KEPCO prevents in-service failure of a 345kV bushing with TOTUS online monitoring

Evidence: Online monitoring showing capacitance increase and arcing events

Action: KEPCO planned offline Capacitance and DGA test confirming online data and issues replacement; thus, preventing an in-service failure

Background

Bushing Power Factor and Partial Discharge (PD) online monitoring was installed on a single-phase transformer bank in Ulsan, South Korea in 2015. The installed device monitors leakage current from the bushings and detects PD activity from the main tank and bushings using tap adaptors installed on the bushing test taps. The monitor acquires leakage current and PD information continuously and simultaneously in all phases with a summary of the data stored hourly.

The transformer bushings were in operation for more than 30 years, and were an OIP type, rated 345 kV, and approximately 430 pF capacitance.

Event

In February 2015, a sudden step increase of capacitance (C1) in the A-phase bushing was detected by the monitoring system. The recorded change in capacitance was ~1.7% which corresponds to an increase of roughly ~7pF and could be caused by a short circuit between two layers in the condenser core. Prompted by this change detected from the monitor, KEPCO planned an offline test to confirm the online readings, but the results proved inconclusive. The offline test indicated the value of the A-phase bushing capacitance had not changed significantly from the previous records, as shown in Table 1.

South Korean Transmission Company was able to take a very successful action thanks to the correlation of online data showing small variations of capacitance and partial discharges.

Still suspicious of a bushing defect, Kelvatek experts reviewed historical data from the online monitor more closely. The relative difference of capacitance between A-phase and B-phase was analysed over time. From this it was possible to spot that this difference was mostly constant in 2012 and 2014; below 2 pF variation. While in 2015, a sudden difference exceeding 12 pF was recorded; this was approximately equal to a 2.7% of capacitance increase.

Table 1. Offline results before (2012, 2014) and after (2015) the online alarm.

345 kV NGK Bushing OFFLINE Capacitance C1 (pF)				
	2012	2014	2015	Increase since 2012
Bushing A	435	429	438	0.60%
Bushing B	433	430	426	-1.60%
Bushing C	432	NA	430	0.46%

345 kV NGK Bushing OFFLINE Capacitance C1 (pF)				
	2012	2014	2015	Increase since 2012
Bushing A	435	429	438	0.60%
Bushing B	433	430	426	-1.60%
Bushing A-B	+2 pF	-1 pF	+12 pF	2.7%

Further analysis also revealed that at the precise moment of the bushing capacitance increase, a high energy discharge event had occurred. High energy events are partial discharges with significantly high magnitude, ~20V peak magnitude or more. High energy event discharges are considered similar to internal arcs that do not fault to ground, but across portions of the electrical insulation. Correlating with the capacitance increase on the A-phase bushing, a high energy discharge event was recorded that had just 8 pulses per-second and occurred just this one instance. This is believed to be the instant when internal layers of the bushing insulation faulted.

Figure 1. Capacitance increase in bushing A1 and high energy event recorded at the same time.

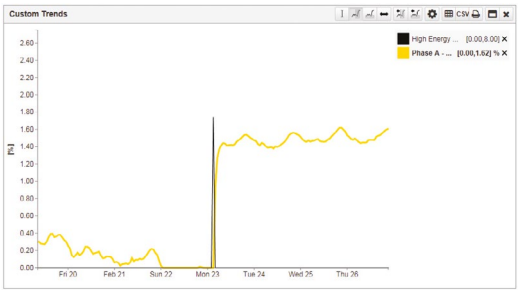

Table 2. Offline DGA results for bushings A and C

OFFLINE DGA results for Phase A and C bushings		
	Phase A	Phase C
H_2	17	28
CH_4	40	39
C_2H_2	76	0
C_2H_4	44	1
C_2H_6	32	62
CO	71	53
CO_2	564	789
N_2	150.862	156.665
O_2	10.280	4.337

The fact that this event was recorded in conjunction with the capacitance increase was an important detail that prompted a second offline test and an oil sample for Dissolved Gas Analysis (DGA). Table 2 reports the results of the DGA analysis for A and C-phase bushings. The C-phase bushing was sampled for comparison. It can be clearly seen that the amount of acetylene in bushing A is well above the accepted levels for safe operation at 76 ppm, while acetylene in the C-phase was not detected

These findings prove that a correlation of phenomena, having high energy discharges with a change in capacitance can be more effective for identifying incipient bushing defects than offline Power Factor testing. In this instance the offline test was not accurate enough to detect the small capacitance change and diagnose the problem.

Action

Following the findings shown in Table 2, KEPCO promptly planned and executed the bushing replacement within a few months, thus saving the bushing from a potentially catastrophic incident. It must be noted that both the capacitance change and the repetition rate of the high energy event were quite small in terms of absolute magnitude. But being able to detect both these phenomena online and see that they occurred in the same moment provided crucial information enabling South Korean Transmission Company to take a very successful action.

Thanks to the genuine 24/7 continuous PD monitoring it was possible to detect and identify the internal arcing activity, leading to the right action.

kelvatek camlin group

Kelvatek

31 Ferguson Drive,
Lisburn, BT28 2EX,
Northern Ireland

Email: support@kelvatek.com
Tel: +44(0) 2892 626 989