture content of 4.8% by mass, validating the online data and indicating a serious insulation defect caused by contamination.

With the defect now verified, the utility prioritised replacement of the bushing under controlled, planned conditions, preventing further deterioration and eliminating the risk of an inservice failure.

OUTCOME
Operational and Commercial Benefits

Technical outcome:

- Early detection of temperature-driven bushing defect
- Correlation of PF, capacitance, and PD trends enabled precise risk localisation
- Defective bushing safely replaced before in-service failure

Commercial & Operational Impact:

- Avoided catastrophic transformer failure and collateral damage (fire, oil spill, equipment loss)
- Maintained network reliability without emergency shutdown
- Optimized maintenance scheduling and resource planning
- Protected **capital investment** and reduced unplanned outage costs

Key Takeaways:

- Temperature-driven PF faults are best detected online, as offline tests may miss elevated losses after cooling
- Continuous monitoring across seasons enables proactive decision-making
- TOTUS converts early warning data into clear, actionable interventions, reducing operational risk