General guidelines for safekeeping of high voltage transformers Part IV

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 400 kV 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

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12. Pre-commissioning tests

Relay settings and testing are the responsibility of the substation manager or engineer at some utilities. However, in most utilities on the global level, the job responsibility lies with a separate division known by such names as "Protection and Testing, "MRT," or "Equipment and Relay Protection."

12.1 Preparing for pre-commissioning tests

Prior to pre-commissioning tests, the responsible authority should calculate and arrive at appropriate settings for each and every protective relay and arrange to test them accordingly.

12.2 Performing pre-commissioning tests

Perform pre-commissioning tests as recommended by the respective utilities. Additional tests may be performed in agreement with OEM commissioning engineers, such as:

a) core insulation test,
b) LV magnetic balance test,
c) LV magnetizing current test,
d) vector group test,
e) short circuit test,
f) SFRA (Sweep Frequency Response Analysis),
g) capacitance and tan-δ of transformer windings,
h) capacitance and tan-δ of bushings,
i) insulation resistance IR value measurement and PI,
j) ratio test,
k) winding resistance measurement,
l) through fault stability test,
m) REF stability tests.

Note: (1) Carry out all pre-commissioning tests above before energizing and commissioning the transformer. Verify test results with FAT results. (2) SFRA (Sweep Frequency Response Analysis) tests should be carried out. Curves obtained during pre-commissioning tests should be verified with the signature curves of the SFRA test taken during FAT. (3) Ensure testing of the transformer first with AC and next with DC. Otherwise, test results taken at the time of FAT will not tally.

Ensure that all protective relays, circuit breakers, CTs, isolators, and LAs are tested and ready for charging.

Note: In the case of an SPR (Single-Pole Reclosure), breaker pole discrepancy protection should be checked. The recommended setting is 300 ms to 500 ms.

13. OTI and WTI settings

Sample procedure for setting OTI & WTI settings:

- Rated temperature rises of oil and winding are embossed on the R&D plate of each transformer.
- For example, suppose the rated oil temperature rise is 45 °C, and the rated winding temperature rise is 50 °C as printed on the R&D plate of the transformer.

Table 2

Settings of OTI and WTI (Col.1)	Rated winding temperature rise; °C (Col.2)	Ambient temperature; °C (Col.3)	Calculation; (Col.2)+(Col.3). °C (Col.4)	Setting recommended °C (Col.5)
Winding temperature trip	50	45	95	100
Winding temperature alarm	50	45	May be set at	90
Oil temperature alarm	45	45	May be set at	80
Oil temperature trip	45	45	May be set at	90
Fan start				60

Note: If overloading is required on the transformer, it can be done with higher settings of OTI and WTI. Overloading may be planned as per the loading guide IEC 60076-7-2018.

Table 3

	Kraft paper in °C	TUP in °C
Effective insulation thermal class	120	140
Average winding temperature rise	75	90
Winding temperature trip	110	130
Winding-temperature alarm	105	125
Liquid temperature alarm	100	105
Liquid temperature trip	110	115

Trip test to be taken through the master-trip relay or module and ensure tripping of HV and LV breakers simultaneously through simulation of master trip relay or module

Assuming maximum ambient temperature is 45 °C in tropical countries:

Note: If overloading is required on the transformer, it can be done with higher settings of OTI and WTI. Overloading may be planned as per the loading guide IEC 60076-7-2018.

13.1 LTI and WTI settings

At present, many utilities are switching over to biodegradable insulation liquids such as ester fluid (fire point above 300 °C) and other solid insulation materials with better thermal capabilities.

13.1.1 Proposed settings for LTI and WTI for ester fluid-filled transformers with Kraft paper and thermally upgraded paper (TUP) as per IEC 60076-14:2013

a) Effective insulation thermal classes for Kraft paper and TUP have been taken into consideration.
b) The average winding temperature rise is taken as 75 °C for the Kraft paper and 95 °C for TUP (see table C.3 of IEC 60076-14: 2013) [6].
c) Maximum temperature is taken as 40 °C.
d) WT trip setting is aligned to the thermal index, and it is 10 °C lower than the effective insulation thermal class for kraft paper and for TUP.

All alarms should be checked by simulating conditions at each relay:

a) low oil level,
b) Buchholz alarm,
c) oil temperature alarm,
d) WTI alarm.

All other annunciations pertaining to a transformer's external protection are to be checked on the operator's desk for their correctness by manually operating or simulating the respective relays such as differential relay, REF (restricted earth fault) relay, backup O/C and E/F and over-fluxing relay.

Trip test to be taken through the master-trip relay or module and ensure tripping of HV and LV breakers simultaneously through simulation of master trip relay or module.

14. Preparation before energizing the transformer

a) The OEM's personnel should be present at the time of initial energization and should ensure the readiness of the NIFPS system.
b) Release air from all ear-marked points, including bushings, before energizing.
c) Release air from each radiator or bank of radiators.
d) Ensure that connectivity of all tan-δ points and core-frame-tank terminals are earthed properly.
e) Before energizing the transformer, release air from the vent plug of the diverter switch.
f) Check oil parameters after filling the oil prior to charging as per Table 3 of IEC 60422-2013 (see Table 4).

Table 4

Recommended limits for mineral insulating oils after filling in new electrical equipment prior to energization (Refer table 3 of IEC 60422-2013)			
Property	**Highest voltage equipment for kV**		
kV level	< 72,5	72,5 to 170	> 170
Appearance	Clear, free from sediment and suspended matter		
Colour (on scale given in ISO 2049)	Max. 2,0	Max. 2,0	Max. 2,0
Breakdown voltage (kV)	> 55	> 60	> 60
Water content (mg/kg) [a]	20 [b]	<10	< 10
Acidity (mg KOH/g)	Max. 0,03	Max. 0,03	Max. 0,03
Dielectric dissipation factor at 90 °C and 40 Hz to 60 Hz [c]	Max. 0,015	Max. 0,015	Max. 0,015
Resistivity at 90 °C (GΩ×m)	Min. 60	Min. 60	Min. 60
Corrosive sulphur	Non-corrosive		
DBDS content (mg/kg)	<5		
Interfacial tension (mN/m)	Min. 35		Min. 35
Total PCB content (mg/kg)	Not detectable (< 2 mg/kg total)		
Particles	-	-	See Table B.1 [d]
[a] The values are not corrected for temperature since not enough time may have elapsed to reach an equilibrium between oil and cellulose insulation.			
[b] For use in transformers under 72,5 kV class, the maximum water content should be agreed between supplier and user depending upon local circumstances.			
[c] Higher dielectric dissipation factor values may indicate excessive contamination, or the misapplication of solid materials used in manufacture, and should be investigated.			
[d] A determination of particle size and quantity should be made as a baseline for future comparison in transformers > 170 kV.			

a) Check the oil level in the conservator.
b) Check the oil level in the diverter switch.
c) Check the health of protection circuits.
d) Check the Aux DC system.
e) Check the pointers of all gauges for a free moment.
f) Check the Buchholz relay and readjust the float and switches if necessary.
g) Check the health of the air cell by oil levels in the prismatic oil level indicator on the conservator tanks.
h) Ensure removal of all discharge rods from HV, IV/LV bays.

15. Energizing the transformer

i. To be on the safe side, charge the transformer at tap no. 2 in case of the CFVV (Constant Flux Voltage Variation) system type of OLTCs.

Note: In the CFVV, the value of HV voltage shall remain constant. Therefore, the flux shall also remain constant in the core irrespective of the tap position of the LV voltage.

ii) When charging the transformer, first switch on the stuck breaker to the "in" position.
iii) Put the NIFP system in service (on) position.
iv) Energize the transformer and keep it without load for at least 24 hrs.
v) The curve of inrush/charging currents may be captured against time since numerical differential relays are in use.
vi) After switching off the transformer for 24 hours, release air from all earmarked points, including bushings, before applying a load.
vii) Switch the transformer on and apply the load.

16. Routine maintenance

i. Earmark the working area of the transformer's HV and LV bays, including all outdoor equipment with red cloth strips about 1 foot wide.
ii) Every precaution to safeguard people and materials at the site should be taken before and after shutting down the transformer.
iii) Carry out routine maintenance according to the schedule defined by the utility.
iv) Transformers equipped with NIFPS:
   a) After the transformer is switched off, perform the following to facilitate periodic maintenance and testing of protection.
   b) Auto/manual switch of NIFPS to be turned to the "off" position on the control panel in the substation control room.
   c) Lock out the nitrogen injection solenoid valve and the oil drain solenoid valve by properly inserting the respective lock pins in the control cubicle in the switchyard.

Caution: Unless the above actions are not taken, it is possible for the NIPFS to malfunction during transformer tests. Nitrogen could be injected into the transformer, and 10% of the oil drained.

While discharging the switched-off transformer, care should be taken to connect the loose end of the earthing lead to a metallic structure first

While discharging the switched-off transformer, care should be taken to connect the loose end of the earthing lead to a metallic structure. First, scrape paint or rust thoroughly at the earthing point. Then connect the earthing clamp / G-clamp of the discharge-rods to the HV-LV jumpers in order to discharge residual charge at high voltage.

After the HV/EHV transformer is switched off and discharged, as mentioned in the previous item, phase jumpers should be removed first. Next, the neutral jumper should be removed from the transformer bushings.

While normalizing the connections of the transformer, first, the neutral jumper / clamps should be connected. Next, connect phase jumpers to respective bushings.

If bushings leak during operation, shut the transformer down immediately.

a) The bushings should be cleaned with a dry cotton cloth during each shutdown.
b) Special emphasis is to be given to tan-δ and capacitance measurement and monitoring of OIP/RIP bushings and transformer windings as stipulated in IEC 60137 or IEEE Std C57.19.01-2000-2003 if applicable.

Check the oil in the transformer and OLTC for dielectric strength and moisture content. Restore quality if necessary.

a) Check the oil level in the oil cup and ensure air passage is free in the breather. If oil is low, add oil.
b) Check the oil for acidity and sludge as per IS 1866-2017(IEC 60422-2013) in the case of mineral oil.
c) If any inspection cover is opened for inspection or work, it should be refitted with a new gasket or O-ring.
d) Check WTI and OTI pockets and replenish the oil if low.
e) Check all bearings and driving mechanisms and lubricate them on schedule.
f) Check the health and readiness of NIFPS.
g) Check the integrity of HV and LV neutral grounding in their respective earth pits.
h) Check the integrity of all equipment earthing in the transformer bays with the help of a primary injection kit.
i) Check the earthing of the tertiary winding bushing.
j) Earth resistance is to be checked periodically.
k) Infrared scanning of all the bushings, bushing clamps, and jumpers of the HV and LV bays should be carried out monthly or at intervals defined by the utility.
l) Check the cooling fan's functions vis-a-vis temperature settings.
m) Check the air cell in the conservator: it should be inflated.

17. Trip / appearance of alarms

i. Check the transformer thoroughly after any alarms or protection events.
ii. Check the HV/IV/LV bays for equipment damage.
iii. After each tripping of transformers, DGA should be carried out, and the results should be compared with the results of earlier DGA reports.

18. Condition monitoring tests

Condition monitoring for transformers is the process of monitoring the parameters to identify a significant change that could indicate a developing fault.

Table 5. Monitoring tests, their frequency and acceptable values for transformers and reactors [4]

<table>
<tr><th>Sl No.</th><th>Test name</th><th colspan="2">Acceptable values</th><th>Frequency</th></tr>
<tr><td>1</td><td>Insulation Resistance Value of Winding Min.</td><td colspan="2">Unless otherwise recommended by the manufacturer, 500 Mega-Ohm for 66kV and above voltage class</td><td>2 Yearly</td></tr>
<tr><td rowspan="7">2</td><td rowspan="7">Polarisation index (Ratio of IR value at 10 min to 1 min)</td><td>Polarisation index</td><td>Insulation Condition</td><td rowspan="7">SOS</td></tr>
<tr><td>Less than 1</td><td>Dangerous</td></tr>
<tr><td>1.0 - 1.1</td><td>Poor</td></tr>
<tr><td>1.1 - 1.25</td><td>Questionable</td></tr>
<tr><td>1.25 - 2.0</td><td>Fair</td></tr>
<tr><td>2.0 - 4.0</td><td>Good</td></tr>
<tr><td>Above 4.0</td><td>Excellent</td></tr>
<tr><td>3</td><td>Winding Resistance Measurement (Resistance converted to 75 °C)</td><td colspan="2">±5% difference between phases or from factory tests</td><td>SOS</td></tr>
<tr><td>4</td><td>TanDelta for bushing and winding</td><td colspan="2">0.007(Maximum) for bushing
0.005(Maximum) for winding
Note:
(i) Tan delta of bushing should not go beyond 0.005 or should not increase more than 0.001 per annum w.r.t. pre-commisioning values in the temperature range 10 C to 40 C
(ii) Winding tan delta should not go beyond 0.005 or should not increase more than 0.001 per annum</td><td>Yearly (bushing)
4 yearly (winding)</td></tr>
<tr><td>5</td><td>Capacitance for bushing</td><td colspan="2">-5% to +5% variation from factory test results</td><td>Yearly</td></tr>
<tr><td>6</td><td>Capacitance for winding</td><td colspan="2">-5% to +5% variation from factory test results</td><td>4 yearly</td></tr>
<tr><td>7</td><td>Oil parameters of use tank oil</td><td colspan="2">Refer IS:186-2017/IEC 60422</td><td>Yearly</td></tr>
<tr><td>8</td><td>DGA of tank oil and OLTC oil</td><td colspan="2">Refer IEC 60599-2007
Note: refer to Table 6 & 7 for DGA interpretations</td><td>Half-yearly</td></tr>
<tr><td rowspan="7">9</td><td rowspan="7">Sweep frequency response Analysis tests (20 Hz to 5 MHz)</td><td colspan="2">In general, changes of ±3 db (or more) in following frequency range may:</td><td rowspan="7">SOS</td></tr>
<tr><td>Frequency range</td><td>Probable fault (assuming no other failure modes exist)</td></tr>
<tr><td>20 Hz - 10 kHz</td><td>Winding turn - to - short circuit (affected winding shows the greatest changes), Core defects (OC test)</td></tr>
<tr><td>5 kHz - 100 kHz</td><td>Axial winding deformation, Bulk winding movement, contact resistance, Open circuit winding</td></tr>
<tr><td>50 kHz - 1 MHz</td><td>Radial winding deformation</td></tr>
<tr><td>100 kHz - 500 kHz</td><td>Floating shield with local insulation carbonization (detectable response with changes in peaks and valleys)</td></tr>
<tr><td>1 MHz - 5 M Hz</td><td>Winding looseness due to transportation (Difference will be greater for the most affected windings), Floating shield with local insulation carbonization (largest differences in peaks and valleys)</td></tr>
<tr><td rowspan="6">10</td><td rowspan="6">Thermovision scanning</td><td colspan="2">Temperature rise above ambient (°C)/criticality</td><td rowspan="6">Half-yearly</td></tr>
<tr><td>0 - 10</td><td>Minor</td></tr>
<tr><td>11 - 39</td><td>Intermediate</td></tr>
<tr><td>40 - 75</td><td>Serious</td></tr>
<tr><td>>76</td><td>Critical</td></tr>
<tr><td colspan="2">Note: Comparison to be made with similar joints/items of the same transformer and values are to be nearly matching</td></tr>
<tr><td rowspan="5">11</td><td rowspan="5">Furan analysis</td><td colspan="2">For calculation of DP (Degree of Polymerization) using Chendong's formula; DP = Log (2FAL) - 1.51/ -0.0035, where 2FAL in ppm; DP values for estimating remaining paper life</td><td rowspan="5">Every 5 years, after the transformer has served for 20 years</td></tr>
<tr><td>New insulation</td><td>1000 DP to 1400 DP</td></tr>
<tr><td>60 % to 66% life remaining</td><td>500 DP</td></tr>
<tr><td>30% life remaining</td><td>300 DP</td></tr>
<tr><td>0-Life remaining (end of life)</td><td>200 DP</td></tr>
<tr><td>12</td><td>PD (Partial discharge)</td><td colspan="2">Recommeded if there is increase in key gases in DGA analysis</td><td>As a supplementary test after DGA</td></tr>
<tr><td>13</td><td>FDS (Frequency Domain Spectrometry) of bushings and windings</td><td colspan="2">Supplemented by DGA is found to be a good method for condition assessment of bushings and windings. Measurement of C & tanδ over a frequency range of 1mHz to 1kHz.</td><td>As a supplementary test after DGA and C & tanδ test</td></tr>
<tr><td colspan="5">Note: SOS context means "As and when" required</td></tr>
</table>

Table 6. Typical faults in power transformers

Type	Fault	Examples
PD	Partial discharges	•Discharges in gas-filled cavities resulting from incomplete impregnation, high-humidity in paper, Oil super saturation or cavitation, and leading to X-wax formation.
D1	Discharges of low energy	•Sparking or arcing between bad connections of different or floating potential, from shielding rings, toroids, adjacent disks or conductors of winding, broken brazing or closed loops in the core. •Discharges between clamping parts, bushing and tank, high voltage and ground within windings, on tank walls. •Tracking in wooden blocks, glue of insulating beam, winding spacers, Breakdown of oil, selector breaking current
D2	Discharges of high energy	•Flashover, tracking, or arcing or high local energy or with power follow-through •Short circuits between low voltage and ground, connectors, windings, bushings and tank, copper bus and tank, windings and core, in oil duct, turret. Closed loops between two adjacent conductors around the main magnetic flux, insulated bolts of core, metal rings holding core legs
T1	Thermal fault t<300 °C	•Overloading of the transformer in emergency situations •Blocked item restricting oil flow in windings •Stray flux in damping beams of yokes
T2	Thermal fault 300 °C < t< 700 °C	•Defective contacts between bolted connections, gliding contacts, contacts within selector switch (pyrolitic carbon formation), connections from cable and draw-rod of bushings. •Circulating currents between yoke clamps and bolts, clamps and laminations. In ground wiring, defective welds or clamps in magnetic shields. •Abraded insulation between adjacent parallel conductors in windings
T3	Thermal fault t > 700 °C	•Large circulating currents in tank and core •Minor currents in tank walls created by a high uncompensated magnetic field •Shorting links in core steel laminations.

19. Don'ts

1. Do not accept the consignment of the transformer on-site if:
   a) Multiple earthing of the core is found while the transformer is still loaded on the low bed trailer.
   b) Nitrogen pressure is not positive.
   c) If the impact (vibration) recorder shows some abnormalities or if LT tests fail while the transformer is on the low bed trailer.

[Note: Inform the OEM about transformer status immediately.]

2. While tightening or loosening any bolt inside the transformer tank through the inspection windows, ensure that personnel do not place any objects in the upper pockets.
3. Do not use low-capacity hydraulic jacks.
4. Do not forget to tie a cotton tape at

Table 7. Interpretation of DGA through ratios of key gas method

DGA Interpretation Table (refer table 2 of IEC 60599-2007)				
Case	Characteristic Fault	C_2H_2/ C_2H_4	CH_4/ H_2	C_2H_4/ C_2H_6
PD	Partial discharges	N sa	<0.1	<0.2
D1	Discharges of low energy	> 1	0.1 -0.5	> 1
D2	Discharges of high energy	0.6 -2.5	0.1 -1	>2
T1	Thermal fault T < 300 °C	NS	>1 but NS	<1
T2	Thermal fault 300 °C < 1 < 700 °C	<0.1	>1	04-Jan
T3	Thermal fault > 700 °C	<0.2 b	>1	>4
NOTE 1 — In some countries, the ratio C2H2/C2H6 is used, rather than the ratio CH4/H2 . Also in some countries, slightly different ratio limits are used.				
NOTE 2 — The above ratios are significant and should be calculated only if at least one of the gases is at a concentration and a rate of gas increase above typical values.				
NOTE 3 — CH4/H2 <0.2 for partial discharges in instrument transformers. CH4/H2 <0.007 for partial discharges in bushings.				
NOTE 4 — Gas decomposition patters similar to partial discharges have been reported as a result of stray gassing of oil.				
a. NS = Non-significant whatever the value b. An increasing value of the amount of C_2H_2 may indicate that the hot spot temperature is higher than 1000 °C				

one end of the spanner or any other tool. The other end of the cotton tape should be tied to any clamp or hook on the transformer while tightening or loosening any bolt inside the transformer through the Inspection window.

5. Do not store transformer / reactor N2 gas filled at the site for more than 6 months.
6. Do not commission the transformer before conducting all pre-commissioning tests.
7. Do not discard a new transformer.
   If the PI value is found close to 1 as:
   a) The polarization index method should not be used for assessing insulation conditions in new power transformers.
   b) The polarization index for insulation liquid is always close to 1. Therefore, the polarization index for transformers with low conductivity liquids (e.g., new mineral oil) may be low despite good insulation conditions.
8. Do not leave delta tertiary winding terminals unprotected outside the tank. They should be connected to LAs/ surge protection capacitors in conjunction with LAs of appropriate rating.
9. Do not move the transformer with bushings mounted.
10. Do not parallel transformers without confirming that they meet all criteria, such as vector group, terminal voltages, voltage ratios, tap variations of OLTC, and % Z.
11. Do not overload the transformer beyond limits as specified in IS:2026 (Part-7):2009(IEC equivalent IEC 60076-7:2005).

Note:

(a) Relative aging rate: if hot spot temperature exceeds 80 °C to 140 °C, lifetime halves for every 6 °C of temperature rise.

(b) Loading beyond the rated current (in pu) as described on the R&D plate:

i. Cyclic overloading: 1.3 pu keeping in view the WTI settings.

ii. Emergency loading (30 min): 1.5 pu keeping in view the WTI settings.

12. Do not change the alarm and trip settings of WTI or OTI frequently.
13. Do not meddle with protection circuits.
14. Do not allow conservator oil to fall below the 35 °C level.
15. Do not allow the bushing oil level to fall: it must be topped off immediately.
16. Do not leave the marshalling box doors open. They should be locked.
17. Do not switch off the heater in the marshalling box.
18. Do not leave the ladder unlocked.
19. Do not allow any unauthorized persons to loiter near the transformers.
20. Do not mix new mineral oil with existing in a working transformer unless it conforms to IS: 1866-2017 / IEC 60422-2013.
21. Do not mix new ester-fluid with existing in a working transformer unless it conforms to IS: 16099 / IEC 61203.
22. Do not continue with deteriorated silica gel. It should be replaced immediately.
23. Do not energize the transformer without thoroughly investigating and testing the transformer after the appearance of the Buchholz relay alarm or trip indication or tripping on differential protection, REF protection, OSR, or PRV.

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24. Do not energize the transformer without thoroughly testing for its health and without analyzing trapped gas in the Buchholz relay and DGA of the transformer oil.
25. Do not parallel transformers without setting them at appropriate tap positions per operating instructions.
26. Do not connect the transformer on a live busbar unless ensuring that the EHV shunt-capacitor bank is in the 'off' position.
27. Do not leave the cap of the tan-δ measurement point on the bushings open or loose.
28. Do not force oil through the drain valve.

20. Conclusion

This article provides general guidelines which can extend the operational life of transformers. Specific instructions from utilities and OEMs must also be followed.

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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.

S. K. Chaturvedi holds a diploma in Electrical Engineering and bachelor's degree in Technology. He presently works as Assistant Engineer (maintenance) 400 kV S/s Katni, since October 2013 in a 950 MVA, 400/220/132 kV /33 kV AIS he is managing the maintenance and erection / installation jobs independently and successfully of EHV equipment up to 400 kV level. He was felicitated by MD MPPTCL for on spot repairing and installation of EMR make diverter switch on a 24-year-old 160 MVA, 220/132 kV TELK make transformer at 400 kV S/s Katni. He successfully assembled a 400 kV, 125 MVAR bus reactor and all associated equipment for the bay at 400 kV S/s Katni, within minimal time. He obtained ISO 9001-2008 certificate in 2015, for 50-year-old 132/33 kV AIS Kymore, for complete renovation. He successfully performed retrofitting and replacement of 220 kV, 132 kV, 33 kV, 22 old pneumatic circuit breakers / VCBs within minimal time and reconditioning of two 40-year-old 132/33 kV transformers.