



# Online Monitoring Identifies Rapidly Escalating Fault in 120 kV RIP Bushing

CASE STUDY





## CHALLENGE

### High-Risk RIP Bushings in Critical Indoor Substation

Resin Impregnated Paper (RIP) bushings are increasingly used in modern substations due to enhanced safety - especially in the case of indoor and horizontally mounted installations, where fire or explosion risks must be minimised.

However, RIP bushings deteriorate faster than traditional OIP designs when defects occur. Internal voids or delamination can escalate rapidly, leaving operators with limited warning before failure.

At this indoor substation in Russia, six horizontally mounted 120 kV RIP wall bushings were operating in a critical environment where failure could have caused:

- Significant operational disruption
- Safety risks to personnel and assets
- Extended outages
- High replacement costs

The utility needed early detection of developing defects to enable proactive intervention and avoid unplanned failure.



## EVENT

### Early Detection with TOTUS

TOTUS online Bushing Monitoring had been installed across all six bushings, continuously measuring:

- Capacitance
- Insulation losses
- Partial Discharge (PD) activity

In the summer of 2019, TOTUS detected a sudden ~12% increase in capacitance on the K2 phase bushing – a strong indicator of structural deterioration. A review of historic partial discharge data showed that PD activity had been present for roughly a month beforehand, with signatures consistent with voids or internal delamination. Importantly, the discharge source was accurately localised within the K2 bushing rather than elsewhere in the transformer.

Together, the early PD activity followed by a sharp step-change in capacitance provided a clear warning of a developing internal bushing fault that was likely to escalate rapidly without timely intervention.

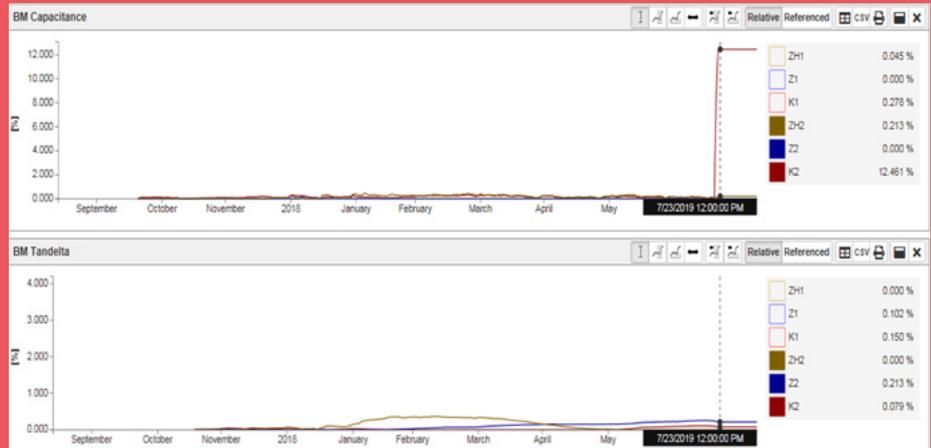
### Figure 1:

Resin Impregnated Paper Wall bushings, horizontally mounted at an indoor substation.



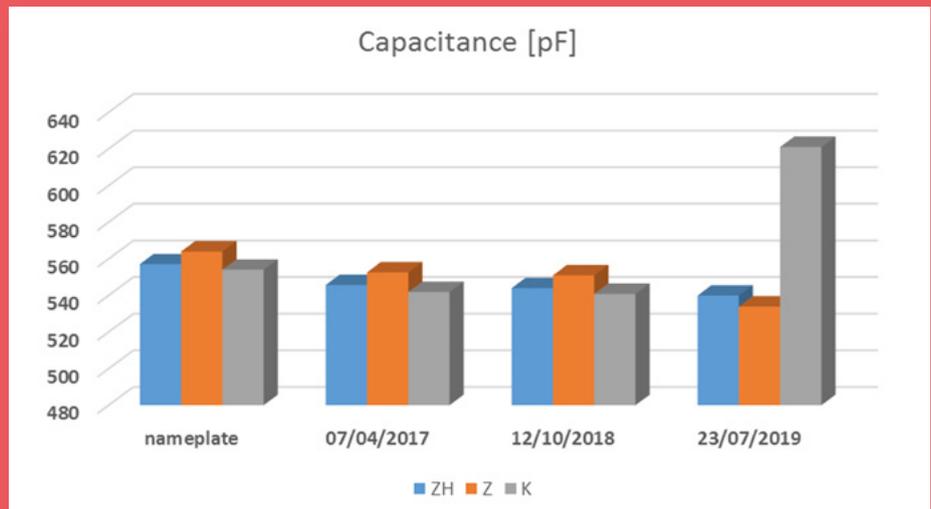
**Figure 2:**

Abrupt increase in Capacitance ~12.5%, observed on 120kV RIP Wall Bushing.



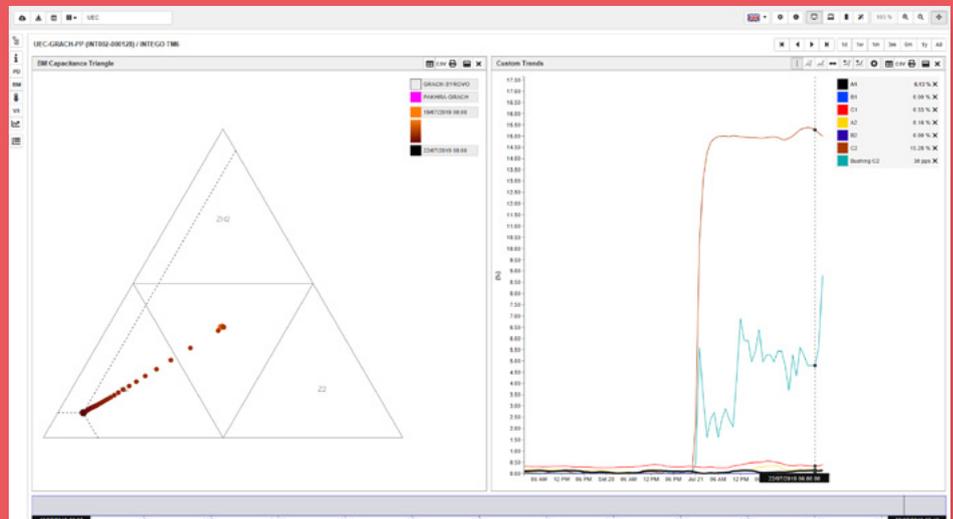
**Figure 3:**

Offline Capacitance and PF tests on RIP 120kV Wall Bushings. Capacitance increase was approximately 10-12% from prior maintenance tests; consistent with change detected by the TOTUS online Bushing Monitoring.



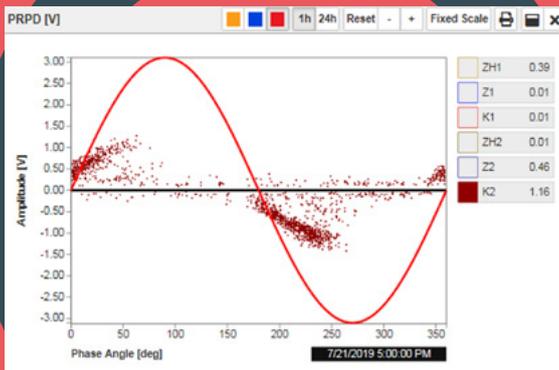
**Figure 4:**

TOTUS online PD shows a developing change in online PD at the moment a capacitance change occurred in the bushing. The Camlin PD triangle indicates the transition and correctly assigns the PD activity on the K2 bushing.



**Figure 5:**

TOTUS online PD shows a phase-resolved PD pattern consistent with patterns typical of voids or delamination in solid resin, and is a typical defect type in RIP bushings.

**ACTION****Proactive Intervention**

With visibility of critical information, the utility scheduled a controlled outage to carry out offline diagnostics. Testing confirmed a ~12% increase in capacitance, fully consistent with the online findings, validating the emerging risk. Based on this evidence, the utility prioritised immediate replacement of the K2 bushing.

By acting proactively instead of relying on reactive decisions, the utility significantly reduced the likelihood of an inservice failure and the potential collateral damage that could have followed.

**OUTCOME****Operational & Commercial Impact****Technical outcome:**

- ↘ Early detection of a rapidly developing RIP bushing fault
- ↘ Successful validation through offline diagnostics
- ↘ Controlled replacement without emergency disruption

**Commercial & Operational Impact:**

- ↘ **Enhanced operational safety:** Eliminated the risk of catastrophic bushing failure, fire, or oil release by intervening early
- ↘ **Reduced operational risk:** No unplanned outage or emergency shutdowns
- ↘ **Enabled safe, controlled planning:** Replacement carried out under planned conditions with full safety precautions in place
- ↘ **Maintained safe network operation:** The substation remained stable and operational throughout, ensuring safety for personnel, assets, and the public