Predicting HV cable failures and completing the test cycle

INTRODUCTION

A mine site in NSW Australia was experiencing reliability issues with their 33 kV cable network. The failures were resulting in a significant loss of production time which was estimated to be costing $140k per hour. LIVE HV was contacted to provide online PD monitoring to detect and locate HV insulation issues prior to failure.

Key Event Timeline:

2012: Multiple failures on 33 kV cable network leading to loss of production

2013: Online PD sensors installed at various locations and PD readings taken

2013: Low level PD detected at several locations – advised to monitor

2014: Moderate PD detected at several locations – advised to repair or continuously monitor

2015: High PD detected – advised to repair immediately

2015: Engineer change at site

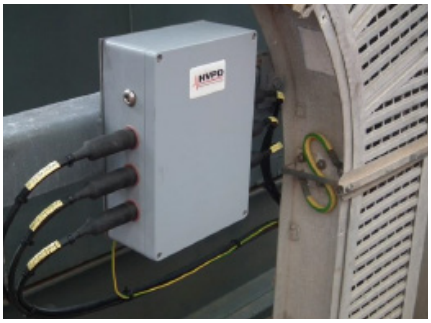
2016 & 2017: No testing and no repairs made

2018: Cable begins to fail at locations identified in 2013

2018: Testing program re-initiated, additional PD sensors installed to give complete network coverage, communication between LIVE HV and client improved

2018: Cables proactively repaired during scheduled outages based on LIVE HV advice. Clear evidence of discharge visible at repair locations. Certain catastrophic failure avoided by enacting repairs.

PD sensors



PD sensor termination box

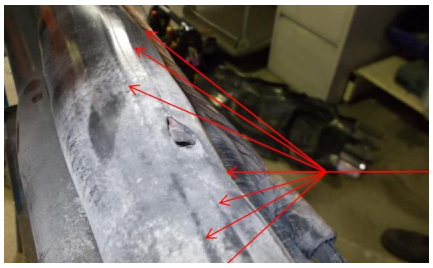
INITIAL APPROACH

To enable online PD measurements, PD sensors were installed at three locations selected by the client on the 33 kV cable ring. Testing was initiated and performed on an annual basis between 2013 and 2015.

PD was immediately identified at multiple locations on the 33 kV cable ring. Using location analysis techniques, the discharge was pinpointed to exact locations on the cable. Initially the PD was of low magnitude and monitoring was recommended. However, in the following two years the PD level steadily increased. Using trend analysis derived from LIVE HV's extensive database, repairs were recommended. This progression of PD and deterioration of the cable is displayed in the following table.

Cable	PD (pC)			Comments
	09/13	12/14	12/15	
2050A	420	960	1580	Mid-range discharge on Cable 2050A Red Phase 230m from RMU2000
2050B	340	1050	1260	
2060A	0	0	450	
2060B	220	470	700	
5050A	1000	1800 pC	3880	High Discharge on Cable 5050A White Phase 535m from RMU5000
5050B	1100	N/A	3240	
5060A	750	2400	1180	High Discharge on Cable 5060B White Phase 380m from RMU5000
5060B	750	2780	3720	

PD Results summary



Cable failure

Cable failure

The cables identified in the table above were not replaced and in 2018, 5 years after initial detection, there were two failures at the precise locations identified, resulting in 68 hours and $9.5 million in lost production.

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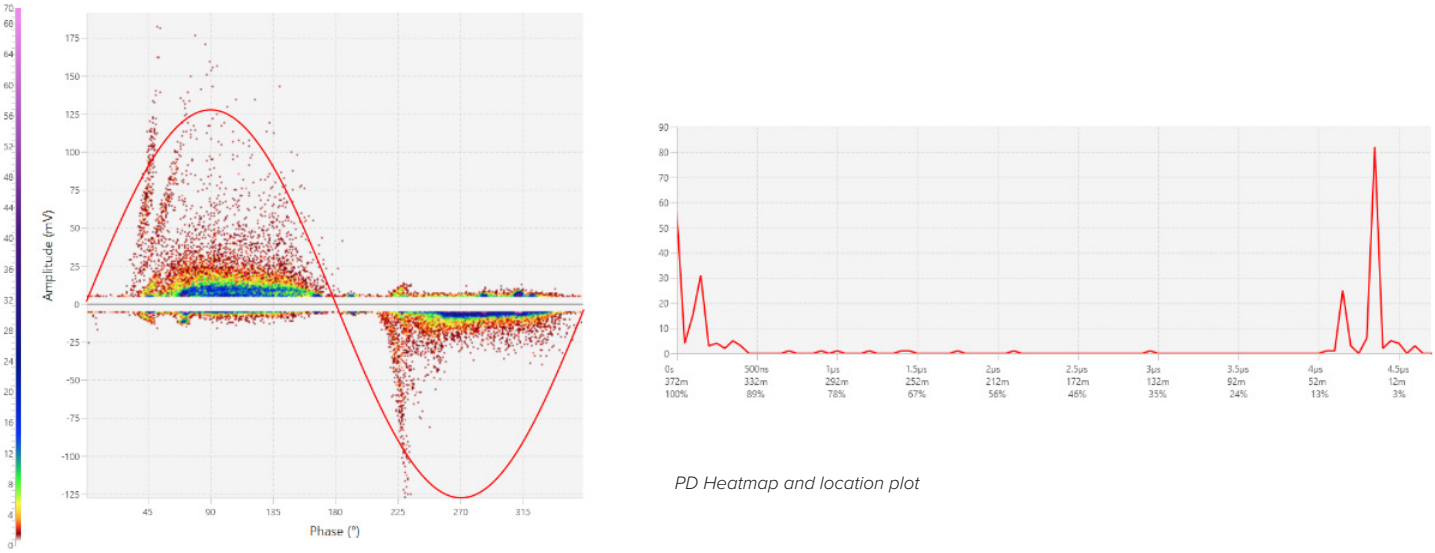
IMPROVED APPROACH

Despite the effectiveness of the testing to accurately forecast cable faults there was ultimately still an unplanned shutdown resulting in the loss of production. Meetings between LIVE HV and the client identified a key change of site personnel, ineffective communication between client and tester and inadequate coverage of PD sensors as the culprit for the failures. To address these issues the following improvements were made to the testing process:

Improvements:

- LIVE HV advised the most effective location where sensors should be installed. This resulted in two additional key sites being selected for sensor install
- 6 monthly automatic testing set up until PD levels improve
- High level PD to be actioned with repairs
- Reports improved. Results displayed on single line diagram and presented on web-based client log in
- Full engagement from all stakeholders – client and test party. An increased level of trust and understanding improves recommendations and ensures actions are taken

Following these improvements several areas on the cable ring were proactively replaced during scheduled shutdowns based upon advice from LIVE HV. Evidence of discharge was clearly visible where the repairs were made as shown below. Without action these would have definitely resulted in failure.



PD Heatmap and location plot

Example of imminent failure detected and repaired prior to failure