General guidelines for safekeeping of high voltage transformers Part III

ABSTRACT

Transformers such as HV/EHV (132kV and above) are the most vital and costly equipment in power systems and large Industries. It is the prime duty of HV/EHV substation managers, asset managers, and substation Operation & Maintenance (O&M) engineers to look after transformers, beginning from receipt on-site through their lifecycle scrupulously with motherly feelings.

Generally, OEM (Original Equipment Manufacturer) guidelines must be followed. This article is a significant and important contribution of experienced engineers in O&M and testing and commissioning up to 400kV in HV/EHV substations. The authors deliberate all the aspects from receiving the consignment of an EHV Transformer on-site through its lifecycle, including O&M and life expectancy enhancement.

This article serves as a guideline for substation managers, asset managers, and substation engineers in the absence of any guidelines issued by their utilities or in the industry.

KEYWORDS:

N_2 (nitrogen gas), SFRA (Sweep Frequency Response Analysis), FAT (Factory Acceptance Test), TCIV (Transformer Conservator Isolation Valve), OEM (Original Equipment Manufacturer), DGA (Dissolved Gas Analysis), FDS (Frequency Domain Spectroscopy), furan analysis

Thermosyphon filter is an ONLINE transformer oil preservation system for power transformers, and it is mounted in transformer oil pipes outside the main tank of the transformer

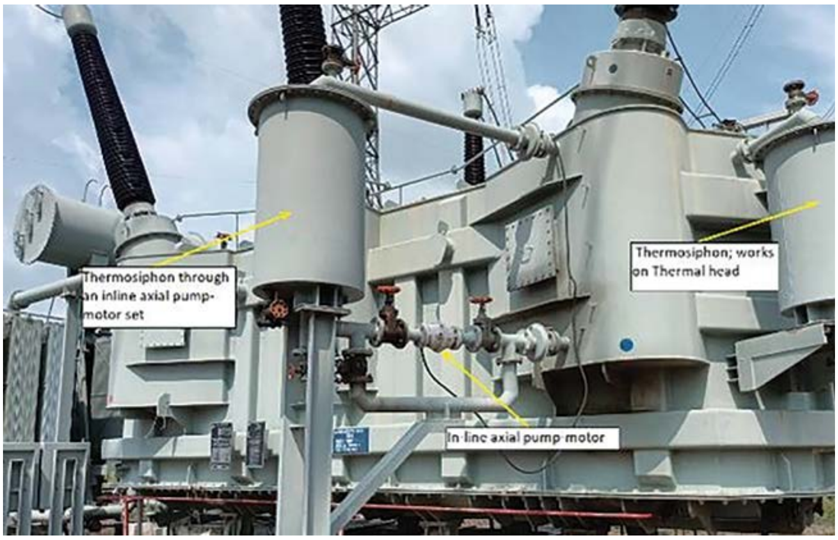

Figure 14: Thermosyphons

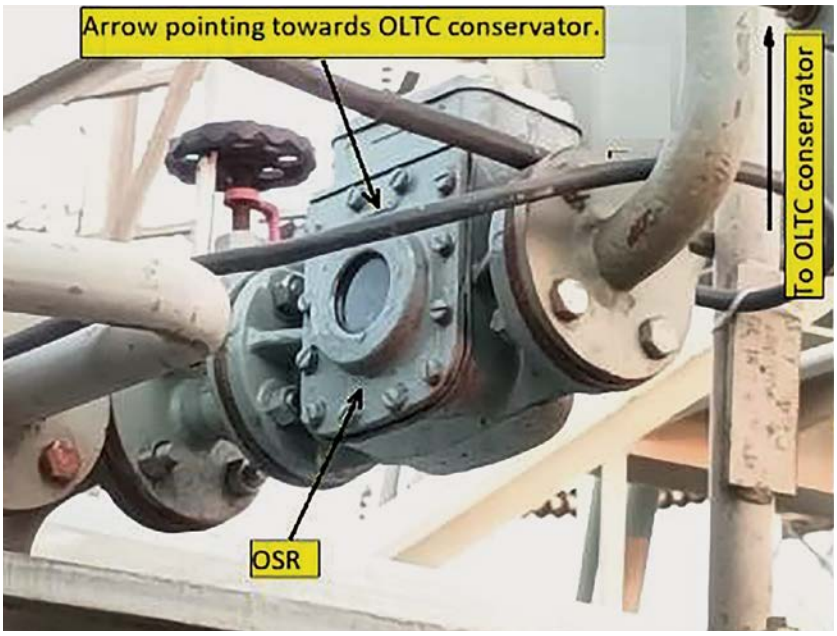

Figure 15A. Oil surge relay (OSR)

Copper flats of suitable size must run through the neutral CT where bushing CT is not provided in the neutral bushing (for REF protection) on the support insulators

7. Thermosyphon filter

Thermosyphon filter is an ONLINE transformer oil preservation system for power transformers. The system consists of a container with absorbent (normally activated alumina) with very high moisture absorption capability. It is mounted in transformer oil pipes outside the main tank of the transformer. While transformer oil circulates through this, the absorbent removes moisture from the oil. Oil circulation can be either under the thermal head or through the forced pump. Moisture content in transformer oil can be maintained at a level below 10 ppm.

8. Oil filtration job

(a) Fill thermometer pockets with oil/ester fluid and dip-calibrated thermometers.
(b) Filter transformer oil until its BDV is greater than 60 kV and moisture content is below 10ppm as per IEC 60422-2013 (Table 4). Make sure that the transformer tank oil temperature does not exceed 50°C.
Note: (a) During filtration work, radiator valves should be kept in closed condition. (b) After filtration, push the oil from the bottom; open radiator valves one by one.
(c) For transformers rated 400 kV or more, the OEM's erection engineer shall take care during erection, then oil filling and drying according to procedures provided by the OEM. The substation manager, substation engineer, and asset manager should extend all possible help and support to the OEM's erection engineer.

9. OLTC erection and inspection

(a) Connect the operating rod and worm gear arrangement. Make sure that taps have the same number as that for the DM (Driving Mechanism) box when connecting the DM with the tap changer.
Note: Presently, the OEMs ship transformers with completely assembled OLTC DMs, including diverter switches.
(b) Connect OSR (Oil Surge Relay) between the OLTC conservator and the diverter switch compartment. Make sure that the arrow on the relay faces the OLTC conservator (Figures 15A and 15B).

(c) Fill diverter switch chambers with newly filtered mineral oil.
Note: All EHV transformers are equipped with in-tank type OLTC (Figure 15C).
(d) Open the air vent from the diverter switch chambers.
(e) Make sure all stop valves between the oil conservator and the OLTC driving unit are open.
(f) Cycle the full range of the tap changer manually and check the end limit switch stops.
(g) Cycle the full range of the tap changer electrically and make sure rotation is correct.
(h) Verify the operation of taps when operated from the RTCC (Remote Tap Changer Control) panel.
Note: The electrical and mechanical interlock should also be tested.
(i) Verify OSR relay contacts if closed operate the master trip relay module.

10. Neutral grounding

(a) Copper flats of suitable size must run through the neutral CT where bushing CT is not provided in the neutral bushing (for REF protection) on the support insulators. Connect them to the earth pit through two ACSR/AAA conductors clamped with a bimetallic pad to the copper flat, as shown in Figures 16A and 16B.
(b) Neutrals of HV and LV sides of star-star transformers are grounded in separate earth pits.
(c) All earth pits are connected in parallel and are, in turn, connected to the earth-mat (earth grid) so that the combined earth resistance is less than 1.0 Ω (preferably as low as 0.5Ω).
(d) Individual and combined earth resistances are measured periodically. Earth pits are maintained regularly, and electrodes are replaced if required.
(e) The tank (body) should be permanently connected to the earth by means of a flat, flexible conductor of suitable size and material (galvanized steel, copper, or acceptable equivalent) terminated on earthing terminals or pads provided at the bottom of the tank (Figure 16C).
(f) The cable, marshalling, and OLTC operating boxes should also be earthed (Figure 16D).
(g) Verify the integrity of the earthing system.

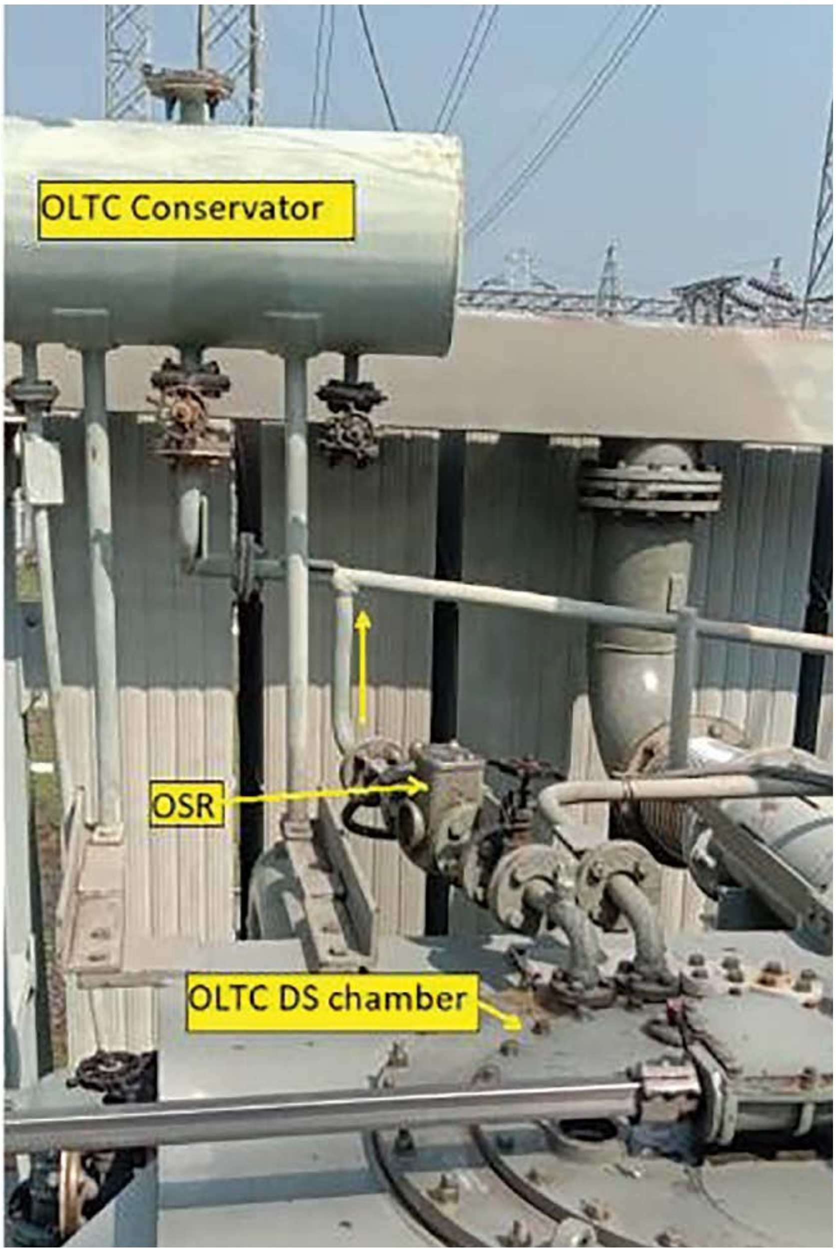

Figure 15B. OSR

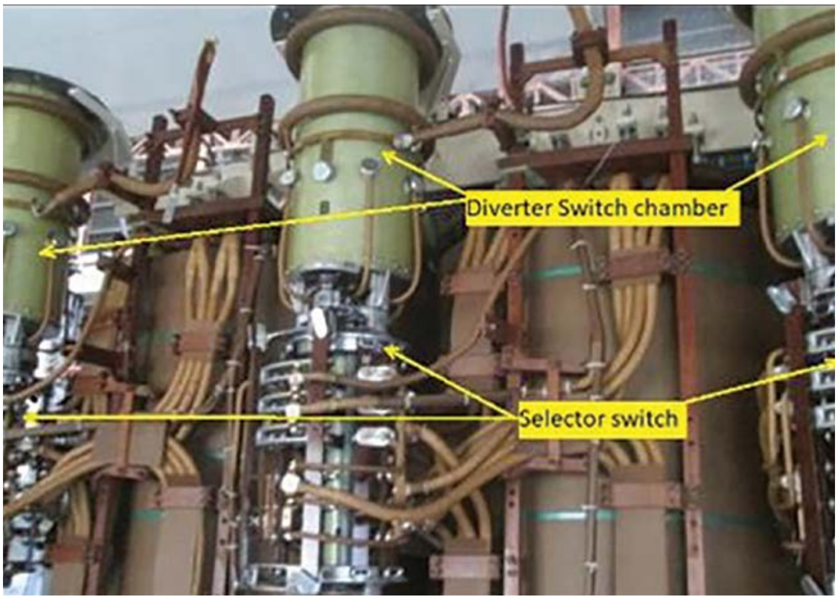

Figure 15C: In-tank type OLTC

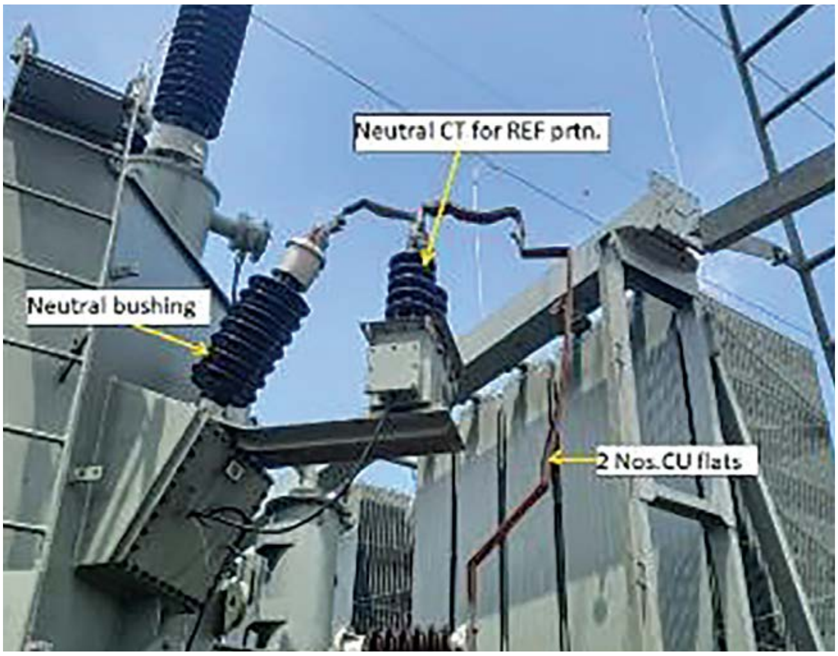

Figure 16A. External neutral CT for REF protection

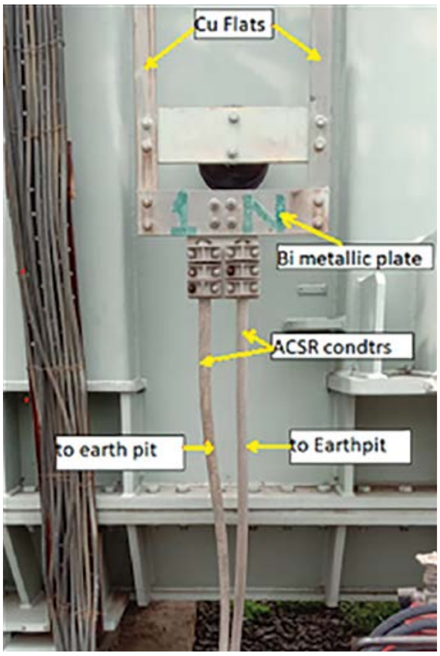

Figure 16B. Earth connection through neutral CT

Figure 16C. Transformer body earthing

11. Delta tertiary winding and bushings: 3U, 3V and 3W or Y1, Y2 Y3 (as per IEEE C57.12.70-2000)

(a) In a transformer bank of three single-phase units, confirm the tertiary winding connection as per vector group YNa0d11 or YNa0d5 of the autotransformer and connect them externally either on a 33 kV or 11 kV bus drawn near the autotransformer or through 33 kV or 11 kV XLPE cables.

(b) Protection against transferred surges:

i. Follow instructions of OEMs.

ii. In the absence of instructions from OEMs, in the case of autotransformers, earth one terminal of the delta tertiary, either 3U or 3W (in UVW nomenclature) or Y1 or Y3 (as per IEEE C57.12.70-2000) of delta tertiary bushing terminals.

iii. In the case of autotransformers rated 400/220/33 kV and above, strictly follow the instructions of OEMs.

iv. To protect the tertiary winding against transferred surges, some OEMs recommend surge protection capacitors in conjunction with LAs on each phase of tertiary winding (Figure 18A and 18B).

(c) Tertiary winding utilized for feeding load

(i) For 33 kV or 11 kV delta tertiary

windings, which feed loads for sub-station supply, 30 kV LAs or 9 kV LAs should be installed on each phase. A DTR of 33/0.433 kV or 11/0.433 kV, Dyn11 of appropriate capacity is required with suitable isolation and protection arrangements in 33 kV or 11 kV as well as on 0.433 kV side.

(ii) For 33 kV or 11 kV delta tertiary windings which feed loads to DISCOMs, a zig-zag neutral grounding transformer of appropriate capacity should also be installed with associated relays, circuit breakers, CTs, isolators, and LAs.

(iii) For 33 kV or 11 kV delta tertiary windings which feed reactive compensation devices such as capacitor banks or reactors, necessary LAs, isolators, CTs, and circuit breakers of adequate capacity should be installed. Some utilities also use NDR (Neutral Displacement Relay) protection with 3 ph, 33 kV RVTs or 12 kV RVTs.

(iv) Ensure that 1U, 1V, and 1W (H1, H2, H3 as per IEEE C57.12.70.2000) designated transformer terminals match with

- R, Y, B (R, S, T) phase configuration of buses respectively of HV switchyards
- 2U, 2V and 2W (x1, x2 and x3) on IV

To protect the tertiary delta winding against transferred surges, some OEMs recommend surge protection capacitors in conjunction with LAs on each phase of the tertiary winding

Figure 16D. Marshalling box earthing

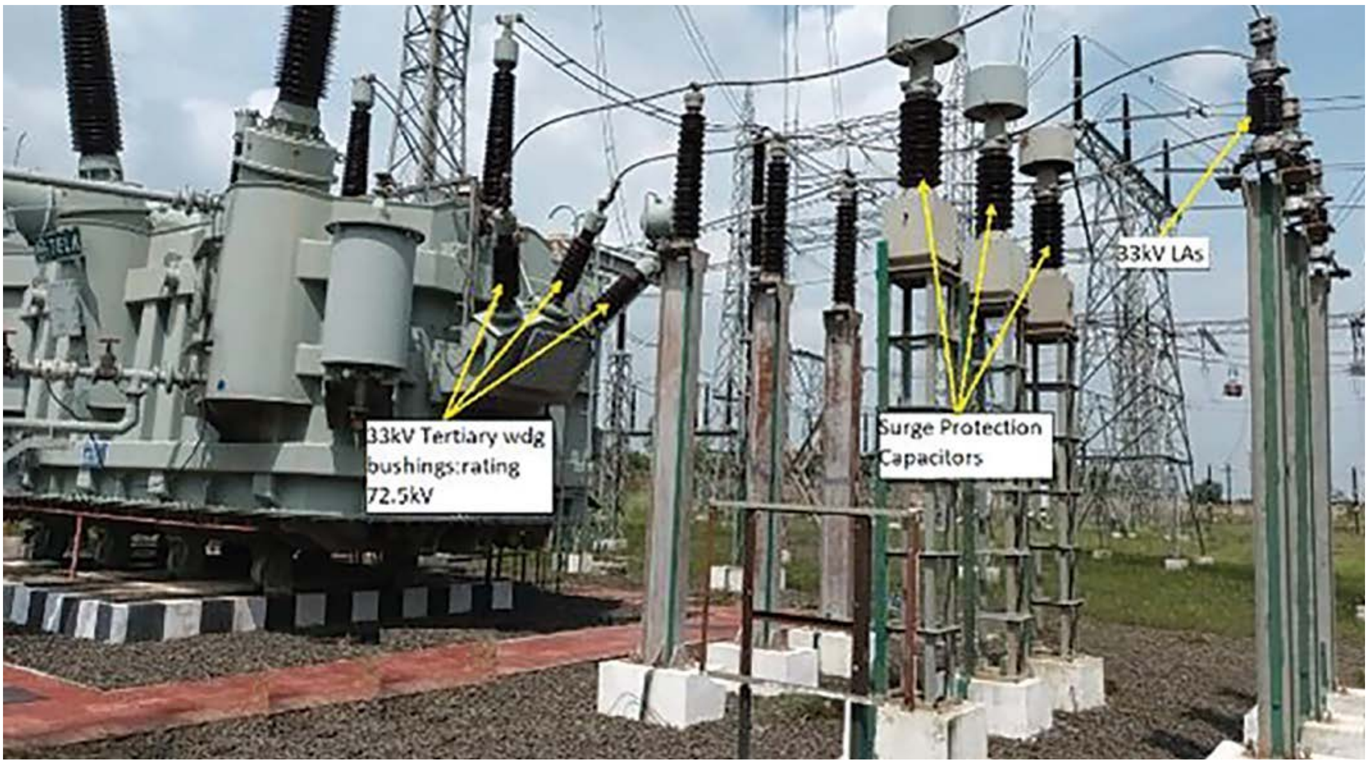

Figure 18A. Installation of Surge protection capacitors for protection of tertiary winding against transferred surges

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(in case of autotransformers / ICTs) and LV side (in case of two winding transformers)
- 3U, 3V and 3W (Y1, Y2 and Y3) in delta tertiary winding in the case of autotransformer (ICTs).

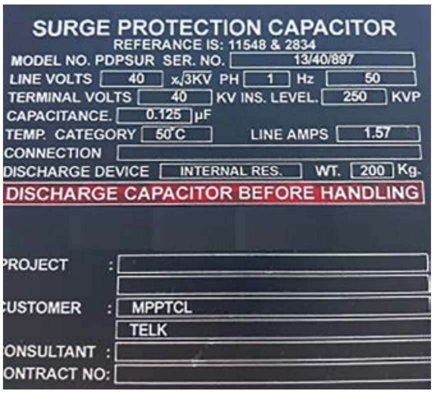

Figure 18B. Surge protection capacitor nameplate

Caution: If a delta tertiary is not used either for reactive compensation equipment, station supply, or feeding 33 kV loads, then one corner of delta tertiary winding should be earthed.

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Authors

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J. J. L. Kapil is a retired assistant engineer, 220 kV S/S, Jabalpur in June 2017, holding a diploma in electrical engineering. Among his commendations, MD MPPTCK has felicitated Mr. Kapil in recognition of his hard and sincere work and for preventing many incidences. He was responsible for the upkeep of 3x40 MVA 220/132/33 kV Mitsubishi transformer bank (1-Ph. units), which are still in service after 53 years.

Santosh Dubey holds a Diploma in Electrical Engineering. He is the Assistant Engineer of 220 kV Substation at Nayagaon and at Sukha, Jabalpur, a prestigious EHV substation in the State of Madhya Pradesh. He looks after Operation & Maintenance and Erection of EHV equipment very efficiently and successfully. Down time of any equipment is minimal due to his sincerity, devotion and relentless efforts. He is an asset to the M.P. Power Transmission Co. Ltd. Jabalpur (India). He has been felicitated and awarded for his exemplary work by the M.D., M.P. Power Transmission Co. Ltd. Jabalpur. Due to his strict execution and monitoring of their maintenance practice, a 55 year-old 3x40 MVA, 220/132/33 kV transformer is still in service. He obtained the ISO-9001-2015 certificate for 220 kV S/S Nayagaon, Jabalpur which is 55 years old. He also removed and cleaned debris of bursted 72.5 kV bushing from the body of a 132/33 kV, 63 MVA Transformer and re-energised it in minimal time by replacing the failed bushing at 132 kV substation at Mansakara.

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