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Bushing Failure- Investigation process & findings

Tarik Al Abri^a, Mohan Lal^a, Ibrahim Al Balushi^a, Mohammed Al Zedjali^a

Oman Electricity Transmission Company ,P.O BOX:1389 ,Al Khoud P.C:132 ,Oman^a

Abstract

Between 28 August 2011 and 8 September 2011, five 33kV OIP bushing failures occurred at JBB Ali Grid Station belongs to Oman Electricity Transmission Company (OETC). Three failures resulted in a complete loss of supply and around 130,000 consumers were reported with a lack of electricity. OETC assigned a third party investigator to conduct a power failure investigation in order to obtain a possible root cause for these failures.

The investigation approach or process that were followed included the following phases:

- Phase 1: Facts finding and preliminary analysis
- Phase 2: Destructive dismantling and laboratory investigation through.
- Phase 3: Root cause analysis.

From the investigation and buildup of hypothesis, no single most likely cause of failure could be identified. Metal migration and semi-conductive copper sulphide migration in the oil that led to surface contamination of insulation in the stress zone is considered causal factor for bushings insulation degradation. Copper sulphide in bushing was detected caused due to corrosive Sulphur in oil. There has to be another factor influencing the weakened insulation breakdown. The source of this factor can be found in the suspected frequently occurring earth faults in the 33 kV line feeders, leading to a line voltage to ground of 33 kV and transient over voltages due to switching off the faulted feeder.

* Tarik Al-Abri. Tel.: +96899501136; fax: +96822309046.

E-mail address: tarik.alabri@omangrid.com

All the OIP bushings were supplied in the same patch filled with the same oil and operated in identical service conditions so degradation of insulation as chemical process can be considered in similar state. Electrically all bushings were subjected to identical voltage and load related stresses as transformers are operated in parallel. Thus combinations of these two factors are considered as causal factor for frequent breakdown of multiple bushings.

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1- Introduction

The OETC network voltages comprise of 400KV, 220kV and 132 kV, and include 132kV/33kV substations feeding into the primary substations of the distribution companies at 33kV. One of the substations among the OETC 132kV network is JBB Ali (132/33kV). Since this substation is a radial substation it is considered a crucial substation. This substation is equipped with two 132/33kV, 125 MVA power transformers. Incoming feeders to the transformer are from the 132kV overhead line from Al-Kamil Power Generation plant.

The following five incidents occurred in 132/33 kV substation JBB Ali:

- On 28th August 2011 at 19:10 hrs, 125 MVA Transformer T2 tripped.
- On 3rd September at 19:25 hrs, 125 MVA Transformer T1 at JBB Ali substation tripped due to failure of 33kV Y-phase bushing. Outages of both transformers at the substation led to a black-out in the zone that was fed from the JBB Ali substation. Following this black-out situation, an OETC maintenance team swapped the R phase bushing of T1 transformer to the Y phase of T2 and energised transformer T2 on 4th September 2011 at 13.26 hrs.
- This replaced bushing failed however after 18 hours, on 5th September 2011 at 07.36 hrs. This caused second subsequent zone black out. To restore this black-out in the shortest time possible, an OETC maintenance team removed one set of identical bushings from Mudhairib substation and replaced the failed bushing of Y phase at T2. This transformer was eventually energised on 6th September 2011 at 3.58 hrs. The other two bushings, received from Mudhairib substation, were assembled on T1 at Y and B phase. Transformer T1 was energised on 7th September at 1.57 hrs.
- On 7th September at 18.33 hrs T2 tripped again due to failure of B phase bushing. Following this failure OETC replaced all the three bushings from T2 with three new bushings received from the manufacturer. T2 was energised on 8th September 18.33 hrs after bushing replacement and was kept at no load.
- On 8th September at 19.48 hrs T1 tripped due to failure of R phase bushing (5th bushing from the lot of 6 at this substation). Following this failure OETC replaced the R phase bushing of T2 with the bushing taken from T2 Y phase, the one brought from Mudhairib substation.

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