

**REPORT ON INVESTIGATION OF FAILURE OF 100 MVA, 220/66-33/11 KV
POWER TRANSFORMER AT 220KV GEETA COLONY SUBSTATION OF DELHI
TRANSCO LTD. (DTL)**

1.0 Introduction:

- 1.1 DTL vide letter No. F.DTL/206/2015-16/Mgr(T)O&M-E-2/22 dated 04.02.2016 requested CEA to investigate the cause of failure of 100 MVA, 220/66-33/11 kV Power transformer (failed on 02.02.16 at 1326 hrs) in Geeta Colony sub-station of DTL.
- 1.2 A team of officers from PSE&TD Division of CEA [Sh. Y.K.Swarnkar, Director(Substation); Sh. Faraz, Assistant Director; and Ms. Bhaavya Pandey, Assistant Director] alongwith officers of DTL visited the site of failure on 05.02.16. The details of visit are as under.

2.0 Background:

- 2.1 One 220 kV double circuit line from Patparganj S/s and one 220 kV double circuit line from South of Wazirabad S/s of DTL are terminating in Geeta Colony substation of DTL. This substation feeds power at 33 kV to Geeta colony-I, Geeta colony-II, Kanti Nagar-I, Kanti Nagar-II, Kailash Nagar-I, Kailash Nagar-II and Shakarpur feeders. Two Nos. of 100 MVA, 220/66-33/11 kV power transformers are in operation on 220 kV Geeta Colony substation. Both transformers are of BHEL make and are operating in parallel.
- 2.2 BHEL make 100 MVA, 220/66-33/11 kV power transformer with serial no. 2015821 failed during operation on 02.02.16 at 1326 hrs.
- 2.3 Brief details of the failed transformer are as follows:

Capacity	100 MVA
Voltage	HV: 220 kV MV: 66-33 kV (33kV tap was in use) LV: 11 kV (Tertiary-unloaded)
Phase	3 phase
S. No.	2015821
Make	BHEL
Type of Cooling	ONAN/ONAF/OFAF
Vector group	YNyn0d11
Insulation level	1050(HV)/325(MV)/170(LV)/95 (N) kVp
Year of manufacturing	2004
Year of commissioning	2005 (31 st August)
Impedance (%)	11.72% (HV-MV) maximum tap 15.21% (HV-MV) normal tap 21.83% (HV-MV) minimum tap
Tap range	-15% to +5% in steps of 1.25% each

3.0 Observations:

- 3.1 Prior to fault, load on transformer was 23 MW. Maximum loading on transformer was 32 MW on the day of fault (2nd February). Transformer was not loaded even up to 50% of its capacity for the last many days. The transformer was operating on tap 5 (Normal Tap is Tap 3) at the time of failure.
- 3.2 Tertiary of transformer is unloaded. All three terminals of tertiary winding have been brought outside the tank and terminals were not insulated.
- 3.3 During physical inspection of the failed transformer at site, it was observed that there was minor dislocation of all three HV bushings from their turrets (Exhibit-I), MV bushing flanges of Y & B phases had cracked, LV bushing of B phase had punctured (Exhibit-II) and transformer tank had cracked at a number of places (Exhibits -III&IV), although there was no visible sign of bulging of the tank.



Exhibit-I

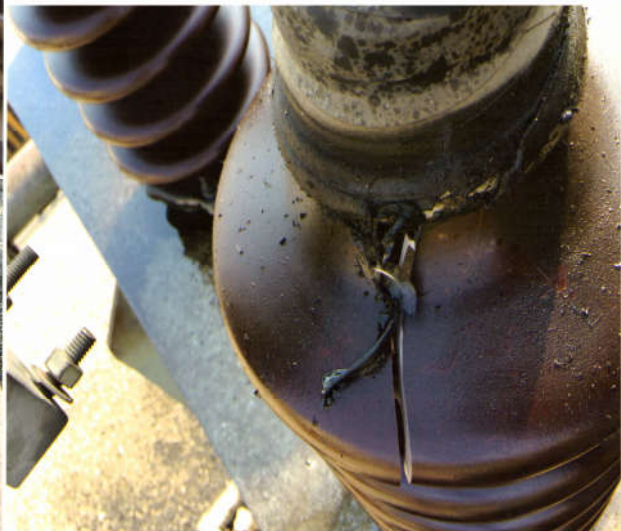


Exhibit-II



Exhibit-III



Exhibit-IV

- 3.4 There was no damage to nearby equipment/ material of the substation.
- 3.5 Transformer was checked for internal damage through inspection window. Visible damage was observed on Y-phase winding (Exhibits- V&VI). Damage on other windings was not visible through inspection window. The extent of damage inside the transformer would be assessed only after opening of tank.



Exhibit-V



Exhibit-VI

- 3.6 As per information provided by DTL the transformer had tripped on Differential relay, Buchholz relay, OSR and PRV.
- 3.7 The event logger data indicates that the contribution of fault current from 220 kV side was 17.266 kA. 220 kV and 33 kV side breaker had opened within 69 ms of operation of differential relay.
- 3.8 There is no provision for fire protection of the transformers in the substation.
- 3.9 Time stamping of the relays/event logger/disturbance recorder at the substation was not synchronised to the Indian Standard Time.

4.0 O &M History of failed transformer:

It was informed by DTL that since 2011, Buchholz relay of the transformer had operated in number of occasions. Most of the times it was found that the winding resistance values were on higher side. During inspection by DTL/BHEL, most of the times it was found that either winding lead connections were loose or core-yoke was found shorted with transformer tank. In last 6 years, MV side bushings have been replaced number of times when tan delta values were found to be alarming.

5.0 Analysis of cause of failure:

5.1 Following tests were conducted on the transformer post failure:

- Magnetic balance test
- Magnetizing current
- Tan δ test of HV, MV and LV windings
- Sweep Frequency Response Analysis (SFRA)
- DGA
- Winding resistance measurement test

5.2 Magnetizing current in Y-phase was found to be 1.06 A compared to 3.6 mA in R-ph and 3.5 mA in B-ph which is very high. Also, very low voltage (0.506 V) was observed in Y-ph in magnetic balance test when 231 V was applied on R-phase which indicates problem in Y-phase winding. DGA of oil indicated high concentration of Hydrogen (H_2 -2064ppm), Ethylene (C_2H_4 -271 ppm), Methane (CH_4 -148 ppm), Acetylene (C_2H_2 -398.8). Total Dissolved Combustible Gases (TDCG) was 3064 which is higher than normal value. These high concentration of acetylene gas could be due to high energy arcing inside the tank. Significant variation was observed while comparing the pre and post fault signatures/ traces of SFRA tests carried out on transformer. The test result indicates problem in core coil assembly.

5.3 Operation of Differential, Buchholz, OSR & PRV relays indicates internal fault of the transformer. The internal winding insulation failure might have led to inter turn winding insulation failure, which is also supported by the test results and preliminary internal inspection. The fault is most likely in Y- ph of winding. The detailed investigation after opening of tank will provide the extent of damage, type of failure(s) and other valuable information.

5.4 High energy arcing inside the transformer tank might have led to sudden pressure rise and tripping of oil surge relay & PRV. Rate of rise of gas pressure might be very high (before operation of PRV), which might have resulted in cracks at weak areas of the transformer tank.

6.0 General Remarks and Recommendations:

6.1 The practice of Condition Based Monitoring with the use of various modern diagnostic tools as suggested in Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010, is recommended.

- 6.2 The frequency/periodicity of measurement should be changed depending on condition/health of transformer in operation.
- 6.3 Fire protection system for transformers should be installed as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010 so that damage due to delay in extinguishing of fires can be prevented.
- 6.4 Except for transformer banks formed out of single phase units and 5- limbed 3-ph units, the tertiary winding may be avoided in line with above mentioned CEA Regulations as it increases the probability of failure of the transformer. Tertiary winding terminals taken out of the tank of transformer to avoid short circuiting between terminals or terminal to ground should be kept insulated.
- 6.5 It was informed by DTL that second transformer commissioned at Geeta colony substation also had problems since commissioning and had tripped many times due to various reasons. It is advised that complete overhaul of this transformer should be taken up in consultation with OEM to avoid repeated failure/outage of transformer.
- 6.6 During visit of CEA officers, the failed transformer tank was inspected through inspection window only. Detail inspection of the transformer is required to be carried out by OEM/ expert of repairing agency after opening the tank, which may not be possible at site. The feedback/ warnings from the investigation should be used for planning future course of action. A detailed report of the failed transformer may be provided to CEA after thorough internal inspection of the failed transformer is carried out.
- 6.7 Time stamping of all relays/DR/event loggers in all substations of DTL should be properly synchronised to Indian Standard Time through GPS so that DR & event logger information may be used for co-relating the sequence of events and operation of protection relays of transformer.