INSTRUCTIONS & GUIDELINES FOR PROTECTION AND MAINTENANCE

P&M MANUAL



OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

Head Office- The Mall, Patiala

From the Desk of Director/Technical, PSTCL

"Knowledge has no value
unless put into practice"
Chekhov

This instruction manual on protection and maintenance practices being published by operation services wing of P&M organization deserves praise as this will not only help new Engineers but also serve as guiding light to all the members of PSTCL family. Till date no standard practices or documentation formats on protection and maintenance were available in the PSTCL but after the publication of this manual, all the testing procedures and documentation formats will be standardised in PSTCL as per the requirements of NRPC/NRLDC and various 3rd party protection audits.

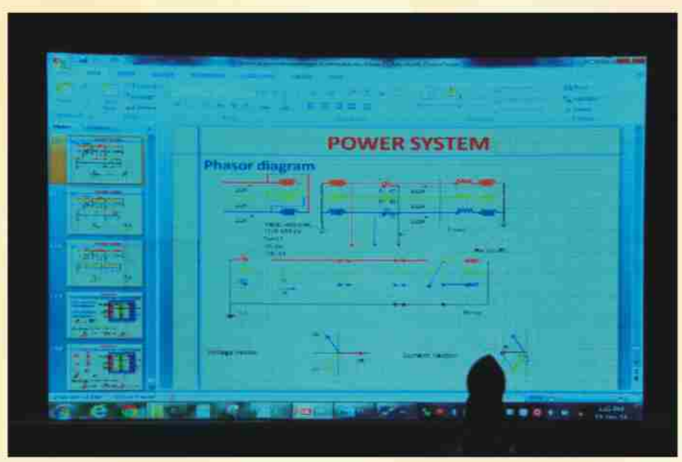
It is sincerely hoped that all these instructions will be followed in true letter and spirit to take PSTCL forward in achieving higher goals.

Dated: 1-08-2016

(Er (Mrs) Shashi Prabha)
Director/Technical
PSTCL, Patiala


pstcl
PUNJAB STATE TRANSMISSION CORPORATION LIMITED
WELCOME
28TH PROTECTION
SUB-COMMITTEE MEETING OF NRPC
HOSTED BY:- PSTCL, LUDHIANA


HVR


POWER SYSTEM
Phasor diagram

INSTRUCTIONS & GUIDELINES ON PREVENTIVE MAINTENANCE & PERIODICAL TESTING SCHEDULE

VOLUME-I

Doc.No.CE/PM/OS/INST-1

OPERATION SERVICES WING (P&M)

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

Head office- The Mall, Patiala





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Sr.No.

PREVENTIVE MAINTENANCE SCHEDULE FOR SUBSTATION EQUIPMENTS

Edition	Date	Department	Signature
First edition-	01-09-16	OS	
1st Revision-			
2nd Revision-			
Prepared by	Er Sukhjinder S. Virk		
AEE	1-4-16	Operation Services	
Reviewed by	Er Rajbir S. Walia		
Adll S.E	29-4-16	Protection & Operation Services	
Recommended by	Er Charanjit Singh Aulakh		
Chief Engineer	5-5-16	P&M	
Approved by			
	23-6-16	BOD's of PSTCL in 37th meeting vide U.O No-1211/BOD/37.21/PSTCL, Dated 8-7-16	

Sl. No.	Activity	Approval	Condition	Periodicity
1.0	TRANSFORMERS AND REACTORS			
1.1	Checking of bushing oil level	SSE	W S/D	M
1.2	Checking of oil level in Conservator	SSE	W S/D	M
1.3	Checking of oil level in OLTC Conservator	SSE	W S/D	M
1.4	Checking of cooler oil pumps and fans			
	a) Manual actuation	SSE	W S/D	M
	b) Auto Starting	SSE	S/D	HY – All S/S's Y -400 KV S/S's
1.5	Checking of oil leaks	SSE	W S/D	M
1.6	Checking condition of Silica gel in breather[10]	SSE	W S/D	M
1.7	Checking of oil level in oil seal of breather	SSE	W S/D	M
1.8	(a) Testing of oil for DGA (Routine sample to be	SSE &	W S/D	HY_1
	(b) other oil parameters[7] (send by SSE/P&M)	ODTL	W S/D	Y
1.9	Measurement of BDV/Tan δ/Sp.R ( ) of OLTC oil	SSE &	S/D	Y
		ODTL		
1.10	Vibration measurements for Shunt Reactors only	ODTL	W S/D	SOS_2
1.11	Tanδ measurement for Bushings (<220 KV/≥220 KV)	ASEP	S/D	$4Y_3/2\ Y_3$
1.12	Tanδ measurement of Windings (<220 KV/≥ 220 KV)	ASEP	S/D	$4Y_4/2\ Y_4$
1.13	IR measurement of Windings(Polarization Index)	ASEPM	S/D	Y_5
1.14	Measurement of Windings resistance at all tap Positions (≥ 220 KV)	ASEP	S/D	$SOS/5\ Y_8$
1.15	Measurement of TTR/ Mag. Balance/Charging current/Winding Resistance	ASEP	S/D	SOS
1.16	Measurement of short circuit Impedance	ASEP	S/D	SOS
1.17	External cleaning of Radiators	SSE	S/D	Y

Sl. No.	Activity	Approval	Condition	Periodicity
1.18	Cleaning of all Bushings (before fog)	SSE	S/D	Y
1.19	Frequency Response Analysis (≥ 220 KV)	ODTL	S/D	PCT/SOS[6]
1.20	Maintenance of OLTC driving mechanism	ASEPM	S/D	Y
1.21	Checking and Cleaning of Diverter Contacts	ASEPM	S/D	5Y or 50,000 operations
1.22	Checking of all remote indication (WTI and Tap position indicator)	SSE	S/D	Y
1.23	Electrical circuit / testing of PRD,Buchholz Relay, OLTC surge Relay, OSR, WTI, OTI etc	ASEP	S/D	HY & Y (for 400 kV)
1.24	Checking/testing of Buchholz relay by oil draining	ASEP & SSE	S/D	2Y
1.25	Marshalling boxes of TRAFO/ICT/Reactor:			
	(a) Cleaning of Marshalling boxes	SSE	S/D	Y
	(b) Tightening of terminations	SSE	S/D	Y
	(c) Checking of contactors, space heaters, illumination etc.	SSE	S/D	Y
	(d) Changing of gaskets	SSE	WS/D	Y
1.26	Checking and calibration of OTI, WTI	SSE	S/D	4Y[11]
1.27	Replacement of oil of OLTC	ASEPM	S/D	SOS
1.28	Filtration/ Degassing of main tank oil	ASEPM	S/D	SOS
1.29	On line moisture measurement (400 KV)	ASEPM	WS/D	HY
1.30	Earth Resistance of transformer Neutral earth pit in summer	ASEP	S/D	2Y
1.31	Thermo-vision Scanning of Transformer & yard	ASEH	WS/D	3M/4M/HY[12]
1.32	Core Insulation Test (if CC,CL&G terminals are accessible)	ASEP	S/D	4Y

1.33	Recovery Voltage/IDA Measurement	ODTL	S/D	PCT/SOS
1.34	On-Line Partial Discharge measurement	ODTL	WS/D	SOS
1.35	Removal of Rust & touch up painting	SSE	S/D	Y
1.36	Testing of Bushing CTs	ASEP	S/D	SOS

NOTE:

1. For 220 KV & above voltage class it is HY but for others it is Y. Frequency of testing can be changed with the advice of ODTL depending on criticality. For newly commissioned or re-commissioned units, DGA shall be carried out (i) before charging (sample to be taken jointly by AEE/P, AEE/Grid & SSE concerned) (ii) after 24 hrs from charging (400 KV Only) (iii) after 7 days (iv) after 15 days (v) after 1 month and then (vi) after 3 months. Then subsequently as per schedule mentioned in ODTL report.
2. Vibration measurement, 3M and 6M after commissioning and then based on abnormality in sound/vibration.
3. Tanδ measurement of bushing first time after one year from commissioning, then within end of warrranty period. Yearly measurement if the value is above 0.006. SSE to monitor test results.
4. First time after one year from commissioning and then once in every four years. To be measured as per all the possible combinations.
5. IR & PI Ratio to be measured as per all the possible combinations
6. Base Signature before commissioning for all ICTs/ Reactors/Power T/F's with capacity ≥ 100 MVA. SFRA should be included as a part of FAT (factory acceptance tests) so as to analyze any deviation in signatures during transportation from factory to site.
7. Water Content, BDV, Sp. Resistance, Tanδ, IFT, Total Acidity, 2-Furfuraldehyde etc.
8. Dynamic switching curve plotting to be recorded for 400 KV rating ICT's. For others-SOS.
9. Corona & thermo vision scanning before foggy season for all 400 KV S/S's by ODTL.
10. Alumina should probably be changed after 3Y or as recommended by manufacturer, whichever is earlier.
11. Pockets on top of cover housing elements of WTI should be checked for oil, 1Y.
12. In case of 400 kV stations (3M), in case of 220 kV stations (4M) & in case of 132 kV stations (6M or HY). Apart from it ODTL will also perform this function along with Corona scanning at 400 kV stations. For other sub-stations corona scanning and thermo-vision scanning will be need based (SOS) so as to diagnose some specific fault.

NOTE:- In case of any doubts regarding the tan delta values, TTR, OLTC analysis, winding resistance matter be referred to ODTL for cross checking of the results as per standard calibrated kits.

Sl. No.	Activity	Approval	Condition	Periodicity
2.0	CIRCUIT BREAKERS			
2.1	BREAKER OPERATION CHECKS			
a	CB Operating Timings (Main, PIR, Aux. Contacts)	ASEP	S/D	Y/2Y/3Y/4Y *
b	Functional checks, duty cycle operation including rapid re-closing (O-0.3s-CO) during Periodical testing	ASEP	S/D	Y/2Y/3Y/4Y *
c	Static Contact Resistance	ASEP	S/D	Y/2Y/3Y/4Y *
d	Dynamic Contact resistance (DCRM), Contact Travel and contact wipe along with injected current and close/ trip coil currents (400 KV CB's)	P Hub	S/D	2Y
e	Checking of Pole Discrepancy relay	SSE	S/D	Y
f	Checking of Anti-Pumping relay	SSE	S/D	Y
g	Checking of all operation lock-outs	SSE	S/D	Y
I	Checking of pressure settings as Applicable	SSE	S/D	Y
j	Cleaning of Breaker Insulator Petticoats	SSE	S/D	Y
2.2	MEASUREMENT/ TESTING			
a	Checking of healthiness of Operation Counter	SSE	S/D	Y
b	Capacitance and tanδ measurement of grading capacitors (400 KV)	P Hub	S/D	4Y***
c	Checking of oil leaks from Grading Capacitors (400KV)	SSE	W S/D	M
2.3	CONTROL CABINET			
a	Checking of tightness of all cable terminations in MB	SSE	S/D	Y
b	Checking of door sealing gaskets and replacement, if necessary	SSE	W S/D	Y

Sl. No.	Activity	Approval	Condition	Periodicity
c	Repainting of metallic surfaces if corroded	SSE	W S/D	SOS
d	Checking of space heater	SSE	W S/D	Y
2.4	**SF6 CIRCUIT BREAKERS**			
a	SF6 gas leakage test	SSE/ODTL	S/D	SOS_1
b	Dew Point measurement of SF6 gas	ODTL	S/D	4Y**
2.4.1	**HYERAULIC OPERATING MECHANISM**			
a	Checking of oil level and topping up/ replenishment, if necessary	SSE	W S/D	M
b	Checking of oil leaks	SSE	W S/D	M
c	Checking of oil pressure drop during duty cycle operation check	SSE	S/D	Y
d	Checking of auto-starting/stopping of oil pump	SSE	S/D	Y
2.4.2	**PNEUMATIC OPERATING MECHANISM**			
a	Functional checking of auto-starting of air compressors and dryers	SSE	S/D	Y
b	Maintenance of Compressor	SSE	S/D	Y
c	Maintenance of Air Dryer, if provided	SSE	W/S/D	HY
d	Checking of air pressure drop during duty cycle operation	SSE	S/D	Y
2.4.3	**SPRING OPERATING MECHANISM**			
a	Lubrication of Chain, Gears	SSE	S/D	Y
b	Checking healthiness and cleaning of Rollers	SSE	S/D	Y
c	Checking healthiness of Springs, application of grease if required	SSE	S/D	Y

Sl. No.	Activity	Approval	Condition	Periodicity
2.5	AIR BLAST CIRCUIT BREAKERS			
a	Air (Pressure) leakage check	SSE	S/D	SOS
b	Dryness of operating air at the outlet of Air Drier	SSE	WS/D	Y
c	Maintenance of Air Compressors	SSE	WS/D	Y
d	Maintenance of Air Dryers as per manufacturers guidelines	SSE	WS/D	Y
e	Regeneration of Air Dryers	SSE	WS/D	SOS
2.6	MINIMUM OIL CIRCUIT BREAKERS			
a	Checking for oil leakage/oil level	SSE	WS/D	M
b	Testing of oil for BDV	SSE	S/D	Y

- * • * First time after one year from the month of commissioning and applicable on all CB's controlling T/F's/Reactors. Periodicity is 1Y for 400 kV, 2Y for 220 kV, 3Y for 132 kV & 4Y for 66 kV
- ** • ** At time of commissioning, then after 6 months and then after one & half years of commissioning and thereafter, once in every four years at 400 KV S/S's.
- *** • First time after one year from commissioning & then 4Y
- Initially it will be checked by SSE/P&M, if required, help of ODTL can be taken to detect leakage.

Sl. No.	Activity	Approval	Condition	Periodicity
3.0	CURRENT TRANSFORMERS & PT'S (AS APPLICABLE)			
3.1	TESTING AND MEASUREMENTS			
a	I R measurement (PI, DAR)	ASEPM	S/D	SOS
b	Measurement of Tanδ & Capacitance	ASEP	S/D	Y*
c	Measurement of CT Sec. resistance	ASEP	S/D	SOS
d	Magnetization Characteristics	ASEP1	S/D	SOS
e	CT ratio test	ASEP	S/D	SOS
f	DGA & other parameters of oil	ASEPM	S/D	SOS**
g	Thermo-vision Scanning of CT and Top dome	ASEH	WS/D	Y
h	N_2 Pressure wherever provision exists	SSE	S/D	2Y
3.0	VISUAL INSPECTION			
a	Checking of Bellow Expansion/oil level	SSE	WS/D	M
b	Visual inspection of CT for oil leakage/ oil level and crack in Insulator etc.	SSE	WS/D	M
c	Checking- oil leakage in Terminal Box	SSE	WS/D	Y
3.3	MARSHALLING BOX			
a	Checking of healthiness of gaskets	SSE	WS/D	Y
b	Checking of space heater/ Illumination	SSE	WS/D	Y
c	Checking the tightness of connections including earthing	SSE	S/D	Y
d	Cleaning of marshalling box and junction box	SSE	S/D	Y

* - Y for TF/ICT/Reactor (capacity ≥ to 50 MVA) controlling CT's. 2Y for <50 MVA capacity of T/F's. Other CT's of ≥132 KV voltage level it will be 4Y. Frequency to be changed depending on the change of Tan delta values-

1. Applicable only till rate of rise in Tan-delta @0.001 up to 0.007
2. 0.007 to 0.010 – Half yearly monitoring or replacement
3. Above 0.010 – Immediate replacement of CT

**- after one month from first charging/re-commissioning as per PSTCL Technical specifications for CTs.

1 To be done by ODTL on request of ASEPM or in case of 400 KV and above CT's

Sl. No.	Activity	Approval	Condition	Periodicity
4.0	CAPACITIVE VOLTAGE TRANSFORMERS			
4.1	VISUAL CHECKS & CLEANING			
a	Visual checking of earthing HF point (in case it is not used for PLCC)	SSE	S/D	Y
b	Checking for any breakage/cracks in cementing joint	SSE	S/D	Y
c	Checking of any breakage/cracks in HF Bushing	SSE	S/D	Y
d	Checking of oil leaks	SSE	WS/D	M
e	Cleaning of CVT capacitor stacks & tightness of terminal connections	SSE	S/D	Y
4.2	TESTING AND MEASUREMENTS			
a	Capacitance and Tanδ measurement	ASEP	S/D	4Y*
b	Measurement of voltage	SSE	WS/D	6 M**
c	Testing of EMU tank oil for BDV (if oil found discolored)	ASEPM	S/D	SOS
d	Thermovision Scanning of Capacitor stacks, terminal connector, tank etc	ASEH	WS/D	HY
4.3	MARSHALLING BOX			
a	Checking of heater & Illumination	SSE	WS/D	Y
b	Checking/tightness of all connections including earth connections	SSE	S/D	Y
c	Cleaning of marshalling & junction boxes	SSE	S/D	Y
d	Checking of healthiness of gaskets	SSE	WS/D	Y

*First time after one year from commissioning and then once in every four years. For CVTs in which isolation of neutral of intermediate PT is not possible at site, this test for bottom stack and complete CVT is not required to be carried out. However, for top/ middle stacks, test is to be conducted in UST mode.

1. change in Tan-delta upto +0.002 (3yearly), +0.002 to 0.003(yearly), above +0.003 (alarming)
2. change in capacitance upto ±2% (3yearly), ±2%to ±3%(yearly), Above±6% (needs replacement)

** If secondary voltage violate norms, voltage measurement interval to be as per CVT replacement norms specified in Doc.No.CE/PM/OS/INST-5

Sl. No.	Activity	Approval	Condition	Periodicity
5.0	ISOLATORS AND EARTH SWITCHES			
5.1	OPERATING MECHANISM			
a	Linkages including transmission gears	SSE	S/D	Y
b	Stopper bolts	SSE	S/D	Y
c	Cleaning of auxiliary switch contacts and greasing with silicon grease	SSE	S/D	Y
d	Lubrication of operating mechanism. hinges, lock joints on levers, Bearings	SSE	S/D	Y
e	Check tightness of all mounting bolts	SSE	W S/D	Y
5.2	ISOLATORS			
a	Cleaning/lubrication of main contacts	SSE	S/D	Y
b	Alignment	SSE	S/D	Y
c	Contact resistance measurement including contact assembly and current transfer assembly	SSE	S/D	4Y
d	Tightness of Bolts, nuts and pins etc.	SSE	S/D	Y
e	Cleaning of support insulators and checking of insulator cracks, if any	SSE	S/D	Y
f	Checking of interlocks (mechanical & electrical)	SSE	S/D	Y
g	Thermovision Scanning	ASEH	W S/D	HY
5.3	EARTH SWTICH			
a	Checking/Alignment of earthing blades	SSE	S/D	Y
b	Cleaning of contacts	SSE	S/D	Y
c	Contact resistance	SSE	S/D	4Y

Sl. No.	Activity	Approval	Condition	Periodicity
d	Operation of earthing switch	SSE	S/D	Y
e	Checking of aluminum/copper flexible conductor	SSE	S/D	Y
f	Checking of earth connections of structure and MOM box	SSE	S/D	Y
5.4	MARSHALLING BOX			
a	Visual check of auxiliary contacts	SSE	S/D	Y
b	Cleaning and tightening of terminals	SSE	S/D	Y
c	Check space heaters & illumination	SSE	W S/D	Y
d	Checking of healthiness of gaskets	SSE	W S/D	Y

Sl. No.	Activity	Approval	Condition	Periodicity
6.0	SURGE ARRESTERS			
a	Checking of leakage current * (Third Harmonic Resistive Current)	ODTL	W S/D	Y
b	Testing of counters	SSE	W S/D	Y
c	Cleaning of L.A. insulator	SSE	S/D	Y
d	Measurement of capacitance and	ASEP	S/D	SOS
	Tanδ of each stack			
e	Measurement of Insulation	SSE	S/D	SOS
	Resistance of each stack			

* Leakage current measurement to be carried out after annual maintenance during which cleaning of insulator will be carried out. THRC for LAs in service upto 150 µA (normal). 150 to 350 µA to be tested for insulation test & if value found very low. If values beyond 350 µA (for gapless type), it is to be removed from service & if beyond 500 µA (for gapped type) it should be removed from service.

Sl. No.	Activity	Approval	Condition	Periodicity
7.0	**BUS-BAR, JUMPERS, CONNECTORS, CLAMPS, STRUCTURES, SWITCHYARD LIGHTING & ILLUMINATION ETC**			
a	Measurement of earth resistance of sub-station	ASEP	W S/D	Y
b	Cleaning of insulators	SSE	S/D	Y
c	Checking of Insulators for cracks	SSE	S/D	Y
d	Thermovision Scanning of conductor joints, Terminal connectors/clamps	ASEH	W S/D	HY
e	Removal of hot spots	ASEH/SSE	WSD/SD	SOS
f	De-weeding of switchyard	SSE	W S/D	SOS
g	Re-painting, rust removal of all structures, equipments etc.	SSE/ASEPM	S/D	SOS
h	Checking of Illumination System (i) healthiness of light fittings (ii) Check lighting panel (iii) tightening of terminals (iv) check output supply after fuse in receptable panel	SSE	W S/D	SOS
8.0	**400 KV FILTER CAPACITOR**			
a	Physical checks like tightness, oil leakages etc.	SSE	S/D	Y
b	Insulation Rresistance values	SSE	S/D	Y
c	Leakage current measurement	SSE	S/D	Y
9.0	**WAVE TRAPS**			
a	Tightness & cleanliness	SSE/COC	S/D	Y
b	General inspection/cleaning of tuning unit	COC	S/D	Y
c	Visual Inspection of LA provided	SSE	S/D	Y
d	Replacement of LA	COC	S/D	SOS

Sl. No.	Activity	Approval	Condition	Periodicity
10.0	PROTECTION SYSTEMS			
10.1	GENERAL			
a	Working of DR/EL & Time Synchronising equipment/GPS clock	SSE	W S/D	M
b	Calibration of panel meters (Indicating/ Recording instruments along with the transducers)	SSE	W S/D	4Y
c	Checking of d.c supply & PT voltages (in service) for relays	SSE	W S/D	Y
	Checking of DC logic circuits for trip and annunciations & timers by simulation	ASEP	S/D	Y
10.2	LINE PROTECTION (as and where applicable) [1]			
10.2.1	DISTANCE TYPE (Numerical) 220 KV & 400 KV Lines #			
a	Reach check for all 4 zones[2]	ASEP	W S/D	2Y
b	Time measurement [3]	ASEP	W S/D	2Y
c	Power swing blocking check	ASEP	W/S D	2Y
d	SOTF	ASEP	W/S D	2Y
e	Level detectors of pps.	ASEP	W/S D	2Y
f	VT Fuse failure check	ASEP	W/S D	2Y
g	Polarization check	ASEP	W/S D	2Y
h	NPS detector check	ASEP	W/S D	2Y
I	Opto-coupler inputs check	ASEP	W/S D	2Y
j	DC supply monitoring checks	ASEP	W/S D	2Y
k	Self diagnostic signals check	ASEP	W/S D	2Y
l	Test for 'a' x 'b' setting for all 3 modes	ASEP	W/S D	2Y
m	Phase sequence check	ASEP	W/S D	2Y
n	WEI check	ASEP	W/S D	2Y
o	Neutral current relay check	ASEP	W/S D	2Y
p	Stability check	ASEP	W/S D	2Y

Sl. No.	Activity	Approval	Condition	Periodicity
q	Fault locator initiation check	ASEP	S/D	Y
10.2.2	PHASE COMPARISON TYPE			
a	DC supply monitoring checks/healthy	ASEP	W/S D	Y
b	Transmitter checks	ASEP	W/S D	Y
c	Receiver checks	ASEP	W/S D	Y
d	Modulation threshold	ASEP	W/S D	Y
e	Reflex test	ASEP	W/S D	Y
f	Comprehensive test	ASEP	W/S D	Y
g	End to end test	ASE/COC& ASEP	W/S D	Y
h	Starters - Non-impulse	ASEP	W/S D	Y
i	Starters - NPS - impulse	ASEP	W/S D	Y
J	Starters - PPS-impulse	ASEP	W/S D	Y
k	Stability check	ASEP	W/S D	Y
l	PSB check	ASEP	W/S D	Y
m	Neutral current relay check	ASEP	W/S D	Y
n	Phase sequence check	ASEP	W/S D	Y

1 Tripping through relays to be checked HY (220 kV & 132 kV) and Y (400 kV) basis. However, pre-commissioning testing of new line or re-commissioning after LILO (for line voltages ≥ 220 kV) falls in the preview of ASEPOS. All relay settings and relay configurations will be provided by OS Wing before commissioning of all EHV transmission elements with voltages (≥132 KV).

For electro-mechanical relays, periodicity time will be 1Y & Line impedance to be measured by ODTL, before charging of EHV lines for accurate settings.

2 -Includes Z1, Z2, Z3 and ZR

3 If dynamic testing of numerical DPR is skipped due to non-availability of 3-Φ kit, even then random testing with 1-Φ kit should be carried in various zones to check the healthiness of tripping circuitry.

Note: The tests listed above W S/D may be carried out without a Line S/D ensuring-

1. Proper isolation of the relay under test.
2. The other Main Protection of the Line is healthy and is in service.

Sl. No.	Activity	Approval	Condition	Periodicity
10.3	AUTO-RECLOSE RELAY	ASEP	S/D	Y[1]
10.4	OVER VOLTAGE PROTECTION	ASEP	S/D	Y
10.5	COMMON TESTS FOR ALL PROTECTIONS (<400 KV/≥400KV)			
a	Trip contacts check	ASEP	S/D	HY/Y
b	Annunciation check	ASEP	S/D	HY/Y
c	Check for carrier send	ASEP	S/D	HY/Y
d	Healthiness of all relays[2]	ASEP	S/D	HY/Y
e	Fault locator initiation check	ASEP	S/D	HY/Y
f	DC logic	ASEP	S/D	HY/Y
10.6	REACTOR PROTECTION (<400 KV/≥400KV)			
a	Reactor back up impedance	ASEP	S/D	HY/Y
b	Carrier send for remote trip	ASEP	S/D	HY/Y
c	Auxiliary relays (Buchholz, PRD, WTI, OTI, SPR etc)	ASEP	S/D	HY/Y
d	Reactor differential protection	ASEP	S/D	HY/Y
e	REF protection	ASEP	S/D	HY/Y
10.7	TRANSFORMER PROTECTION (<400 KV/≥400KV)			
a	Over fluxing relay	ASEP	S/D	HY/Y
b	Over load	ASEP	S/D	HY/Y
c	Directional over current	ASEP	S/D	HY/Y
d	Auxiliary relays (Buchholz, PRD, WTI, OTI, Oil Surge Relay etc)	ASEP	S/D	HY/Y
e	Transformer differential protection	ASEP	S/D	HY/Y
f	Restricted earth fault	ASEP	S/D	HY/Y
10.8	LBB PROTECTION	ASEP	S/D	HY/Y
10.10	BUS BAR PROTECTION			
a	Primary Injection Test	ASEP	S/D	SOS*

Sl. No.	Activity	Approval	Condition	Periodicity
b	Protection stability/sensitivity checks	ASEP/OS	S/D	SOS[3]
c	Bus Bar Protection Relay checking	ASEP	S/D	2Y
	(* to be done whenever the protection & AC circuits are disturbed like addition of new feeder etc)			
10.11	PLCC SYSTEM[3] (Falls in preview of CO&C)	SSE	S/D	SOS
a	LMU composite/ Return loss	SSE	S/D	Y
b	Power supply measurements	SSE	S/D	Y
c	Transmitter checks	SSE	S/D	Y
d	Receiver checks	SSE	S/D	Y
e	Checks for Alarms	SSE	S/D	Y
f	Protection Coupler loop test	SSE	W S/D	Y

NOTE-

1. **Initial Commissioning of AR scheme falls in preview of ASEPOS but routine testing will be done by ASEP**
2. **Relays not specifically mentioned in this document.**
3. **Initial Commissioning of BBPS falls in preview of ASEPOS but routine testing will be done by ASEP. ASEP will extend full cooperation during PCT also.**
4. **Initial Commissioning of Carrier Protection falls in preview of ASEPOS, ASECOC & ASETC but routine E to E & local testing will be done by concerned ASEP in co-ordination with CO&C team**

Sl. No.	Activity	Approval	Condition	Periodicity
11.0	**TELEPHONE EXCHANGE (IF APPLICABLE)**			
a	Maintenance of EPAX as per recommendations of the manufacturer	SSE		
12.0	**AIR CONDITIONING PLANT (AS APPLICABLE)**			
12.1	**COMPRESSORS**			
a	Checking or belt tension.	SSE	S/D	M
b	Leakage checks for refrigerants & oil	SSE	S/D	M
c	Check oil level, top up if required	SSE	S/D	M
d	Checking tightness of flywheel, bolted joints, leakages of oil etc.	SSE	S/D	HY
e	Checking of oil pressure switch. LP/HP, cut-out switches, solenoid valve, thermostat, humidstat etc	SSE	S/D	Y
12.2	**CONDENSER UNIT**			
a	Checking water pressure- inlet/outlet & cleaning of side plates	SSE	S/D	HY
b	Checking for water leaks	SSE	S/D	M
c	Operation of inlet/outlet valve	SSE	S/D	M
d	De-scaling of cooling water circuit	SSE	S/D	SOS
12.3	**WATER TREATMENT PLANT**			
a	Checking Operation of Level switch	SSE	S/D	HY
b	Checking Water quality	SSE	W S/D	HY
c	Cleaning of Soft water tank and regeneration of chemicals	SSE	S/D	M
12.4	**COOLING TOWERS**			
a	Cleaning of nozzles for clogging	SSE	S/D	QY
b	Flow switch performance checking	SSE	S/D	QY
c	Cleaning of sediment	SSE	S/D	M

Sl. No.	Activity	Approval	Condition	Periodicity
12.5	**ELECTRICAL MOTORS**			
a	Lubrication of moving parts	SSE	S/D	QY
b	To tighten terminal connections	SSE	S/D	QY
c	Overhauling	SSE	S/D	SOS
12.6	**LT PANELS**			
a	Cleaning of Bus Bars, Insulators etc.	SSE	S/D	Y
b	Tightness of the connections	SSE	S/D	Y
12.7	**AIR HANDLING UNITS**			
a	Cleaning of suction air filters	SSE	S/D	QY
b	Checking of all interlocks	SSE	S/D	Y
13.0	**PACKAGE AC/ SPLIT AC**			
a	Maintenance as per manufacturer's guidelines	SSE	S/D	Y
b	Leakage check for refrigerant gas	SSE	S/D	Y
c	Healthiness of Stabilizer	SSE	S/D	SOS

Sl. No.	Activity	Approval	Condition	Periodicity
13.0	**BATTERIES AND DC DISTRIBUTION SYSTEM**			
a	Measurement of Specific gravity and voltage of cell, with charger off	SSE	W S/D	M[1]
b	Checking electrolyte level and topping up with DM water, if required	SSE	W S/D	W
c	Checking of Emergency DC lighting in control Room	SSE	W S/D	M
d	Checking of electrical connections of charger panel & DCDB panels for tightness and cleanliness	SSE	S/D	Y
e	Checking of electrical connections for batteries and application of petroleum jelly or spray on cell terminal, if required	SSE	S/D	M
f	Checking control cards of charger & measurement of test point voltage values, wherever applicable.	SSE& ASEPM	S/D	SOS
g	Discharge & Impedance test of battery set (400KV)	ODTL	S/D	3Y[2]
h	Checking of any earth fault (If E/F relay not provided)	SSE	W S/D	M[3]
i	Working of battery charger & testing of DC E/F relay and under voltage relays	ASEP	S/D	HY
j	IR measurement of charger transformer	SSE	W S/D	Y
k	Checking of tightness of VRLA* Battery and dusting/ cleaning	SSE	W S/D	HY
l	Servicing of air conditioners for VRLA batteries	SSE	W S/D	Y

* All other tests as mentioned above are common for VRLA and conventional batteries.

1. Capacity test by loading upto 25% by heaters after switching the battery charger off, should be done at least once in six months by SSE under the supervision of ASEPM.
2. ODTL to perform in following conditions for 220/132 KV S/S's – SOS & PCT.
3. To be attended by SSE & if DC leakage is due to any protective relay, help of ASEP may be taken. ASEPM to ensure fault free DC distribution system.

Sl. No.	Activity	Approval	Condition	Periodicity
14.0	**FIRE PROTECTION SYSTEM** (ASEPM to supervise all the checks)*			
14.1	**COMPRESSOR**			
a	Cleaning/Replacement of Air Filter	SSE	W S/D	M
b	Checking of compressor oil and replace if necessary	SSE	S/D	QY
c	Maintenance & cleaning of compressor valves, gaskets, valve plates and replace, if necessary	SSE	S/D	QY
d	Operation check of low oil level switch	SSE	S/D	QY
e	Cleaning and checking seating of the breather valve	SSE	S/D	QY
f	Cleaning of NRV/HP tank	SSE	S/D	Y
g	General overhaul	SSE	S/D	SOS
h	Checking of V-Belt tightness	SSE	S/D	QY
14.2	**FIRE ALARM SYSTEM**			
a	Detectors			
	i. Sequence test for annunciation in Control Room panel	SSE	W S/D	M
	ii. Smoke test	SSE	W S/D	M
	iii. Cleaning	SSE	W S/D	M
	iv Battery Electrolyte level checking	SSE	W S/D	M
14.3	**DIESEL ENGINE**			
a	Checking auto starting of diesel engine	SSE	W S/D	M
b	Check oil level, top up if required	SSE	W S/D	M

Sl. No.	Activity	Approval	Condition	Periodicity
c	Checking/replacement of fuel oil filter Lube oil filter, Air filter	SSE	S/D	Y
14.4	**MOTORS**			
a	Tightness of terminal connection checking	SSE	S/D	HY
b	Lubrication of Bearings	SSE	S/D	HY
c	Overhauling	SSE	S/D	HY
14.5	**PUMPS**			
a	Checking of operation of hydrant pumps Sump pumps, Jockey pumps.	SSE	W S/D	M
b	Adjustments of glands for leakages and tightening of nuts and bolts	SSE	S/D	HY
c	Checking of alignment of pump set	SSE	S/D	Y
d	Replenishment of grease	SSE	S/D	SOS
e	Overhauling	SSE	S/D	SOS
f	Checking leakage & lubrication of jockey Pump	SSE	S/D	M
14.6	**HYDRANT SYSTEM**			
a	Checking the pressure of hydrant system at remotest end, auto-starting of pumps, diesel engine etc.	SSE	S/D	Y
b	Cleaning of strainer	SSE	S/D	QY
c	Checking the pressure of gauges and to replace the defective ones.	SSE	S/D	Y
14.7	**EMULSIFIRE SYSTEM**			
a	Operation of emulsifire system, to check the outlet pressure 'check' alarm and the starting of diesel/electrical pump.	SSE	S/D	Y
b	Checking the fire detector bulbs, nozzle angle/blocking etc.	SSE	S/D	Y

Sl. No.	Activity	Approval	Condition	Periodicity
14.8	**ELECTRICAL MOTORS**			
a	Cleaning	SSE	S/D	Y
b	Tightening of terminals	SSE	S/D	Y
c	Checking of Gaskets	SSE	W S/D	Y
14.9	**GENERAL**			
a	Greasing of all valves	SSE	W S/D	HY
b	Painting of pipes, air lines, marshaling boxes etc, if required.	SSE	W S/D	Y
14.10	**FIRE EXTINGUISHERS**			
a	Re-filling of Fire Extinguishers	ASEPM	W S/D	SOS

NOTE- NIFPS (Nitrogen injection fire protection system) to be checked by manually blocking its operation-

1. Control dc circuitry to be checked for annunciations from protective relays by ASEP. "HY"
2. Healthiness to be checked by ASEPM with mock operations
3. N_2 pressure to be monitored monthly by SSE.

Sl. No.	Activity	Approval	Condition	Periodicity
15.0	**DIESEL GENERATOR SET**			
15.1	**LUBRICATING SYSTEM**			
a	Check for oil leaks	SSE	W S/D	M
b	Replacement of oil filter after recommended running hours	SSE	W S/D	Y/SOS
15.2	**COOLING SYSTEM**			
a	Checking of radiator air blocking and coolant level	SSE	W S/D	M
b	Check for fan hub, drive pulley and water pump	SSE	W S/D	T
15.3	**AIR INTAKE SYSTEM**			
a	Check for air leaks	SSE	W S/D	M
b	Cleaning of air filters	SSE	W S/D	Y/SOS
c	Replacement of Air cleaning element	SSE	W S/D	Y
15.4	**FUEL SYSTEM**			
a	Check for Governor linkages, fuel transfer pump, fuel line connections	SSE	W S/D	Y
b	Drain Sediments from fuel tank, change fuel filter and clean fuel tank breather	SSE	W S/D	Y
15.5	**MAIN GENERATOR**			
a	Check for air inlet restrictions	SSE	W S/D	M
b	Checking of electrical connections for tightness	SSE	S/D	Y
c	Stator winding IR measurement	SSE	S/D	Y
d	Checking/Cleaning of slip ring and its brushes	SSE	S/D	Y
e	Testing of protection/control relays and alarms	SSE	S/D	2Y
15.6	**EXHAUST**			
a	Checking airleaks and exhaust restriction	SSE	S/D	Y
b	Tight exhaust manifold & turbo charger cap screw	SSE	S/D	Y

Sl. No.	Activity	Approval	Condition	Periodicity
15.7	GENERAL			
a	Battery voltage & specific gravity measurement	SSE	W S/D	M
b	Check for rusting & package casing and rectification	SSE	W S/D	Y
c	Overhauling of DG set as per manufacturer's recommendation	SSE	S/D	SOS

16. MAJOR OVERHAUL & REPLACEMENT OF EQIPMENTS

A. MAJOR MAINTENANCE & OVERHAUL OF

i Circuit Breakers

ii Transformers

iii Reactors

TO BE DONE AFTER STUDYING VARIOUS REPORTS OF OS/ODTL/ PROTECTION & IN CONSULTATION WITH SE/Dy CE/CE/EIC.

TO BE DONE AFTER STUDYING VARIOUS REPORTS OF OS/ODTL/ PROTECTION & CONSULTATION WITH SE/Dy CE/CE/EIC

B REPLACEMENT OF ANY MAJOR EQUIPMENTS DUE TO VIOLATION OF MAINTENANCE TEST RESULTS

C REPAIR OF CTS AND CVTS AT SITE

For newly commissioned CTs/ CVTs, no repair at site to be carried out.

For CTs/ CVTs in service, repair to be carried out in consultation with CE/SE/OS

Sl. No.	Activity	Approval	Condition	Periodicity
17.0	LT SWITCHGEAR, LT TRANSFORMER , LT PANLE ETC.			
17.1	LT PANELS			
a	Cleaning of panels, bus bar insulators etc.	SSE	S/D	Y
b	Relays testing	SSE	S/D	2Y
c	Tightness of all electrical connections	SSE	S/D	Y
d	Checking of Indicating meters	SSE	W S/D	Y
e	Check for change-over facility	SSE	W S/D	Y
f	Check operation/Indications in Off-load condition of Air CB	SSE	W S/D	Y
g	Check spring charging of Air CB	SSE	W S/D	Y
17.2	LT SWITCHGEARS			
a	Functional checking (Trip, close etc.) of 33/11 KV CBs.	SSE	S/D	Y
b	Measurement of Operating timings if provided	SSE	S/D	SOS
c	Cleaning of Insulators and tightness of terminal connections of CB's, CT's, PT's, Isolators etc.	SSE	S/D	Y
d	Alignment checking of Isolators	SSE	S/D	Y
17.3	LT TRANSFORMERS/ TERTIARY TRANSFORMERS			
a	Testing of oil BDV	SSE	W S/D	Y
b	IR measurement	SSE	S/D	2Y
c	Testing/Checking of OTI, WTI and Buchholz or oil surge relay (if provided)	SSE	S/D	Y
d	checking of pressure relief system	SSE	S/D	Y

GENERAL INSTRUCTIONS

18.

1. Sr XEN/ASE/P&M will visit all the sub-stations under their jurisdiction and ensure that maintenance & testing schedule is adhered and will countersign the maintenance sheet or register. (Monthly) 'M'.
2. SE/Dy C.E/P&M will visit all the sub-stations under their jurisdiction and will countersign the maintenance sheet or register to ensure meticulous compliance of instructions issued by BOD's of PSTCL. (Quarterly) 'QY'
3. For implementation of "Report of Task Force on Power System Analysis under contingencies" received by Worthy CMD, PSTCL (STU) vide F No- 11/48/2012-PG, Dated- 9th June 2014 (Ref- DN-397/PS/CMD, Dt- 18-6-14 & DN- 712/D(T), Dt- 23-06-14), ASE/POS will perform all the functions on behalf of C.E/P&M (after approval) like issuing centralized computer aided relay settings for adoption- duly authorized and approved for the field testing in charge, periodic review of settings, shall also perform the root cause analysis of the event and this analysis should address the cause of fault, any mal-operation or non-operation of relays or protection schemes, to ensure that field testing teams adopt the relay settings in the relays at sub-stations as per computer based studies & periodically verify the implemented settings at site through an internal audit process as per formats of protection audit provided in report, etc. No relay setting in the field should be changed without proper documentation and approval by the OS group/department and this OS group shall keep proper records of corrective and improvement actions taken for future study.
4. The copy of the settings issued to field offices shall be returned to OS wing after signing by ASEP & AEEP as a mark of compliance.
5. ASE/POS will also ensure compliance of statutory instructions issued by NRPC/NRLDC/CEA etc. In addition to this co-ordinations/standardization of settings, configurations, functions in whole of state/ STU transmission system be ensured.
6. To ensure timely testing as per schedule by protection or any other testing agency, O&M officers will be equally responsible. In case of any lack of co-ordination, matter should be brought to the notice of next higher authority.
7. ASE incharge of construction wing, whose element is to be charged, will intimate the complete details at least two weeks before & not more than one month earlier about expected date of charging for issuing of coordinate relay settings for the field teams.
8. All the statutory clearances for charging or re-commissioning of elements (≥ 220 kV) to SLDC will be given by ASEPOS after apprising C.E/P&M about any shortcomings or requirements as per CEA/IEGC/SGC standards.

SL. NO.	ABBREVIATION	EXPANSION
1	AC	ALTERNATING CURRENT
2	BDV	BREAK DOWN VOLTAGE
3	B/U	BACK UP
4	CB	CIRCUIT BREAKER
5	CFC	CONVERTER FIRING CONTROL
6	OS	OPERATION SERVICES
7	CT	CURRENT TRANSFORMER
8	CVT	CAPACITIVE VOLTAGE TRANSFORMER
9	DAR	DIELECTRIC ABSORPOTION RATIO
10	DC	DIRECT CURRENT
11	DCCT	DIRECT CURRENT CURRENT TRANSFORMER
12	DCDB	DIRECT CURRENT DISTRIBUTION BOARD
13	DGA	DISSOLVED GAS ANALYSIS
14	DM	DE MINERALISED
15	DR	DISTURBANCE RECORDER
16	EL	EVENT LOGGER
17	EPAX	ELECTRONIC PRIVATE AUTOMATIC EXCHANGE
18	ESDD	EQUIVALENT SALT DEPOSIT DENSITY
19	FL	FAULT LOCATOR
20	HP	HIGH PRESSURE
21	HVDC	HIGH VOLTAGE DIRECT CURRENT
22	HY	HALF YEARLY
23	ICT	INTER CONNECTING TRANSFORMER
24	IFT	INTER FACIAL TENSION
25	IR	INSULATION RESISTANCE
26	KV	KILO VOLT
27	LA	LIGHTNING ARRESTOR
28	LBB	LOCAL BREAKER BACKUP
29	LP	LOW PRESSURE
30	M	MONTHLY
31	MB	MARSHALLING BOX
32	MOM	MOTOR OPERATED MECHANISM
33	MRTP	METALIC RETURN TRANSFER BREAKER
34	MV	MILLI VOLT
35	NPS	NEGATIVE PHASE FEQUENCE
36	NRV	NON RETURN VALVE
37	OLTC	ON LOAD TAP CHANGER
38	FAT	FACTORY ACCEPTANCE TESTS
39	OTI	OIL TEMPERATURE INDICATOR
40	O/L	OVER LOAD

SL. NO.	ABBREVIATION	EXPANSION
41	PD	PARTIAL DISCHARGE
42	PI	POLARIZATION INDEX
43	PIR	PRE INSERTION RESISTOR
44	PLCC	POWER LINE CARRIER COMMUNICATION
45	PPS	POSITIVE PHASE SEQUENCE
46	PRV	PRESSURE RELIEF VALVE
47	PSB	POWER SWING BLOCKING
48	QY	QUARTERLY
49	REF	RESTRICTED EARTH FAULT
50	C.E	CHIEF ENGINEER
51	SCADA	SUPERVISORY CONTROL & DATA AQUISITION
52	SER	SEQUENCE EVENT RECORDER
53	SF6	SULFUR HEXA FLUORDIE
54	SI	STATION INCHARGE
55	SOS	AS AND WHEN REQUIRED
56	SOFT	SWITCH ON TO FAULT
57	SSI	SUBSTATION INCHARGE
58	S/D	SHUT DOWN
59	VH	VALVE HALL
60	VRLA	VALVE REGULATED LEAD ACID
61	VT	VOLTAGE TRANSFORMER
62	W S/D	WITHOUT SHUT DOWN
63	WEI	WEAK END INFEED
64	WTI	WINDING TEMPERATURE INDICATOR
65	Y	YEARLY
66	2Y	TWO YEARLY
67	3Y	THREE YEARLY
68	4 Y	FOUR YEARLY
69	5 Y	FIVE YEARLY
70	6Y	SIX YEARLY
71	10 Y	TEN YEARLY
72	SSE	SENIOR SUB-STATION ENGINEER (MTC. TEAM)
73	ASEPM	ADDL. S.E/P&M (Team)
74	ASEP	ADDL SE/PROTECTION (Team)
75	ASEH	ADDL. S.E/HOTLINE (Team)
76	ODTL	OIL & DIAGNOSTIC TESTING LAB
77	POS	PROTECTION & OPERATION SERVCES (Team)

SL. NO.	ABBREVIATION	EXPANSION
78	SAP	SUB-STATION AUTOMATION & PROTECTION Team
79	HUB	400 KV PROTECTION HUB (Team)
80	CO&C	CARRIER (OP& CONST)
81	LMU	LINE MATCHING UNIT
82	EMU	ELECTRO MAGNETIC UNIT
83	CEA	CENTRAL ELECTRICITY AUTHORITY
84	IEGC	INDIAN ELECTRICITY GRID CODE
85	SGC	STATE GRID CODE
86	STU	STATE TRANSMISSION UTILITY
87	NRPC	NORTHERN REGIONAL POWER COMMITTEE
88	SLDC	STATE LOAD DISPATCH CELL

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

(Punjab Govt. Undertaking, Regd. Office – PSEB Head office, The Mall, Patiala)

Subject:- To assign duties to Engineers incharge of sub-stations (SSE's/SCE's) in PSTCL keeping in view the latest equipment/switchgear installed at sub-stations.

It has been noticed that most of the new officers posted as Sr Sub-station Engineers/shift charge Engineers (SCE's) at 400/220/ 132 KV sub-stations are not aware of their responsibilities and duties. Since a lot has changed in terms of manpower, equipment etc in sub-stations of PSTCL, so it has become important to circulate a set of instructions to sub-station incharge & shift charge engineers for meticulous compliance as given below-

1. Single line diagram of sub-station should be displayed prominently in a sub-station and a diary of all the equipment/ switchgear installed in a sub-station specifying its make, YOM, DOC etc should be maintained.
2. Possible sources of back-feeding in case of emergency should be displayed prominently in a sub-station.
3. SSE/SCE should have knowledge of basic ferruling used in wiring such as for DC, AC, PT's, CT's etc
4. SSE/AEE should personally monitor the maintenance work in a S/S and enter the work done in the EMR's. All EMR's should be properly maintained.
5. Circuit Breakers- If there is any leakage of air or SF_6 gas in a CB prompt action is required on part of SSE/SCE. Trippings should be checked as per instructions already issued by C.E/P&M.
6. Isolators- Where ever they are working electrically, their working should be checked during periodic maintenance shutdown.
7. NIFPES System- Officer should keep a check on pressure of Nitrogen cylinder periodically. They should co-ordinate with protection staff to check the circuitry healthiness.
8. Double Bus arrangement- Officers should keep a check on healthiness of PT selection relays periodically. If required contacts of isolators should be cleaned periodically. No wedging should be done at any cost.
9. Upkeep of batteries- SSE's should keep a check of healthiness of battery bank & battery charger. Battery should be charged at boost mode periodically. Capacity test by loading upto 25% by heaters after switching the battery charger off should be done at least once in six months under the guidance of Sr XEN/ ASE/ P&M.
10. If DC load is more than 10 to 13 Amps, matter should be brought in the notice of Sr XEN/ ASE/ P&M and a second set of Battery & battery charger should be installed as per instructions already conveyed by the office of CE/P&M.
11. SSE/SCE should have full DC circuit distribution layout of sub-station.
12. Number of circuits being fed from switches of DCDB should be as per instructions already issued by CE/P&M.
13. Bus- Bar Differential scheme- Should ensure that it is in circuit and in case of any alarm the

matter should be brought in the notice of controlling officer & protection staff.

14. SSE/SCE should take a round of control room or kiosks (at least once in his shift) frequently and ensure that Green Healthy LED is glowing on all numerical relays and no VT fail block or any other un-wanted alarm LED is glowing on any relay.
15. SSE/SCE should have a brief and working knowledge of protection relays and equipment/ switchgear installed at their sub-stations.
16. Surge Arrestors- SSE/SCE should monitor the healthiness from surge counters & co-ordinate with ODTL for its LCM testing.
17. Oil Sampling-SSE's/AEE's should ensure that oil sampling is done as per IS Standards and guidelines issued by CE/P&M in his presence.
18. Oil sample testing in case of “New/ First” charging and “IN” service power transformers should be done as per guidelines mentioned in oil testing reports.
19. SSE's/AEE's should ensure proper follow up of results and take remedial action as per recommendation in testing reports.
20. SSE's/AEE's should ensure that all periodical testing's by protection teams are done as per schedule and in case of any delay bring that in the notice of his ASE/Sr XEN.
21. Maintenance of sub-station equipments must be done as per maintenance schedule.
22. It should also be ensured that sub-station yard is clean and clear of any debris/ dismantled material. Non-gravel area should not have any wild growth.
23. Front & entrance lobby of a sub-station should present a good aesthetic look with a notice board and plantation etc.
24. Structures should be painted with aluminum/grey paint as per requirement, keeping in view their condition. While carrying out such a activity, purchase/ work order regulations of PSTCL should be adhered. Prevalent lowest rates of other divisions & circles should also be taken into consideration for a similar activity/work.
25. In case of power transformers, replacement of SILICA GEL and condition of AIR CELL are VERY IMPORTANT for the life of a transformer.
26. NCT's (Neutral CT's)- It should be ensured that connections from neutral of power transformer to NCT and then to earth should are cleaned & tightened to avoid mal-operation of REF relays periodically.
27. There is no place for temporary/adhoc-ism in relay circuitry. Proper ferrules for identification should be used in wiring.
28. No joints should be there in wiring. Proper termination with thimbles should be ensured. No twisting is allowed in control circuitry.
29. Copper leads should only be used in CT/PT/DC control circuitry. Single lead should never be used but only stranded type leads should be used in CT/PT/DC control circuitry.
30. CT secondary circuit should be properly closed/ shorted & Proper CT ratios should be displayed on panel. Core used shall be underlined, such as 400-<u>200</u>/0.577-1-1-1 etc
31. SSE's/SCE's should randomly check the D.C healthy, T.C healthy etc and record the same on log sheet/EMR etc

32. A.C & D.C supply should be through different cables. DC emergency light of control room should be from separate cable & point of D.C distribution board. For new works, workmanship of grid construction organization should also be monitored.
33. Cables should be entered in marshalling boxes, panels, equipment through glands of proper sizes. This is also applicable on grid construction teams.
34. Control cables & power cables should be properly laid in cable trenches. There should be no jumbling of power cables in the yard of a sub-station. For new works it should be ensured that before closing the work grid construction teams or distribution offices follow the instructions.
35. Alumina should be replaced in thermo-siphons of power transformers after a fixed time as recommended by manufacturers.
36. SSE's/SCE's should check the working of temperature gauges & auto-working of fans of power transformers and ensure their proper functioning.
37. Oil in pots housing gauge elements on top of power transformer should be checked periodically.
38. After HSU operations of power transformers, matter should be taken with owner of feeders/ lines i.e concerned officer of distribution organization.
39. Proper fault analysis for each tripping should be done. Any mal-operation should be discussed with protection officers and controlling officer.
40. Drawings/ literature of C&R panels, CB's, other equipment installed at a S/S should be available in the room of SSE or in the sub-station library.
41. SSE/SCE should ensure that operators on duty are daily checking the healthiness of time synchronizing equipment. Necessary action must be taken as per requirement to ensure its proper functioning.
42. SSE/SCE should ensure that during remote operation of isolators and circuit breakers, one JE/SSA should watch the operation locally from a safe distance and remain in contact on phone with the person giving the commands at remote end (i.e control room) in the absence of field cameras.
43. In case of double bas bar arrangement, if a bus coupler is open, close command should not be attempted on 89B isolator if 89A is closed or vice-versa. In other words paralleling or shifting of buses should be done through bus-coupler only in online conditions.
44. SSE/SCE should ensure that corona disc/ring on EHV isolators should not be loose in any case and its tightness should be checked during periodic maintenance checks.
45. Results of online water & gas analyser installed on 400 KV ICT's/Reactor's should be downloaded monthly by SSE. If any value exceeds the limits matter should be brought to the notice of ASE/POS or AEE/ODTL for necessary action.

GENERAL INSTRUCTIONS FOR MAINTENANCE PROCEDURES OF SWITCHYARD EQUIPMENT

Volume 2

Doc.No.CE/PM/OS/INST-2

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

LUDHIANA


SIEMENS

MAINTENANCE PROCEDURES FOR SWITCHYARD EQUIPMENTS VOLUME-II (EHV CBS, CTS ETC.)

Edition	Date	Department	Signature
First edition-	01-04-16	OS	
1^{st} Revision-			
2^{nd} Revision-			
Prepared by Er Sukhjinder S. Virk			
AEE	1-4-16	Operation Services	
Reviewed by Er Rajbir S. Walia			
Adll S.E	1-4-16	Protection & Operation Services	
Recommended by Er Charanjit S. Aulakh			
Chief Engineer	5-5-16 P&M		
Approved by			
	23-6-16	BOD's of PSTCL in 37^{th} meeting videU.O No- 1211/ BOD/37.21/PSTCL, Dated 8-7-16	

INDEX

GENERAL INSTRUCTIONS FOR MAINTENANCE OF SWITCHYARD EQUIPMENTS

1.0 Purpose

The equipments shall be inspected at regular intervals in line with general guidelines already circulated vide document no**:** Doc.No.CE/PM/OS/INST-1 or manufacturer's recommendations for such equipments for which guidelines have not been circulated by CE or OS so far.

2.0 General checks/maintenance instructions

i) External cleaning

The insulators of the Breaker/CT/CVT/Isolator shall be cleaned from salt and dirt/dust deposition together with the cleaning of the other insulators in the substation. The time interval for this cleaning shall be based on the polluting atmosphere or the periodicity mentioned in document Doc.No.CE/PM/OS/INST-1(whichever is earlier).

ii Rust Protection

Some parts of the mechanism in the operating mechanism are made of steel and are surface treated against rust. In spite of the good rust protection, minor corrosion will occur after some years, especially when the breaker / isolator is standing in strong corrosive surroundings. The rust stains shall be sand papered away and new rust protection shall be painted or sprayed on. As rust protection, grease G or Tectyl 506 is recommended.

iii) Tightness check

The breakers are provided with density monitor switches (temperature compensated pressure gauges). Every density monitor switch, is provided with an alarm contact which gives an electrical signal if abnormal leakage takes place. All the bolted joints on the breaker and operating mechanism shall be tightened up. All the wiring joints in the terminal blocks of the operating mechanism shall be re-tightened at regular interval as per Doc.No.CE/PM/OS/INST-1. SF6 gas leakage is to be detected using suitable gas leak detector available in each circle. In case matter remains un-resolved, it may be referred to ODTL for detection using a camera.

iv) Lubrication

For lubrication, the lubricants recommended as given below shall primarily be used. The bearings of the breaker and operating mechanism of isolator and breaker are to be lubricated with grease G

v) Treatment of gaskets and sealing surfaces

Whenever any gasketted part is opened, all the gaskets shall always be replaced by new ones.

General

Sealing surfaces and O-rings shall be sparsely greased to accomplish a better sealing against this surface and at the same time protecting it against corrosion.

Material for de-greasing and cleaning: Tricloroethane

Material for greasing of O-ring: Grease- G

Material for greasing of O-ring and nitrate rubber in moving sealings: Grease- G

Material for removal of contact glue: Acetone

Material for rust protection of untreated or phosphatised steel: valvoline Tectyl 506

vi) Treatment of contact surfaces

The contacts of breaker/isolator/ground switch shall be treated as per the the following directions-

Silvered contact surfaces : Silvered contact surfaces shall be cleaned, if necessary, with a soft cloth and solvent (trichloroethane). Steel brushing or grinding is not allowed.

Copper surfaces : Copper surfaces shall be clean and oxide free. If necessary, they shall be cleaned with cloth and solvent (Trichloro-ethane) or steel brushing- After steel brushing, the surface shall always be cleaned from loose particles and dust.

Aluminium surfaces : Aluminium contact surfaces shall be cleaned with steel brush or emery cloth. Directly afterwards the surface is thoroughly cleaned from particles and dust with a dry cloth. After this, a thin layer of vaseline is applied. This shall be done within 5 minutes after the cleaning. The joint shall be assembled within 15 minutes.

Moving contact surfaces

Silvered : Cleaned if necessary, with soft cloth and solvent (tri-chloro ethane). No steel brushing is allowed.

Lubrication : Lubricant - Grease K is applied in a very thin layer on the surfaces of the male contact and the puffer cylinder. The superfluous grease is carefully removed.

vii) Emptying and re-filling of gas

The breaker is evacuated by means of the gas treatment equipment that purifies and compresses the gas, so that it can be re-used. For economic and ecological reasons,

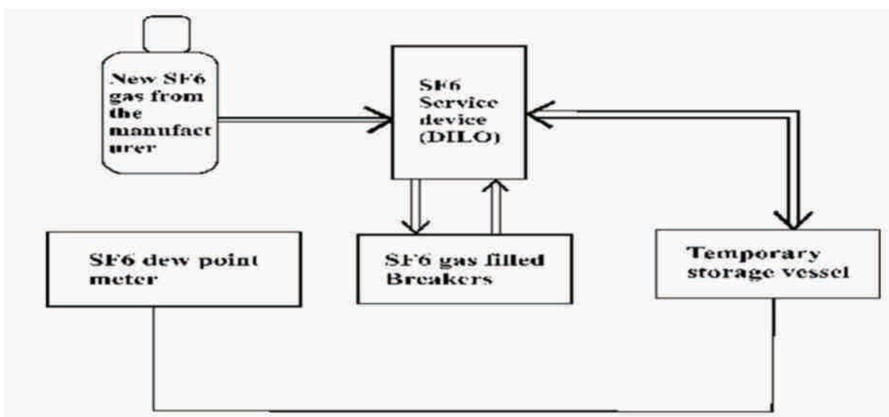
SF_6 contained in electrical equipments, should not be vented into atmosphere. Prior to the removal, the quality of gas should be verified. The gas from the equipment is temporarily stored in a suitable vessel having following features:

Material of vessel/container should be such that it resists the potentially corrosive effects of SF_6 decomposition. (2) Oil free (3) Gas storage is in liquid or gaseous phase (4) Removal of gas from CB upto 50 mbar (5) Transportable and easy to handle

Operational contamination should be absorbed with suitable filter unit provided in the gas handling plant. Such filters/ sieves should already be installed into the SF_6 gas maintenance/handling unit. Filters must meet the following requirements:

1. Transportable and easy to handle
2. Dust particles must safely be filtered
3. Molecular filters remove humidity and SF6 decomposition products
4. Desiccative in easily exchangeable cartridges for safe and trouble free disposal

Inputs and outputs should be equipped with self-closing couplings in order to avoid a saturation of the desiccative by ambient air.



Block diagram of SF6 gas handling plant

When SF_6 is suctioned from a gas compartment, the gas is passed automatically hrough filters which dry and purify the gas.

Filling of re-generated SF6 gas in the equipment

Service devices have to be used to enable the maintenance personnel to fill generated SF_6 from the storage tanks in SF_6-switchgears. The following criterions, should be granted by such a device:

1. Gas tightness & free from Oil
2. Filling pressure which can be pre- set by pressure reducer
3. Easy handling and mobility

Evacuation of SF6 gas Circuit Breakers

After maintenance/overhaul of the Circuit Breaker, it should be evacuated by vacuum pump before filling the SF_6 gas so that SF_6 gas does not mix with ambient air and also humidity and dust particles are removed from the Circuit Breaker. With vacuum pump, a final vacuum of less than 5 mbar must be reached.

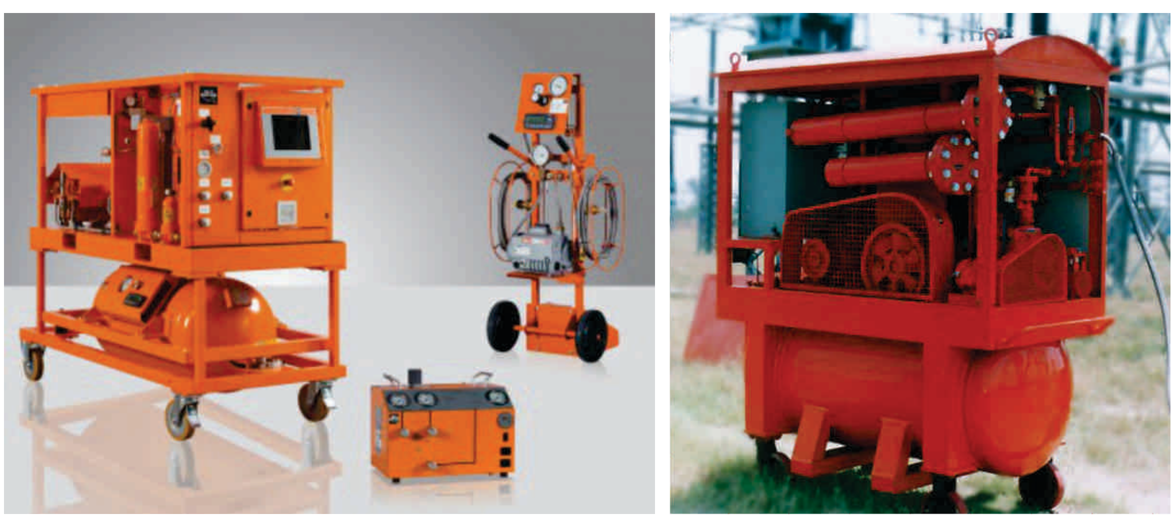
Tools for General Maintenance:

The tools required for general maintenance as well as overhauling of breaker/ isolator/ground switch etc. as follows :

Tools:

1. A normal tool kit with torque wrenches (10-300 Nm).
2. Lifting equipment and slings.
3. Special tools as prescribed in the overhaul instructions of the breaker

Gas treatment equipment for evacuating, cleaning, compression and storage of used SF_6 gas together with instruments for pressure and vacuum monitoing-



Gas Handling Plant

TAN DELTA & CAPACITANCE MEASUREMENT

1. **TEST NAME-** Capacitance and Tan delta measurement for:

1. Current Transformers (CTs)
2. CB Voltage Grading Capacitors
3. Capacitive Voltage Transformers (CVTs)

PURPOSE

2. To measure dissipation factor/loss factor (Tan delta) and Capacitance measurement of EHV class CTs, CVTs and Voltage Grading Capacitors by applying test voltages upto 10kV. The purpose of the dissipation factor measurement of high voltage insulation is to detect incipient weaknesses in HV insulation. The most important benefit gained from this measurement is to obtain a "bench-mark reference reading" on costly and high voltage equipment when the equipment is new and insulation is clean, dry and free from impurities. Later readings taken during service can be compared with the "benchmark reference".

3. **DEFINITION- Dissipation Factor**

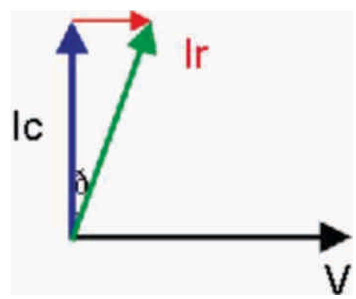
Dissipation factor/loss factor (Tan delta)is defined as the ratio of resistive component (Ir) of current to that of capacitive current (Ic) flowing in an insulating material.

Power Factor

Power factor is the ratio of resistive current to that of total current. For very low value of resistive currents, values of dissipation factor and power factor are same (upto 2%).

Tan delta = Ir / Ic

Capacitance C = åA/d, where å=permittivity, A=Area and d = distance between Capacitance electrode/terminals



High Voltage Terminal- The terminal to be connected to the power line

UST MODE

Test set connected for ungrounded specimen test mode is used when specimen is isolated from earth e.g transformer bushing, CTs with test tap, CVTs and CB voltage grading capacitors. The test mode is used to reduce the effect of stray capacitance losses to ground and to reduce the effect of interference from energized apparatus.

GST MODE

Test set connected for grounded specimen test mode is used when specimen does not have the specific point of isolation from the ground fort tan delta measurement e.g Transformer/Reactor winding, CTs without test tap etc.

GSTg- This test is used to separate the total values of a GST test into separate parts for better analysis. Often this test is used with GST test to confirm the test readings made using the UST mode.

4. ABBREVIATIONS

SFT	:	SANCTION FOR TEST
PTW	:	PERMIT TO WORK
EHV	:	EXTRA HIGH VOLTAGE
HF TERMINAL	:	HIGH FREQUENCY TERMINAL
AC	:	ALTERNATING CURRENT
UST	:	UNGROUNDED SPECIMEN TEST MODE
GST	:	GROUNDED SPECIMEN TEST MODE
PSI	:	PSTCL SAFETY INSTRUCTIONS

5. TESTING SCHEDULE AND FREQUENCY

As per Maintenance Schedule Doc. No: Doc.No.CE/PM/OS/INST-1

6. TEST EQUIPMENT

10 kV Capacitance and Tan Delta test set having normal and reverse mode of operation as well as Interference Suppression Units.

7. ISOLATION REQUIRED

CT's

a) Open jumper from HV terminal of CT (not provided with test tap) and line CTs.

b) Test tap of CT should be disconnected from ground.

Circuit Breakers

a) CB should be in open condition with isolators on both the sides should also be in open condition.

CVT's

a) Open jumper from HV terminal of line/bus CVTs.

b) Remove earth connection/earth from neutral point/bushing of EMU tank.

8. SAFETY INSTRUCTIONS

As per Safety Manual of PSTCL.

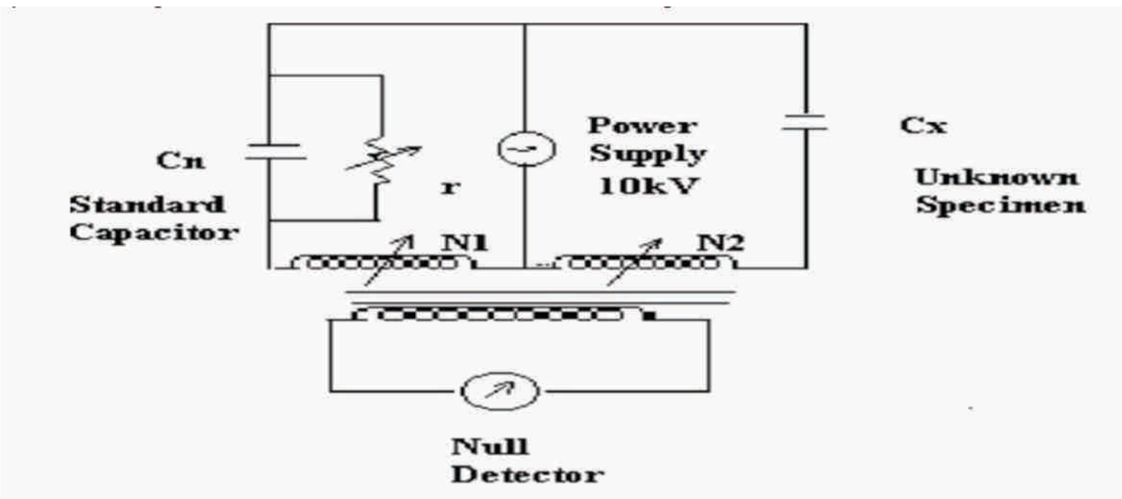
9. PRECAUTIONS

1. Ensure that SFT/PTW is taken as per norms.
2. There should be no joints in testing cables.
3. HV lead should be double shielded / screened.
4. Both the shields should not get shorted, otherwise tests in GST/GSTg modes, shall not be possible. Check the same by Insulation Tester(100V)
5. Test leads should not touch any live part.
6. Never connect the test set to energised equipment .
7. The ground cable must be connected first and removed at last
8. High voltage plugs should be free from moisture during installation and operation.
9. It should be ensured that whole testing equipment alongwith Operation Manual of the kit testing procedures are available at testing site. Testing must be carried out in presence of authorized testing personnel only.
10. After testing with high voltage (10 kV), test terminals must be grounded before being touched by any personnel.

NOTE: Before carrying out the measurement, the insulator petticoats of CTs/CVTs/ Grading Capacitor should be cleaned from moisture, sand, dust particles or salt deposition etc. Otherwise measured values obtained will not be accurate. Test tap of CTs/ Earth connection of CVTs should be re-connected to ground after the test.

10. MAINTENANCE/TESTING PROCEDURE:

Typical arrangement for Tan delta measurement is given below:



Typical Sketch of Tan Delta
Merasurement Kit

A) CURRENT TRANSFORMERS

a) CTs with test taps:

i) Tan delta tap should be disconnected from ground.

ii) High voltage lead from tan delta kit should be connected to primary (HV) terminal and LV lead should be connected to the tan delta test tap.

iii) Before applying HV, interference is to be nullified using Interference suppression unit (ISU).

iv) Measurements have to be taken in UST– Mode.

v) Standard procedure(as specified by kit supplier) for measuring Capacitance and tan delta in charged switchyard/induced voltage conditions should be followed for measurement of Capacitance and Tan delta values.

vi) Measurement to be carried out at 2kV and then at 10kV.

b) CTs without test tap:

i) Jumpers are to be opened before carrying out measurements.

ii) High voltage lead from tan delta kit should be connected to primary (HV) terminal and LV lead should be connected to the CT tank/ground/earth.

iii) Before applying HV, interferrence is to be nullified using Interferrence suppression unit (ISU).

iv) Measurements have to be taken in GST–Mode.

v) Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/ induced voltage conditions should be followed.

vi) Measurement to be carried out at 2kV and then at 10kV.

vii) All secondary terminals should be isolated and earthed in case of SF_6 filled CT's

B) CB VOLTAGE GRADING CAPACITOR

i) Connect LV cable to the middle of the double interrupter. Connect HV cable to the other end of the Grading capacitor to be tested.

ii) The opposite end of the grading capacitor has to be grounded using earth switch. Before applying HV, interference is to be nullified using Interference suppression unit (ISU).

iii) Measurements have to be taken in UST Mode only.

iv) Disconnect the HV cable and connect the same to the other grading capacitor and ground the previous grading capacitor.

v) Now the second grading capacitor is ready for testing.

vi) Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/induced voltage conditions should be followed.

vii) Measurements are to be carried out at 10 kV.

C) CAPACITOR VOLTAGE TRANSFORMES

Testing Procedure for Top and Middle Stacks:

1. i) Apply 10 kV between flanges of Top/Middle stacks (whichever is being tested).
   ii) Carry out measurements in UST mode at 10 kV.
2. Testing Procedure for Bottom Stack connected to EMU PT.
   i) Connect HV of the test kit at the top flange of bottom stack and LV of the test kit to the EMU Tank/Ground.
   ii) HF point is to be grounded.
   iii) Earth connection of neutral of the PT to be opened/isolated from ground.
   iv) Top of CVT to be guarded.
   v) Carry out measurements in GSTg mode at 10.0 kV.
   vi) Repeat the test with neutral of PT connected to ground. In case tan delta value is negative or irratic, only capacitance values are to be monitored.
3. Standard procedure (as specified by kit supplier) for measuring capacitance and tan delta in charged switchyard/ induced voltage conditions should be followed.
4. Carry out the measurements as per recommendations of the manufacturer.

11. EVALUATION OF TEST RESULTS

(A) Factors affecting the Measurement

Significance of Temperature

Insulation measurements have to be interpreted based on the temperature of the specimen. The dielectric losses of most insulations increase with temperature. Rise in temperature causes a rise in dielectric loss which in turn causes a further rise in
temperature etc.

The change in tan delta value with reference to temperature depends on moisture content in paper insulation. The moisture content in insulation depends on moisture absorption and also ageing pattern of the equipment. Hence, rate of change of tan delta with rreference to temperature even for a particular make/type shall be different. Hence, no standard temperature correction factors can be used for practical purpose.

Significance of Humidity

The exposed surface of the CT/CVT insulators, bushings under adverse humidity conditions, acquire a deposit of surface moisture which can have a significant effect on surface losses and consequently on the results. Dielectric strength of insulation decreases with increase in moisture content. Surface leakage errors can be minimized if dissipation factor measurements are made under conditions where the weather is clear and sunny and where the relative humidity does not exceed 80%.

Surface Leakage

Any leakage over the insulation surfaces of the specimen will be added to the losses in the insulation and may give false impression of the condition of the test specimen. Surfaces of insulators should be clean and dry when making a measurement. CTs provided with power factor test tap, the effect of leakage current over the surface of porcelain bushings may be eliminated by measuring in UST mode.

Electrostatic Interference

When tests are conducted in energised sub-stations, the readings may be influenced by electrostatic interference currents resulting from the capacitive coupling between energised lines and the specimen. Jumpers connected need to be opened while carrying out the measurement in GST and GSTg modes to avoid effect of high interference. In EHV Substation, the effect of electrostatic interference currents can also be cancelled by using the interference suppression circuit. Measurements are to be taken in Normal and Reverse polarity to cancel any residual interference currents.

Negative Tan delta

In isolated case, negative tan delta values are recorded in measurement of dielectric specimen of low capacitance. This condition arises when making UST and GSTg measurements on specimen which have capacitance of a few hundred pico-farads such as bushings, circuit breaker grading capacitors etc. Sometimes tan delta of CVTs may give negative values. This may be due to the tan delta value of the EMU transformer winding being higher.

(B) Interpretation of test results

Main reason for increase of tan delta value is because of presence of inherent air voids which are created during manufacturing process. During application of high voltage, these voids are ionized which result in deterioration of insulating properties of the insulation. Increase in the value of tan delta will indicate the following conditions-

i) Chemical deterioration due to age and high temperature, including certain cases of acute deterioration caused by localized overheating.

ii) Contamination by water, carbon deposits, bad oil, dirt and other chemicals.

iii) Severe leakage through cracks and surfaces

iv) Ionization.

Adverse effect of moisture in Paper insulation

Dielectric strength of insulation decreases with increase in moisture content. And also, moisture in cellulosic insulation can lead to bubble formation under high load conditions. Moisture accelerates the ageing of paper insulation. If moisture content in paper nsulation increases from 1% to about 2%, it will lead to increase in ageing of the insulation by almost two times.

At high temperature, moisture is pushed out of the paper insulation into the oil. As insulation cools down, water begins to migrate slowly from the oil into the paper. The time for the temperature drop in the oil may be much quicker than the water can return to the cellulosic insulation. Hence depending upon these conditions, dissipation factor also changes.

Monitoring of dissipation factor/capacitance value

A large number of equipment insulation failures can be anticipated in advance by carrying out testing of Tan delta/dissipation factor and capacitance measurement. Changes in the value of capacitance, indicate abnormal conditions such as presence of moisture, layer short circuits or open circuits in the capacitor elements of CVT stacks.

An increase in only tan delta value (not appreciable change in capacitance value) indicates deterioration of cellulosic insulation whereas increase in both tan delta and capacitance values indicates entry of moisture in the insulation.

Effect of ambient temperature

If tan delta measurement is carried out at ambient other than 20ºC, then it is likely that the values may vary since tandelta values are temperature sensitive. In absence of temperature correction factors, effort should be made to carry out this measurement at 20 to 40°C. Correction factors in circulation by manufacturer's may not be applicable for all make/types of equipments and hence may not be applied. However, it is must to record the ambient temperature while carrying out the measurement for future references.

Effect of system frequency

Tan delta values are also affected by system frequency since capacitive current is directly proportional to system frequency. If tandelta kit is not provided with device which produces output voltage of constant frequency, then it is essential to record the system frequency at the time of carrying out these tests.

12. MANPOWER REQUIRED

ASSISTANT ENGINEER -1

JUNIOR ENGINEER -1

SSA -1

13. Duration of Testing :

Two hours per specimen (Average)

14. FORMATS

As per Doc.No.CE/PM/OS/INST-3

INSULATION RESISTANCE MEASUREMENT FOR EHV CLASS CURRENT TRANSFORMERS

1. EQUIPMENT AND TEST NAME

Insulation Resistance measurement for EHV class Current Transformers.

2. PURPOSE

IR measurement of 400, 220, 132 kV Current Transformer between HV (Primary) Winding and Test tap (for CTs having test taps) and between HV and Earth (for CTs not having test taps), Sec to Sec terminals & secondary terminals to E.

3. DEFINITION

Insulation Resistance: is defined as ratio of applied voltage (DC) to total leakage current (capacitive, absorption and conduction currents).

4. ABBREVIATIONS

PSI	:	PSTCL SAFETY INSTRUCTION
SFT	:	SANCTION FOR TEST
PTW	:	PERMIT TO WORK
EHV	:	EXTRA HIGH VOLTAGE
HF TERMINAL AC	:	HIGH FREQUENCY TERMINAL
AC	:	ALTERNATING CURRENT

5. TESTING SCHEDULE AND FREQUENCY

As per Maintenance Schedule Doc. No: Doc.No.CE/PM/OS/INST-1

6. TEST EQUIPMENT

5 kV Megger and associated accessories like test leads etc.

7. ISOLATION REQUIRED

i) CB should be in open position.Isolators from both sides of CT should be in open position.

ii) Earth switch should be open at the time of IR measurement.

8. SAFETY REFERENCE

As per Safety Rules of PSTCL.

9. PRECAUTIONS

i) Ensure that SFT/PTW is taken as per norms.

ii) There should be no joints in testing cables.

iii) Test leads should not touch any live part.

iv) Megger body should be earthed (if separate terminal is provided).

v) Surface/terminals should be cleaned.

vi) IR measurement should be carried out preferably in dry and sunny weather.

i) Never connect the test set to energised equipment.

ii) The ground terminal must be connected first and removed at last.

iii) High voltage plugs should be free from moisture during installation and operation.

iv) If oil traces are found on the surface of CT, the same should be cleaned by Methyl alcohol only.

v) Petrol or diesel should never be used.

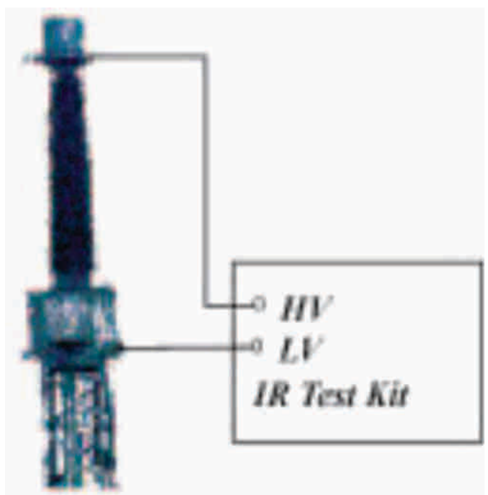
vi) It should be ensured that whole testing equipment alongwith testing procedures are available at testing site.

vii) Testing must be carried out in presence of testing engineer only.

viii) After testing with high voltage, test terminals must be grounded before being touched by any personnel.

10. MAINTENANCE/TESTING PROCEDURE

Connect the Megger as per figure given below. Connect the HV terminal to the primary terminal of CT by using crocodile clip for firm grip.



Carry out the measurement as per standard procedure given by the kit supplier. Note down the values as per format in Doc. No: Doc.No.CE/PM/OS/INST-2

A test voltage as specified is applied as per the above connections and successive readings are taken. Values of IR should be recorded after 15 seconds, 60 seconds and 600 seconds. Ambient temperature and weather conditions are to be recorded.

11. EVALUATION OF TEST RESULTS

Changes in the normal IR value of CT indicate abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of CT and degradation of insulation. Changes in IR value of CT are also based on the weather conditions. It is advised to carry out IR measurement during sunny & dry weather preferably. Insulation Resistance changes with deterioration in insulating properties. Absolute value of IR is important to monitor but the rate of change is equally important.

Analysis of IR values

If readings of IR increase with time, the insulation is good but if readings remain same over the time span, insulation is contaminated. This is due to the fact that charging current and absorption currents subside with time and only conduction current remains. This indicates that total current taken by insulation changes with time. However, if there is no appreciable change in the total current drawn by the insulation, it is an indication of domination of conduction current over charging and absorption currents. The different currents involved in IR measurement are given below:

a) Charging Current

Due to the application of Voltage to a Capacitance, it gets charged to the applied voltage. The length of time it would take to charge the capacitance would vary according to the magnitude of the capacitance and the resistance of the voltage source.

b) Dielectric Absorption Current

When capacitor is insulated with material other than vacuum or air, the current that flows when a direct voltage is applied is no longer the charging current alone. The additional current is known as dielectric absorption current. This current is due to the presence of polar molecules in the insulation system.

c) Conduction current

When a direct voltage is applied to a capacitor, the steady state value of the current is known as the conduction current. This is if one waits until the dielectric absorption current has decayed to zero, the remaining current is the conduction current. Conduction current is directly affected by temperature, humidity, contaminants and voltage stress. In solid insulating materials which have absorbed moisture, there will be a non-linear large increase of the conduction current for increase in the voltage stress. This is known as the EVERSHED affect.

1. Dielectric absorption ratio $= \dfrac{\text{IR value after 60 seconds}}{\text{IR value after 15 seconds}}$

2. Polarisation Index $= \dfrac{\text{IR value after 600 seconds}}{\text{IR value after 60 seconds}}$

If Dielectric Absorption Ratio is above 1.5 then insulation quality is assumed to be good.

If Polarisation Index is more than 1.3 then also insulation quality is assumed to be good.

12. MANPOWER REQUIRED

JE - 1

SSA - 1

13. DURATION OF TESTING

TWO HOURS FOR A SET OF CT (AVERAGE)

14. FORMATS

As per DOC. NO : Doc.No.CE/PM/OS/INST-3

DEW POINT MEASUREMENT OF SF_6 GAS / OPERATING AIR

1. EQUIPMENT AND TEST NAME

Dew Point measurements of SF6 gas/operating Air for Cbs.

2. PURPOSE

To measure Dew point of SF6 gas & Air for 400/220/132/66 kV CB's.

3. DEFINITION

Dew Point:

Dew Point is the temperature at which moisture content in SF6 gas/air starts condensing.

Dew Point at rated pressure of CB:

Dew Point when measured keeping regulating valve in service at the outlet of dew point kit to allow required flow rate of gas/air, is called at rated pressure of CB.

Dew Point at atmospheric pressure :

Dew Point when measured by regulating the gas flow at the inlet of dew point kit and keeping outlet regulating valve (if provided) in fully open condition so that flow rate of gas/air is maintained as required, is called at atmospheric pressure.

4. ABBREVIATIONS

PSI	:	PSTCL SAFETY INSTRUCTION
PTW	:	PERMIT TO WORK
AC	:	ALTERNATING CURRENT

5. TESTING SCHEDULE AND FREQUENCY

As per Maintenance Schedule Doc. No: Doc.No.CE/PM/OS/INST-1

6. TEST EQUIPMENT

Dew Point kit and associated accessories.

7. ISOLATION REQUIRED

CB should be in open condition.

8. SAFETY REFERENCE

As per PSI of PSTCL.

9. PRECAUTIONS

i) Ensure that PTW is taken as per norms.

ii) Pipe should be of PTFE (Teflon) or having stainless steel tubing (as per IEC 61634/60480).

iii) All the joints/connectors should be dust and moisture free. If required, same should be cleaned by clean cloth. Dry the joints and pipe by dry air.

10. MAINTENANCE/TESTING PROCEDURE

i) Make the connections to the kit from CB pole ensuring that regulating valve is fully closed at the time of connections of the Dew Point kit

ii) By regulating the flow rate of SF_6 gas (0.2 liter/min to 0.5 liter/min-Ref. IEC 60480),the value of dew point is observed till it becomes stable.

(iii) If the regulating valve is provided at outlet of the dew point kit then values as given for rated pressures are to be monitored.

Typical Arrangement for Dew Point Measurement

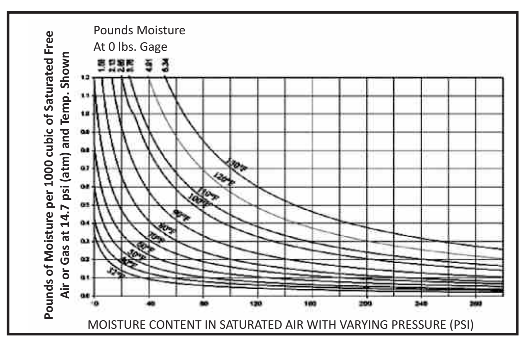
11. EVALUATION OF TEST RESULTS

Dew point Measurement of SF6 Gas in CBs:

Measurement of Dew Point of SF6 gas is an adequate parameter for condition monitoring SF6 gas in a CB. Dew Point measurement of SF6 gas in a CB indicates the change in the value of dielectric properties of SF6 gas. The dielectric properties of SF6 gas do get changed with time due to mixing of impurities like moisture, decomposition products of SF6 gas i.e Hydro Fluorides, lower valence Sulfur Fluorides, etc.

a) Exudation of moisture contained during manufacturing from insulation materials used in Circuit Breakers.

Sf_6 gas



Relation between dew point & moisture content

b) Permeation of moisture through sealed sections i.e. gaskets, 'O'-Rings etc.

During arc interruption in CB's, decomposition of SF6 gas takes place, which in presence of moisture, may result in deterioration of organic Insulating materials inside the interrupting chamber and also corrosion of metals due to formation of hydro fluorides. Therefore, in order to avoid dielectric failure of CBs, monitoring of moisture content in SF6 gas is very important. Chemical reactions under moisture conditions are given below:

When moisture density is low

$SF_4 + H_2O = SOF_2 + 2HF$

$SOF_2 + H_2O = SO_2 + 2HF$

When moisture density is high

$SF_4 + 3H_2O = H_2SO_3 + 4HF$

$2SF_2 + 3H_2O = H_2SO_3 + 4HF$

Sulfur Oxyfluorides, Hydrogen fluoride and H_2SO_4 formed in these reactions vigorously attack all materials containing Silicon di-oxide. Primary and secondary decomposition products in presence of moisture forms corrosive electrolytes which may cause damage and operational failures.

Powder Deposits

The solid deposit is composed of CuF produced from metal and metal scrap. The Sulfur Fluorides are electrical insulation material, featuring sublimation hydration and hydrolysis reaction. Powder deposits are observed after the discharging process, however, if temperature is raised to the sublimation temperature of CuF_2, then powder deposits are formed directly in the form of solid body from gas.

CuF_2 (Milky white) + $2H_2O = CuF_2.2H_2O$ (Blue)

Frequency of Dew point measurement

Moisture from the organic Insulating material is discharged at faster rate initially and the rate of release is almost negligible after 4-5 years of commissioning and moisture entry is only through permeation. In the first year, about 50% of moisture is released and in another 4 years, 90% moisture is released. The frequency of dew point measurement is as given below:

First at the time of commissioning

After six months

After one year

Once every two years

Monitoring of Dew point values

Dew Point of SF6 gas varies with pressure at which measurement is being carried out. This is due to the fact that Saturation Vapour Pressure decreases with increase in Pressure of the SF6 gas. Hence, dew point of SF6 gas at higher pressure is lower than dew point at atmospheric pressure. Therefore, it is to be ensured that if measurement has been done at a pressure other than the atmospheric pressure, same is to be converted to the atmospheric pressure as given in the table below for various CB manufacturers: Method for converting dew point at different gas pressures, is given/described in IEC-60480.

Sl. No.	Make of CB	Dew point at rated pressure	Dew point at Atmospheric pressure (limits)	Remarks
1.	BHEL	- 15° C	- 36° C	At the time of commissioning
		- 7° C	- 29 ° C	During O&M
		- 5° C	- 27 °C	Critical
2.	M & G		- 39° C	At the time of commissioning
		-	- 32° C	During O&M
3.	CGL	- 15° C	- 35° C	At the time of commissioning
		- 10° C	- 31° C	During O&M
4.	ABB	- 15° C	- 35° C	At the time of commissioning
		- 5° C	- 26° C	During O&M
5.	NGEF	- 15° C	- 36° C	At the time of commissioning
		- 7° C	- 29° C	During O&M
		- 5° C	- 27° C	Critical
6.	For all make of Cbs	-15° C	(-) 35°C	To be followed for substations having ambient temperature less than zero degree centigrade

Dew point Measurement of Air in ABCB's

Measurement of Dew Point of air in ABCB's indicates the moisture content in the air being used as insulating and arc quenching medium in these breakers. The arc quenching/ dielectric properties of dry air do get changed with aging of CB and quality of air deteriorates as moist air travels to the interrupting of circuit breaker. This will result in deterioration of internal insulation which could possibly lead to unsuccessful arc quenching due to poor dielectric strength of interrupting medium. It is , therefore, necessary to carry out measurement of Dew Point of air in ABCB's. The permissible limits of dew point of air in ABCBs are prescribed

12. MANPOWER REQUIRED

AEE - 1

SSA/JE - 1

13 DURATION OF TESTING

TWO HOURS PER CB (AVERAGE)

14. FORMATS

Doc.No.CE/PM/OS/INST-3

MEASUREMENT OF CIRCUIT BREAKER OPERATING TIMINGS INCLUDING PREINSERTION TIMINGS

1. EQUIPMENT AND TEST NAME

Measurement of Circuit Breaker operating Timings including Pre-insertion Timings.

2. PURPOSE

To measure Operating timings of Circuit Breakers.

3. ABBREVIATIONS

PSI	:	PSTCL SAFETY INSTRUCTION
SFT	:	SANCTION FOR TEST
PTW	:	PERMIT TO WORK
EHV	:	EXTRAHIGH VOLTAGE
C	:	CLOSING OF CIRCUIT BREAKER
C-O	:	CLOSE - OPEN OPERATION OF CIRCUIT BREAKER
O-C-O	:	OPEN - CLOSE OPEN - OPERATION OF CIRCUIT BREAKER

4. TESTING SCHEDULE AND FREQUENCY

As per Maintenance Schedule Doc. No: Doc.No.CE/PM/OS/INST-1

5. Circuit Breaker Operational Analyser or timer and associated accessories.

6. ISOLATION REQUIRED

a) Isolators on both sides of CB should be in open position.

b) Earth switch should be in closed position.

7. SAFETY REFERENCE

As per PSTCL Safety Rules

8. PRECUATION

a) Ensure that SFT/PTW is taken as per norms.

b) There should not be any joints in testing cables.

c) Test leads should not touch any live part.

d) Never connect the test set to energised equipment.

e. The ground cable must be connected first and removed at last & High voltage plugs should be free from moisture during installation and operation.

f. Circuit Breaker Analyser body should be earthed (if separate earth is provided).

g. It should be ensured that whole testing equipment alongwith testing procedures are available at testing site.

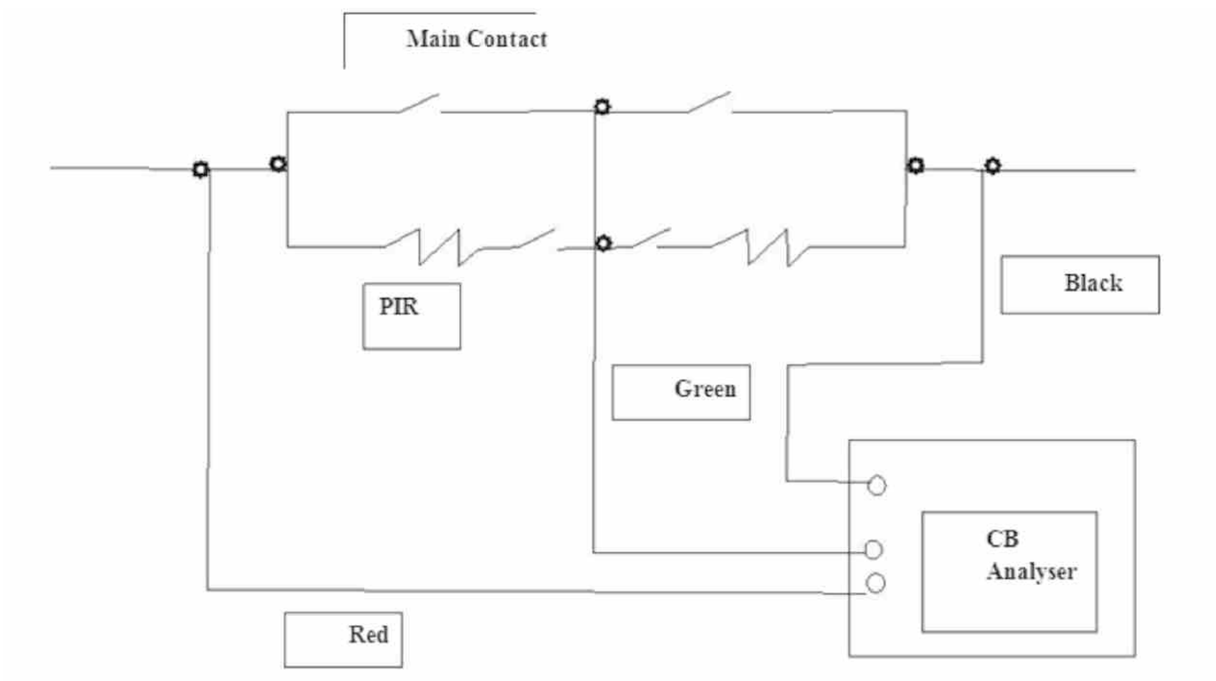
h. Testing must be carried out in presence of testing personnel only.

i. Surface/terminals where the connections are to be made should be cleaned.

j. Clean earth point with sand paper/wire brush where earth terminal is to be provided.

k. Ensure that all the poles trip simultaneously through single close/trip command.

9. MAINTENANCE/TESTING PROCEDURE



Typical Arrangement for 400 kV Operating Timings Measurement of CB

i) Make connections as shown in the figure.

ii) It is to be ensured that R, Y and B phase marking cables are connected at a proper place in the CB analyser and colour codes are to be maintained for all the three poles of CB.

iii) Make connections for recording operating timings of auxiliary contacts.

iv) Extend power supply to Circuit BreakerAnalyzer.

v) Give closing command to closing coil of CB and note down the PIR and main contact closing time. Take the print out from the analyser.

vi) Give tripping command to trip coil-I of CB and note down the main contact tripping time.

vii) Give tripping command to trip coil-II of CB & note the main contact closing time.

viii) Note down the timings for 'CO', and 'OCO' by giving respective commands.

ix) CO command to be given without time delay but 300ms time delay to be given between O and CO operation in testing for OCO.

x) To find out opening time of PIR contacts, PIR assembly has to be electrically solated from Main contacts and then PIR contacts are to be connected to separate digital channels of the Analyzer.

10 EVALUATION OF TEST RESULTS

A) CLOSING TIMINGS

Closing timings and Discrepancy in operating times of PIR and main contacts should not exceed the permissible limits as specified by company. In case, main contacts should not close prior to closing of PIR contacts and PIR contacts should not open prior to closing of main contacts.

In case, contact bouncing is observed in operating timings for PIR and main contacts, same should be rectified by tightening the cable connections.

B) TRIPPING TIMINGS

Trip time and pole discrepancy in operating timings should not exceed beyond permissible values prescribed. In case of ABB, NGEF and CGL make CBs, while tripping, PIR contacts should not open after opening of main contacts.

C) 'CO' TIMINGS

CO timings should be within permissible limits as specified by different anufacturers If operating timings of CB poles are not within limits, same may be corrected by:

i) Equalizing the SF_6 gas pressure in all the poles

ii) Adjusting plunger movement of trip/ close coils

iii) Adjustment in operating mechanism

iv) Changing of trip/close coils (if required)

v) It is also important to measure timings of auxiliary contacts from the point of view of variations w.r.t. the main contacts.

11. MANPOWER REQUIRED

AEE - 1

SSA/JE - 1

12. DURATION OF TESTING

Two Hours Per CB (Average)

13. FORMATS

Doc.No.CE/PM/OS/INST-3

MEASUREMENT OF SECONDARY WINDING RESISTANCE OF CT'S

1. EQUIPMENT AND TEST NAME

Measurement of Secondary Winding Resistance for EHV Current Transformers.

2. PURPOSE

To measure secondary winding resistance of 400/220/132/66 kV Current Transformers.

3. DEFINITION

Secondary DC winding resistance of CT.

4. ABBREVIATIONS

PSI	:	PSTCL SAFETY INSTRUCTION
SFT	:	SANCTION FOR TEST
PTW	:	PERMIT TO WORK
EHV	:	EXTRAHIGH VOLTAGE
AC	:	ALTERNATING CURRENT

5. TESTING SCHEDULE AND FREQUENCY

As per Maintenance Schedule Doc.No.CE/PM/OS/INST-1

6. TEST EQUIPMENT

Current source and volt meter or winding resistance meter with appropriate leads.

7. REQUIRED.ISOLATION

CB should be in open position.

Isolators from both sides of CT should be in open position.

8. SAFETY REFERENCE

As per PSTCL Safety Rules.

9. PRECAUTIONS

i) Ensure that SFT/PTW is taken as per norms.

ii) There should be no joint in testing leads/cables.

iii) It should be ensured that all testing equipment along with testing procedures are available at testing site.

iv) Testing must be carried out in presence of testing personnel only.

v) Test links should be opened in the CT MB prior to measurement of secondary resistance.

vi) It should be ensured that associated CTs are not in charged condition. For example- Main and Tie CT's for differential relays should not be in charged condition.

vii) If any earth is provided in the secondary circuit of CT, same is to be removed prior to measurement

10. MAINTENANCE/TESTING PROCEDURE

Connect leads of OHM meter between different terminals of CT secondary cores. Select the range of OHM meter as per pre-commissioning/factory test results. Record the values in the format as per Doc.No.CE/PM/OS/INST-3.

11. EVALUATION OF TEST RESULTS

Value of secondary winding resistance should be within acceptable limits. Extreme low value of resistance indicates turn to turn shorting whereas if the value is high, it indicates some loose connection which is to be identified and tightened before repeating the measurement.

12. MANPOWER REQUIRED

AEE	-	1
JE/SSA	-	1

13. DURATION OF TESTING

One Hour Per CT (Average)

14. FORMATS

As per Doc.No.CE/PM/OS/INST-3

MAGNETIZATION CHARACTERISTICS OF CT'S

1. **EQUIPMENT AND TEST NAME**

   To carry out Magnetization Characteristics of CT cores for EHV class current transformers.

2. **PURPOSE**

   To carry out Magnetization Characteristics of CT cores for 400/220/132/66 kV Current Transformers.

3. **DEFINITION of KNEE POINT VOLTAGE**

   Knee Point Voltage is defined as the voltage at which a 10 % increase in flux density would cause 50% increase in exciting ampere-turns.

4. **ABBREVIATIONS**

   PSI : PSTCL SAFETY INSTRUCTION

   SFT : SANCTION FOR TEST

   PTW : PERMIT TO WORK

   EHV : EXTRAHIGH VOLTAGE

   AC : ALTERNATING VOLTAGE

5. **TESTING SCHEDULE AND FREQUENCY**

   As per Maintenance Schedule Doc. No: Doc.No.CE/PM/OS/INST-1

6. **TEST EQUIPMENT**

   Voltage source of 5 kV, Voltmeter of range 0 to 5 kV, Ammeter, of range 0 to 100 Amps, testing leads/cables etc OR CT analyser.

7. **ISOLATION REQUIRED**

   CB should be in open position.

   Isolators from both sides of CT should be in open position.

8. **SAFETY REFERENCE**

   As per PSI of Safety Rule Hand Book of PSTCL.

9. **PRECAUTIONS**

   a. Ensure that SFT/PTW is taken as per norms.

   b. There should be no joints in testing leads/cables.

   c. Test links should be opened in the CT MB prior to measurement.

   d. It should be ensured that all testing equipment along with testing procedures are available at testing site.

   e. Testing must be carried out in presence of testing personnel only.

   f. If any earth is provided in the secondary circuit of CT, same is to be removed prior to measurement.

g. It should be ensured that associated CT's are not in charged condition. For example, Main and Tie CT's for differential relays should not be in charged condition.

h. Applied voltage to the CT core should not exceed the rated Knee Point voltage of the CT.

10. MAINTENANCE/TESTING PROCEDURE

After making proper connections, applied voltage is increased from zero to rated knee point voltage in steps of 25%, 50%, 75% and 100%. Measure the current drawn by the CT secondary core at respective applied voltages and record the test results as per formats given in Doc.No.CE/PM/OS/INST-3

11. EVALUATION OF TEST RESULTS

The magnetization test is conducted in order to see the condition of turns of CT secondary.This test gives indication regarding shorting of turns of CT secondary winding. Magnetization characteristics also indicate the suitability of CT for keeping it in service or not.

Knee Point Voltage is normally defined as the voltage at which 10% increase in the applied voltage causes 30 to 50% increase in secondary current. The magnetization current at rated Knee Point Voltage should not be more than the specified/ designed value.

A curve can be drawn between applied voltage and magnetizing current. From the magnetisation curve, it can be implied that up to rated KPV (Knee Point Voltage), the VI curve should be almost a straight line. However, if this line is not linear, this indicates that the magnetizing characteristics are not desirable. If the slope of the curve starts increasing, it indicates that magnetizing induction becomes low and total primary current is utilized in exciting the core alone. Consequently, out put of CT secondary disappears.

12. MANPOWER REQUIRED

AEE - 1

JE - 2

13. DURATION OF TESTING

Two Hours

14. FORMATS

As per Doc.No.CE/PM/OS/INST-3

STANDARD FORMAT is given for CT Analyser by M/s Omicron

MEASUREMENT OF STATIC CONTACT RESISTANCE OF EHV CB'S

1. **EQUIPMENT AND TEST NAME**

   Measurement of Static contact resistance of EHV CB main contacts and isolator main contacts.

2. **PURPOSE**

   To Measure Contact Resistance of 400/220/132/66 kV Circuit Breaker and Isolator Main Contacts.

3. **ABBREVIATIONS**

   PSI : PSTCL SAFETY INSTRUCTION

   SFT : SANCTION FOR TEST

   PTW : PERMIT TO WORK

   EHV : EXTRAHIGH VOLTAGE

   AC : ALTERNATING CURRENT

4. **TESTING SCHEDULE AND FREQUENCY**

   As per Maintenance Schedule Doc.No.CE/PM/OS/INST-1

5. **TEST EQUIPMENT**

   Contact resistance kit (100A DC minimum)

6. **ISOLATION REQUIRED**

   CB should be in open position.

   Isolator on either side of CB should be in open position.

   Earth switch of both side of the CB should be in closed position.

7. **SAFETY REFERENCE**

   As per PSI of Safety Rules of PSTCL.

8. **PRECAUTIONS**

   a. Ensure that proper SFT/PTW is taken as per norms.

   b. There should be no joints in testing leads/cables.

   c. It should be ensured that whole testing equipment along with testing procedures are available at testing site.

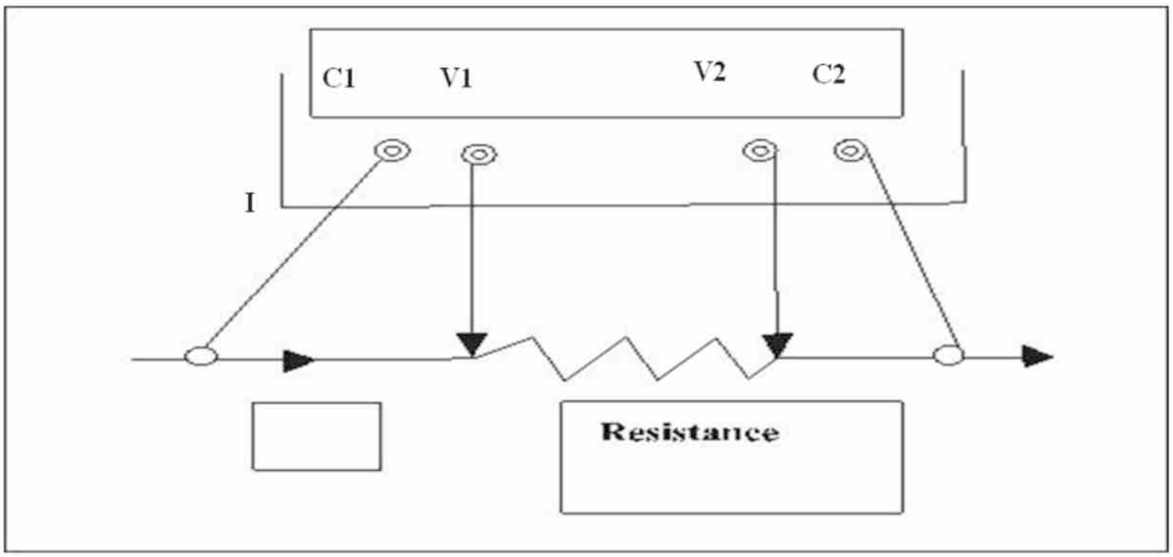
   d. Testing must be carried out in presence of testing personnel only.

   e. At the time of connections, both sides of isolator should be earthed by closing earth switches or by temporary earths. After the connections, earthings should be removed.

9. MAINTENANCE/TESTING PROCEDURE

The measurement is taken at CB in closed position. The Ohm Meter operates on the four wire measurement principle. To measure the contact resistance connect the respective leads and adjust the terminals. So that applied 100 amps current flow through the contacts. Value of contact resistance is directly displayed on the digital LED display screen.

By using four terminal method, we can nullify the resistance of test leads if input impedance of measuring device (IC) is very high.



Four Terminal method of Contact Resistance Measurement

10. EVALUATION OF TEST RESULTS

Contact resistance of the main contacts indicates their wear out and misalignment. If the value of contact resistance exceeds the permissible limit i.e. 150 micro ohms for CBs and 300 micro ohm for Isolators (Ref. Doc.No.CE/PM/OS/INST-5). This could result in overheating of the contacts. Therefore, the problem of high contact resistance should be attended immediately by making proper alignment of contacts or by replacing finger contacts.

11 MANPOWER REQUIRED

AEE - 1

JE - 1

12. DURATION OF TESTING

One Hour

13. FORMATS

As per Doc.No.CE/PM/OS/INST-1.

DYNAMIC CONTACT RESISTANCE MEASUREMENT (DCRM) & CONTACT TRAVEL MEASUREMENT OF CB'S

1. EQUIPMENT AND TEST NAME

Measurement of Dynamic Contact Resistance (DCRM) and contact travel of EHV CB's

2. PURPOSE

To monitor condition of CB main and arcing contacts without opening the interrupter hence decision regarding major/final overhauling/inspection of main/arcing contacts may be taken.=

3. ABBREVIATIONS

PSI	:	PSTCL SAFETY INSTRUCTION
SFT	:	SANCTION FOR TEST
PTW	:	PERMIT TO WORK
EHV	:	EXTRAHIGH VOLTAGE
AC	:	ALTERNATING CURRENT

4. TESTING SCHEDULE AND FREQUENCY

As per Maintenance Schedule Doc.No.CE/PM/OS/INST-1

5. TEST EQUIPMENT

100Amp. DCRM kit with CB operational analyzer with 10k Hz sampling frequency.

6. ISOLATION REQUIRED

a) CB should be in open position.
b) Isolator of both sides of CB should be in open position.
c) Earth switch of one side of CB should be in open position.

7. SAFETY REFERENCE

As per PSI of Safety Rules of PSTCL.

8. PRECAUTIONS

a. Ensure that proper SFT/PTW is taken as per norms.
b. There should be no joints in testing leads/cables.
c. It should be ensured that whole testing equipment along with testing procedures are available at testing site.
d. Testing must be carried out in presence of testing personnel only.
e. Current leads should be connected such that voltage leads are not outside area of current flow.

9. MAINTENANCE/TESTING PROCEDURE

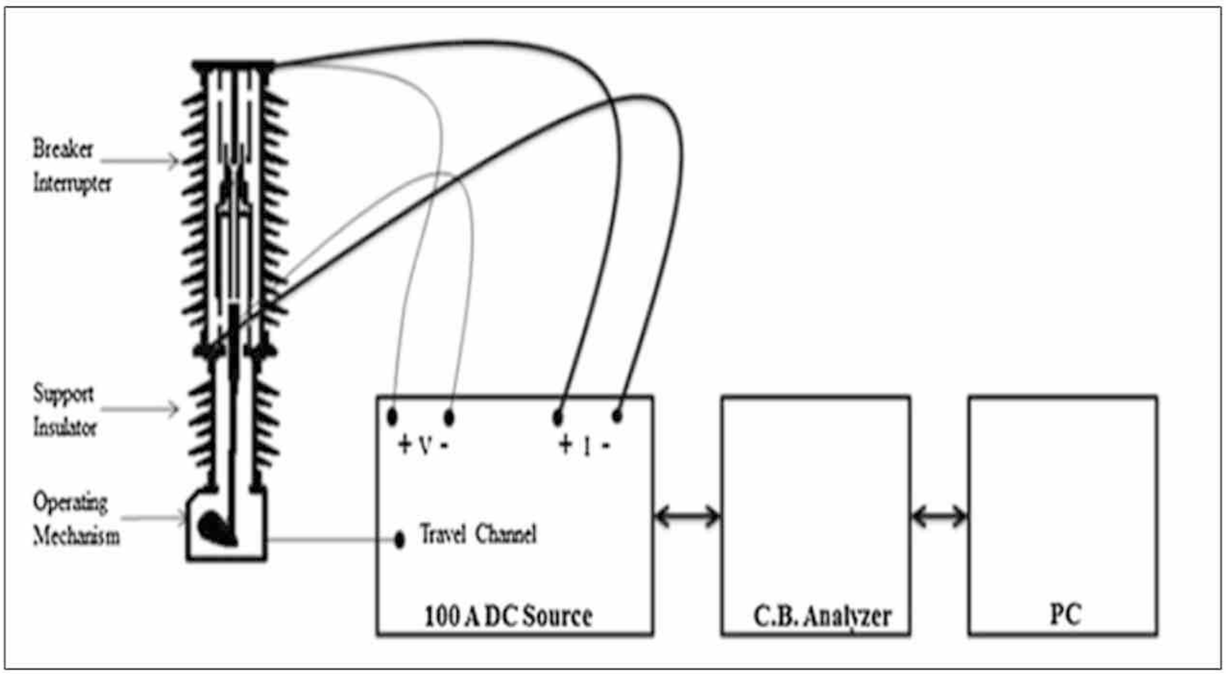
a. Follow the standard procedure as given in instruction manual of DCRM kit.
b. The tightness of connections at CB flanges is most important to ensure error free measurement.
c. CB during CO operation generates lot of vibrations and failure of connections during this period can dramatically change the dynamic signature of CB resistance.

d. DCRM signatures should be recorded for CO operation. Open command should be extended after 300 ms from the close command.

e. Clean portions of incoming and outgoing flanges of CB with polish paper to remove paint, oxidation etc, at points where Current clamps are mounted.

f. Select this point of connection, as close as possible to the end of porcelain insulator to ensure that minimum resistance is offered by flanges, bolts, terminal connectors etc. It should be ensured that Travel Transducers are properly fitted.

g. Sampling frequency during measurement should be 10 KHz.



Basic Connection for DCRM Testing

10. EVALUATION OF TEST RESULTS

Dynamic Contact Resistance Measurement (DCRM) is the technique for measuring Contact Resistance during operation (Close/Trip) of a Circuit Breaker. A DC current is injected through the circuit breaker. The current and voltage drop are measured and resistance is calculated. The resistance versus time data provides useful information on the condition of the circuit breaker contacts as is used as a diagnostic tool.

The variations in the measured resistance versus time will be seen as a finger print for the breaker contacts and can be used as a bench mark for comparing with future measurements on the same breaker. This provides information on the condition of the breaker contacts.

Dynamic Contact Resistance Measurement for Arcing Contact conditions

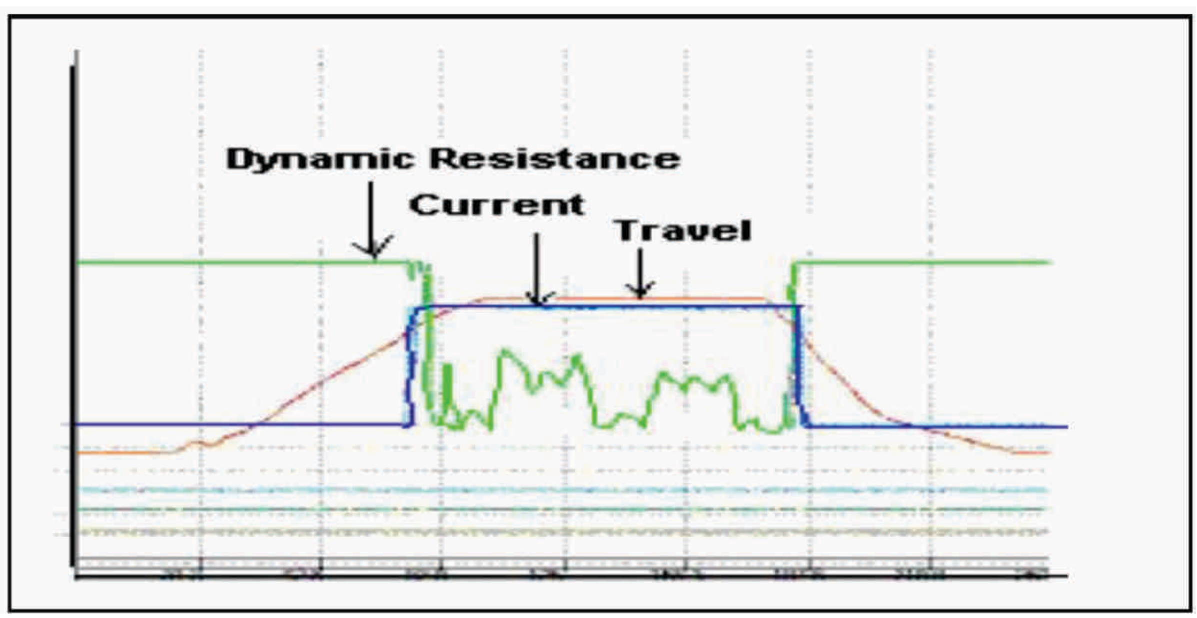
By application of Dynamic Contact Resistance Measurement, condition of arcing contact can be predicted. If DCRM signature shows vide variations and also there is change in arcing contact insertion time, it indicates erosion of the arcing contacts and main contacts and subsequent failure.

Contact Travel Measurement

Transducers are attached to the operating rod or interrupting chamber in order to record the contact travel. When CB closes, contact travel is recorded. Contact bounces or any other abnormality is also clearly indicated by the Contact Travel

If contact travel, contact speed and contact acceleration signature are compared with the original signatures, then it may indicate problems related with the operating mechanism, operating levers, main/ arcing contacts, alignments etc.

DCRM alongwith contact travel measurement is useful in monitoring length of arcing contacts. Erosion of arcing contacts may lead to commutation failures and current may get transferred to main contacts. Due to heat of arc, main contacts may get damaged.



Typical DCRM Signature

11 MANPOWER REQUIRED

AEE	-	1	JE	-	1
SSA	-	1			

12. DURATION OF TESTING - One day per CB

13. FORMATS

As per Doc.No.CE/PM/OS/INST-3

CHECKING OF POLE DISCREPANCY RELAY FOR CB'S

1. **EQUIPMENT AND TEST NAME**

   Checking of Pole Discrepancy relay and timer for EHV Circuit Breakers.

2. **PURPOSE**

   Pole Discrepancy and timer checking for 400 & 220 kV CBs.

3. **DEFINITION**

   Pole Discrepancy is defined as the difference in closing & opening timings of different poles of CB.

4. **ABBREVIATIONS**

PSI	:	PSTCL SAFETY INSTRUCTION
SFT	:	SANCTION FOR TEST
PTW	:	PERMIT TO WORK
EHV	:	EXTRAHIGH VOLTAGE
HF TERMINAL	:	HIGH FREQUENCY TERMINAL
AC	:	ALTERNATING CURRENT

5. **TESTING SCHEDULE AND FREQUENCY**

   As per Maintenance Schedule Doc.No.CE/PM/OS/INST-1

6. **TEST EQUIPMENT**

   Testing Leads, Standard timer etc.

7. **ISOLATION REQUIRED**

   Isolators on both sides of CB should be in open position.Earth switch should be in closed position.

8. **SAFETY REFERENCE**

   As per PSI of Safety Rules of PSTCL.

9. **PRECAUTIONS**

   a) Ensure that SFT/PTW is taken as per norms.

   b) There should be no joints in testing cables.

10. **MAINTENANCE/TESTING PROCEDURE- WHEN CB IN OPEN POSITION**

    Closing Command is extended to close one pole, say R-Pole of CB. After closing R-Pole of CB, this Pole should automatically open after 3 seconds (as per pole discrepancy timer settings) & 0.1 seconds for line & power transformer respectively. Repeat the test for remaining two poles of CB.

WHEN CB IN CLOSED POSITION

Tripping Command is extended to trip one pole, say R-Pole, of CB. Remaining Y and B- Poles of CB should automatically open after 3 seconds & 0.1 seconds for line & Power transformer respectively. Repeat the same test for remaining two poles of CB.

11. EVALUATION OF TEST RESULTS

Permissible value of pole discrepancy between two poles of CB is 3.33 msec.

12. MANPOWER REQUIRED

Engineer	-	1
J.E	-	1
Technician/operator	-	1

13. DURATION OF TESTING

One Hour

14. FORMATS

As per Doc.No.CE/PM/OS/INST-3

OPERATIONAL LOCKOUT CHECKING FOR EHV CB'S

1. EQUIPMENT AND TEST NAME

Operational Lockout checking for EHV Circuit Breakers.

2. PURPOSE

To check operational lockouts for 400/220kV CB's.

3. ABBREVIATIONS

PSI : PSTCL SAFETY INSTRUCTIONS

SFT : SANCTION FOR TEST

PTW : PERMIT TO WORK

4. TESTING SCHEDULE AND FREQUENCY

As per maintenance schedule document No. Doc.No.CE/PM/OS/INST-1

5. TEST EQUIPMENT

Multimeter, testing leads etc.

6. ISOLATION REQUIRED

a. CB should not be in service & isolators on both sides of CB should be in open position.

b. DC supply should be switched off as a precautionary measure.

7. SAFETY REFERENCE

As per PSI of Safety Rules of PSTCL.

8. PRECAUTIONS:

Ensure that SFT/PTW is taken as per norms.

9. MAINTENANCE/TESTING PROCEDURE:

A. SF6 GAS PRESSURE LOCKOUT

a) Low PressureAlarm

Close isolation valve between CB Pole(s) and density monitor (wherever provided). Start releasing SF_6 gas from density monitor till the low pressure gas alarm contacts are actuated which is detected by Multimeter. Note down the pressure and temperature at which the contacts get actuated. Circuit can also be tested by shorting terminals of DM.

b) Operational Lockout

Continue releasing SF_6 gas from isolated zone till the operational lockoutAlarm Contacts are actuated which are detected by Multimeter. Note down the pressure and temperature at which the contacts get actuated. This is called operational lockout pressure.

B. PNEUMATIC OPERATING SYSTEM LOCKOUT

a) Compressor START/STOP Switch

Close the isolating valve of CB. Release air into atmosphere from the compressor. Note down the value of pressure at which Compressor starts building up air pressure and pressure at which Compressor stops.

b) CB AUTO RECLOSE LOCKOUT

Close Isolation valve between pneumatic system and pressure switches. Release air from the isolated zone to atmosphere. Note down pressure at which A/R L/O contacts of pressure switch get actuated which are detected by multimeter. The leads of the multimeter should be connected to the contactor where the AR L/O of CB are made.

c) CB CLOSING LOCKOUT

Release air from the isolated zone to atmosphere. Note down pressure at which CB Closing L/O contacts of pressure switch get actuated which are detected by Multimeter.

d) CB OPERATIONAL LOCKOUT

Release air from the isolated zone to atmosphere. Note down pressure at which CB operational L/O contacts of pressure switch get actuated & which are subsequently detected by multimeter.

e) MECHANICAL CLOSING INTERLOCK

(FOR ABB CBs ONLY) CB should be in closed position. Release air from pneumatic system of CB's to atmosphere and observe whether CB poles start opening, ifso, note down the pressure at which tie rod starts coming down. In such case the closing interlock is to be opened for inspection and if required, replace the closing interlock.

10. EVALUATION OF TEST RESULTS

A. SF6 GAS PRESSURE LOCKOUT

All the SF6 gas pressure switch settings should be checked and corrected with ambient temperature. Settings of SF6 gas pressure switches should be within ± 0.1 bar (Kg/cm^2) of the set value (after taking into account the temperature correction factor).

B. AIR PRESSURE LOCKOUT

All the air pressure switches settings should be checked and corrected and should be within ± 0.3 bar (Kg/cm^2) of the set value.

C. OIL PRESSURE LOCKOUT

All the oil pressure switches settings should be checked and corrected and should be within ± 0.3 bar/ Kg/cm of the set value.

11. MANPOWER REQUIRED

AEE/AE	-	1
JUNIOR ENGINEER	-	1
SSA	-	1

12. DURATION OF TESTING

TWO HOURS

13. FORMATS

Doc.No.CE/PM/OS/INST-3

MEASUREMENT OF THIRD HARMONIC RESISTIVE CURRENT FOR SURGE ARRESTERS

1. EQUIPMENT AND TEST NAME

Measurement of Leakage Current (Third harmonic resistive current) for EHV Surge Arresters.

2. PURPOSE

To monitor health of Surge Arresters by monitoring third harmonic resistive current from the leakage current.

3. ABBREVIATIONS

PSI : PSTCL SAFETY INSTRUCTIONS

SFT: SANCTION FOR TEST

4. TESTING SCHEDULE AND FREQUENCY

As per maintenance schedule document No. Doc.No.CE/PM/OS/INST-1

5. TEST EQUIPMENT

Leakage Current Monitor suitable to filter out third harmonic resistive current from total leakage current.

6. ISOLATION REQUIRED

No isolation required since it is an on line measurement.

7. SAFETY REFERENCE

As per PSI of Safety Rules of PSTCL.

8. PRECAUTIONS

Ensure that SFT is taken as per norms. Ensure that arrester is mounted on isolated base. Test leads should be fully screened to nullify the effect of electromagnetic interference.

9. MAINTENANCE / TESTING PROCEDURE

a. Make the connections as per the diagram given below (Fig-I)

b. The kit should be properly earthed as per the recommendations of the kit supplier.

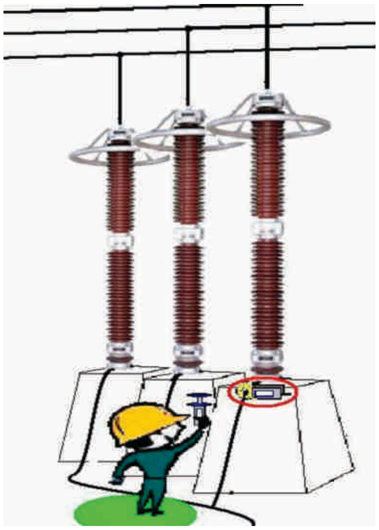
c. Clamp On type CT should be placed above the surgemonitor to pick up the total leakage current.

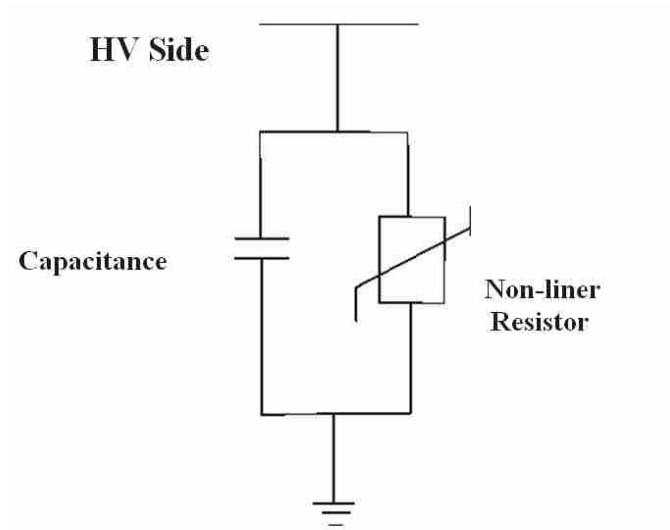
d. Carryout the measurements as per standard procedure supplied by the test kit manufacturer.

e. Note down the system voltage and ambient temperature along with the test current value.

f. Avoid measurement during monsoon.

10. EVALUATION OF TEST RESULTS





a. ZnO SurgeArrester continuously conducts a small leakage current as shown in Fig. The resistive component of this leakage current may increase with time due to different stresses causing ageing and finally becomes the causeof arrester failure

b. The limiting value of third harmonic resistive current is given in the Doc.No.CE/PM/OS/INST-2

c. issued by CE or OS on behalf of CE. Arresters are to be removed from service if norms are violated.

c. While monitoring third harmonic resistive current, temperature and voltage correction factors are to be applied because leakage resistive current also depends on these factors apart from ageing of the arrester discs.

d. As Indian manufacturers are yet to develop the correction factors and still working on to it, it is advisable to carry out the measurements at temperature from 20ºC to 30ºC.

e. If Harmonics are present in the system voltage, it shall effect the value of measured third harmonic current. Compensating device provided to be used to nullify the effect.

11. MANPOWER REQUIRED

AEE - 1

SSA - 1

12. DURATION OF TESTING

15 minutes to half an hour per Surge Arrester

13. FORMATS

As per DOC. NO: Doc.No.CE/PM/OS/INST-3

MANUAL & FORMATS

VOLUME-iii

Doc.No.CE/PM/OS/INST-3

MAINTENANCE CHECKS OF SUBSTATIONS

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

Head office- The Mall, Patiala

INDEX

GENERAL INSTRUCTIONS

01 Preventive maintenance schedule as appoved by BOD's of PSTCL for substation equipment shall be implemented in PSTCL as per approved formats.

02. Yearly/Half yearly testing of Protection Schemes/relays shall be carried out as per procedures/formats given or any other formats recommended by OS/HOD.

03. Test Results to be compared with factory test results/pre-commissioning/previous test results and acceptable/permissible Limits as approved vide Doc.No.CE/PM/OS/INST-5.

04. Instructions for filling up of Equipment Failure Report (EFR) is included with the Maintenance Formats.

05 Reasons for not carrying out any test/ inspection activity may be written clearly in remarks column and countersigned by concerned sub-station in-charge (SSE) and seen by Sr XEN/ASE of sub-station.

06 DGA Testing and other tests for oil are being done by ODTL and hence formats for the same are not included in this document.

07 SOME Test results are to be reviewed and approved by competent authority as specified in Preventive Maintenance Schedule & Doc.No.CE/PM/OS/INST-5. In case of violation/sudden rise in deviations from standard test results, reasons for the same needs to be brought out/Investigated by sub-staion incharge

Edition	Date	Department	Signature
First edition- 1st Revision- 2nd Revision	01-04-16	OS	
Prepared by AEE	Er Sukhjinder S Virk 1-4-16	Operation Services	
Reviewed by Adll S.E	Er Rajbir S. Walia 1-4-16	Protection & Operation Services	
Recommended by Chief Engineer	Er Charanjit S. Aulakh 5-5-16	P&M	
Approved by	23-6-16	BOD's of PSTCL in 37th meeting vide U.O No-1211/BOD/37.21/PSTCL, Dated 8-7-16	

ANNUAL MAINTENANCE/PT PLAN OF A SUB-STATION
SCHEDULED SHUT DOWN MAINTENANCE ACTIVITIES
(To be maintained at Division level & circle level)

SUB-STATION/
DIVISION:

Circle:
YEAR :

SN	NAME OF LINE/ BC/ TRANSFORMER BAY	SCHEDULED MONTH	MAINT. DONE YES	NO	RESCHEDULED MONTH	REASON FOR RESCHEDULING	APPROVED BY-SSE (I/C)

Format No.: SS/MAIN/AMP/GEN-1

SHUT DOWN MAINTENANCE ACTIVITIES
(SCHEDULED PLANNED / UNSCHEDULED FORCED)
(For Substation/ TL office)

DIVISION

SUB-STATION/ CIRCLE:

LINE: YEAR :

SN	NAME OF LINE	SCHEDULED MONTH	MAINT. DONE		RESCHEDULED MONTH	REASON FOR RESCHEDULING	APPROVED BY-AEE/TL
			YES	NO			

Format No.: SS/MAIN/AMP/GEN-2

SHUT DOWN MAINTENANCE ACTIVITIES
(SCHEDULED PLANNED / UNSCHEDULED FORCED)
(For Substation/ TL office)

DIVISION
YEAR : CIRCLE:
SUB-STATION/TL OFFICE

SN	NAME OF LINE/ ICT/BAY/ EQUIPMENT	DETAILED ACTIVITY	FREQ	DATE	DURA- -TION	REQUIRED FORMATS FILLED UP YES/NO	JOB COPML-ETED (IN %)	SIGNATURE (MAINT. ENGR.)	SIGNATURE (S/S OR T/L IN CHARGE)

Format No.: SS/MAIN/AMP/GEN.

TRANSFORMERS & REACTORS - MONTHLY MAINTENANCE
Monthly Maintenance Activity without Shutdown

SUB-STATION/
DIVISION:
CIRCLE :
MONTH :

Bay code ....

SN	Description of Activity	ICT-I/ T-I	ICT-II/ T-II	ICT-III/ T-III	ICT-IV/ T-IV	BUS REACTOR	REACTOR	LINE REACTOR	REMARKS
1	Date of Commissioning								
2	Make/YOM								
3	Rating								
4	Sl. No								
5	Equipment code								
6	Bushing Oil Level								
7	Oil level in Conservator								
8	Oil level in OLTC C-Tank								
9	Manual Starting of Oil Pumps & Fans								
10	Checking of Oil Leak								
11	Oil level in breather seal								
12	Condition of Silica Gel								

Sign. of Maintenance Engineer /JE/AAE

Sign. of SSE

Note: No. of columns to be adjusted as per the population of Transformers & Reactors.

Format No.: SS/MAIN/TRAFO.REACTOR/MONTHLY

TRANSFORMERS & REACTORS - YEARLY MAINTENANCE

SCHEDULED MONTH.................... ACTUAL MONTH...................

DATE.............. PTW NO.................

(I) AUTOSTARTING OF FANS AND PUMPS:

(II) OLTC OIL TEST RESULTS DONE/ NOT DONE

PROPERTY	R PHASE	Y PHASE	B PHASE	PERMISSIBLE LIMITS	OBSERVATION
BDV (IN KV)				MINIMUM 50 KV	

(III) MAINTENANCE OF OLTC DRIVING MECHANISM DATE

S N	DESCRIPTION	STATUS		REMARKS
		OK	NOT OK	
1	VISUAL INSPECTION OF EQUIPMENT			
2	HAND OPERATION ON ALL TAPS & HANDLE INTERLOCK			
3	OVERLOAD DEVICE OF DRIVING MOTOR			
4	LOCAL & REMOTE OPERATION (ELECTRICAL) & L/R SWITCH			
5	STEPPING RELAY IN REMOTE OPERATION			
6	CORRECT OPERATION OF TAP POSITION INDICATOR			

(IV) CHECKING OF REMOTE INDICATIONS OF WTI/ REMOTE TAP INDICATION: OK/ NOT OK

(V) EXTERNAL CLEANING OF 1. RADIATORS DONE/ NOT DONE

2. ALL BUSHINGS DONE/ NOT DONE

Tightening of Terminations TRANSFORMERS & REACTORS - YEARLY MAINTENANCE

VI) MARSHALING BOX-MAINTENANCE DATE ....

Description	DONE/NOT DONE Termination Tightening	Cleaning DONE/ NOT DONE	Checking of contactors space Heater /illumination	Condition of gaskets
MB OF OLTC				
MB OF REACTOR				
MB OF T/F OR ICT				
TB OF PRD/PRV				
TB OF BUCHOLZ RELAY				
TB OF OILSURGE RELAY				
TB OF OLTC BUCHOLZ				
TB OF BUSHING CT				

(VII) ON LINE MOISTURE MEASUREMENT (400 KV)

NAME OF THE ICT/ REACTOR	OIL TEMPERATURE	WINDING TEMPERATURE	% AGE MOISTURE	REMARKS

RUST, DAMAGES AND REPAINTING, IF REQUIRED (details)

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/TRAFO.REACTOR/YEARLY

TRANSFORMERS & REACTORS - YEARLY MAINTENANCE

DATE...

Temp.. ICT No..

(VIII) ALARM/TRIP TEST

DATE...

ALARM TEST						TRIP TEST							
NIFPS SIGNALS	Main Buchholz	OTI	WTI	O/L	MOG Low oil level	DIFF TRIP	O/C TRIP	Main Buchholz	REF TRIP	OTI	PRD	WTI	R/Y/B OLTC Bucholz

MAIN BUCHOLZ ALARM IS ALSO STAGE-1 TRIP, WHERE AS MAIN BUCHOLZ TRIP IS STAGE-2 TRIP NOW

(IX) NEUTRAL EARTH RESISTANCE MEASURMENT

NAME OF ICT/REACTOR/TRANSFORMER	RESISTANCE VALUE PIT-1	PIT-2	REMARKS

(X) WTI AND OTI SETTINGS

WTI	SET FOR	TEST VALUE		OTI		TEST VALUE	
		Actual	Remarks		SET FOR	Actual	Remarks
ALARM				ALARM			
TRIP				TRIP			
				OTI NGR			
FAN START				ALARM			
PUMP STR				TRIP			

TRANSFORMERS & REACTORS - 2 YEARLY MAINTENANCE

TAN δ MEASUREMENT FOR BUSHINGS BY TAN DELTA KIT

SN	Bushings	Capacitance				Tan δ				Remarks
		Pre-commg* Values		Measured Values		Pre-commg* Values		Measured Values		Measurement should be taken after cleaning
	400 KV Bushings	C1	C2	C1	C2	Tanδ1	Tanδ2	Tanδ1	Tanδ2	For measurement of C1 values of the bushings, connection will be between HV and test tap and measurement will be in UST mode at 10 kV. For measurement of C2 values of the bushings, connection will be between test tap and ground and HV will be connected to guard. The measurement will be in GSTg mode at 10 kV. * If Pre-commissioning values are not available, comparison with previous year test results may be done
	R ø									
	Y ø									
	B ø									
	220 KV Bushings									
	R ø									
	Y ø									
	B ø									
	66 or 44 KV Bushings									
	R ø									
	Y ø									
	B ø									
	Line reactor Bushings									
	R ø									
	Y ø									
	B ø									
	145 KV Neutral Bushings									
	NGR 145 KV									

AMBIENT TEMP............ºC
MAKE OF MEASURING EQUIPMENT.............................
REMARKS-

Sign. of Protection Engineer

Sign. of Sub-station Incharge

FormatNo.:SS/MAIN/TRAFO.REACTOR/2YEARLY

TRANSFORMERS & REACTORS - 4 YEARLY MAINTENANCE

(i) TANS δ AND CAPACITANCE MEASUREMENT OF WINDINGS BY TAN DELTA KIT

Date of Measurement -	Ambient Temp -		Make of Tan δ & Capacitance Kit –		
Test Modes	Pre-Commissioning Values		Actual Measurement		Remarks
HV-LV in UST Mode	Capacitance	Tanδ	Capacitance	Tanδ	Ensure that Jumpers are disconnected from all the bushings before start of the tests and all bushings of a individual windings are shorted alongwith neutral and neutral to be dis-connected from Ground.
HV-Ground in GSTg Mode					
LV- Ground in GSTg Mode					

(ii) CHECKING AND CALIBRATION OF OTI AND WTI

Set	OTI	WTI-HV	WTI-IV	WTI-LV
Temp. Ambient to 110ºC in step of every 5 ºC				

(iii) CORE INSULATION TEST
Apply 1.0 kV DC between CL & CC + G
Insulation value =
(Recommended Value > 10 m Ohms)

REMARKS-

(ii) CHECKING AND CALIBRATION OF OTI AND WTI

Sign. of Maintenance/Protection Engineer

Sign. Of Substation Incharge

Format No.: SS/MAIN/TRAFO.REACTOR/4 YEARLY

TRANSFORMERS & REACTORS – 5 YEARLY MAINTENANCE

S/D –ACTIVITY PTW NO.................. DATE..................

(I) CHECKING AND CLEANING OF DIVERTER SWITCH CONTACTS (AFTER 50,000 OPERATIONS OR 5 YEARS WHICHEVER IS EARLIER)

	Description	Done/ Not done
1.	Check for signs of moisture, rusting, oxidation or free standing water and leakages	
2.	Inspect barrier board for tracking and cracking	
3.	Clean the inner walls of the diverter switch housing by Nylon Brush	
4.	Check the fixed and moving contacts are properly engaged or not by performing manual operation for each step.	
5.	Make sure each washers and screws put back again.	
6.	Check the degree of contact burning. It should be within specified limit given by manufacture.	
7.	Do not file or smooth the burned and pitted contact surfaces.	
8.	Before installing the divertor switch, make sure that no foreign objects, tools, wires, rags etc are left in the diverter switch housing.	
9.	When the divertor switch is lowered, check visually that its plug –in contacts are aligned with the contacts in the cylinder wall.	
10.	Replace the oil.	
11.	After filling the oil, manually crank through out entire range.	
12.	Oil BDV and moisture contant (PPM) to be measured and recorded.	

REMARKS-

Sign. of Maintenance Engineer Sign. of Substation Incharge

(II) WINDING RESISTANCE MEASUREMENT

Make of Winding Resistance measurement Kit –

MEAUREMENT OF HV SIDE WDG RESISTANCE AT ALL TAPS (IN m OHM)									
TAP POSN.	FACTORY TEST VALUES			MEASURED WDG. RES. (mΩ)			WDG RESIS AT 75^{0} C		
	R	Y	B	1R1-1N	1Y1-1N	1B1-1N	R	Y	B
1									
2									
3									
-									
MAX									
Norm Tap									

MEAUREMENT OF WDG RESISTANCE (IN mΩ) –IV SIDE			
BETW.WDGS	FACTORY VALUES	MEASURED WDG. RESIS (mΩ)	WDG RESISTANCE AT 75^{0} C
2R1-N			
2Y1-N			
2B1-N			

MEAUREMENT OF WDG RESISTANCE (IN milli OHM) -LV SIDE			
BET.WDGS	FACTORY VALUES	MEASURED W R Valuees (mΩ)	WDG RESISTANCE AT 75^{0} C
3R1-3B1			
3Y1-3R1			
3B1-3Y1			

Sign. of Protection Engineer　　　　Sign. Of Substation Incharge

Format No.: SS/MAIN/TRAFO.REACTOR/ 5 YEARLY

TRANSFORMERS & REACTORS – SOS ACTIVITIES MAINTENANCE

Bay No. /Location

(I) VIBRATION MEASUREMENT (For Reactors only) Make / Sr. No.
Measurement of vibrations to be done by indicating the drawing with location of testing marked
Scheduled Date of Measurement

Make / Sr. No. of testing Kit

Ambient Temperature | Actual Date of Measurement

WTI Reading | System Voltage

OTI Reading | System Frequency

ZONE NO.	LOCATION OF MEASUREMENT (VIBRATION IN MICRON)																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1																			
2																			
3																			

(II) MEASUREMENT OF IR VALUES (DA RATIO)-

DATE OF MEASUREMENT

Test Modes	IR value after 15 Secs		IR value after 60 Secs		IR value after 600Secs		IR60/IR15	IR600/IR60
	PCT	Actual	PCT	Actual	PCT	Actual	PCT	Actual
HV+ IV to Tank								
LV to Tank HV to LV								

MEGGER- MAKE/SR. NO./SCALE
WEATHER CONDITION
AMB TEMP –

(III) FREQUENCY RESPONSE ANALYSIS (FRA) BY ODTL

Sl. No	Description		Status
1.	Factory and site FRA test report available at site	Yes	
2.	Interpretation of test results carried out	Yes	

REMARKS BY ODTL ENGINEER-

MEASUREMENT OF VOLTAGE RATIO (To be carried out preferably using Automatic Turns Ratio kit)

D. RATIO BETWEEN HV & IV

Tap Pos	Voltage Applied			Voltage Measured			Ratio			Factory/Required Results		
n	1R-N	1B-N	2R-N	2R-N	2Y-N	2B-N	R	Y	B	R	Y	B
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												

Note: The table is meant for Voltage method. If turns ratio kit is used, ratio to be recorded straightaway.

AMBIENT TEMPERATURE:

TESTING INSTRUMENT DETAILS:

REMARKS-

E. RATIO BETWEEN HV & LV (where tertiary is in use)

Tap Pos	Voltage Applied			Voltage Measured			Ratio			Factory/required Results		
	1R-N	1Y-N	1B-N	3R-3Y	3Y-3B	3B-3R	R	Y	B	R	Y	B
Lowest												
Normal												
Highest												

F. RATIO BETWEEN IV & LV

Tap Pos	Voltage Applied			Voltage Measured			Ratio			Factory/required Results		
	2R-N	2Y-N	2B-N	3R-3Y	3Y-3B	3B-3R	R	Y	B	R	Y	B
Lowest												
Normal												
Highest												

REMARKS

Sign. of Protection Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/TRAFO.REACTOR/SOS

CIRCUIT BREAKER- MONTHLY MAINTENANCE

Bay Location-

DOC-

Make-

Rating-

Sr No-

Date-

PTW No (if taken)-

ACTIVITY		OBSERVATION & REMARKS
a.	Oil Leakage in Operating Mechanism	
b.	Oil Level in Operating Mechanism (Top up, if required)	
c.	Oil leakage/ oil level in MOCB	
d.	Oil Leaks from Grading Capacitors	
e.	SF_6 gas pressure checking	
f.	To check for auto-moisture release valve (for ACB only)	

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CB/MONTHLY

CIRCUIT BREAKER - HALF YEARLY MAINTENANCE

(B) HALF YEARLY MAINTENANCE WITHOUT SHUT DOWN

Bay Location-

DOC-

Make-

Rating-

Sr No-

Date-

PTW No (if taken)-

SF-6 CIRCUIT BREAKER (PNEUMATIC OPERATING MECHANISM)

MAINTENANCE OF AIR DRYER- As per manufacturer's recommendations

DETAIL OF ACTIVITY IN BRIEF-

Sign. of Maintenance Engineer   Sign. of Substation Incharge

Format No.: SS/MAIN/CB/HALF YEARLY

CIRCUIT BREAKER - YEARLY MAINTENANCE

(C) YEARLY MAINTENANCE WITH SHUT DOWN

(ii) SF6 CIRCUIT BREAKER

Bay Location-
DOC-
Make-
Rating-
Sr No-
Date-
PTW No (if taken)-

(a) AIR/ OIL PRESSURE DROP DURING DUTY CYCLE OPERATION - O-0.3 S-CO

AIR/ OIL PRESSURE		
	Pre commg / Previous Results.	Actual
Before operation		
After Operation		

(a) Checking of Air Compressor/ Hydraulic Pump operation

	START (Pressure)	STOP (Pressure)
Set values		
Actual		

(ii) AIR BLAST CIRCUIT BREAKER

Done / Not done
VALUE

(a) Maintenance of Air Compressors/ Air dryers as per Manufactures guideline
(b) Humidity (DEW POINT) Measurement of operating air

(Limit : -45 ° C at atmospheric Pressure)

(iii) MINIMUM OIL CIRCUIT BREAKER (MOCB)

BDV Of Oil- ....KV (Avg of Six Readings)

(iv) BREAKER OPERATION CHECKS - S/D ACTIVITY

(a) CB timing including PIR checks

PHASE	BREAK	DETAILS		TRIP		CLOSE TRIP (CO)*		Closing coil current	Trip coil current	Remarks
			CLOSE	TRIP-I	TRIP-II	TRIP-I	TRIP-II			
R	BREAK 1	MAIN CONTACT								
		PIR CONTACT								
		PIR &MAIN CONT OVERLAP TIME/PIR								
		OPENING TIME PRIOR TO MAIN CONT								
		AUXILIARY CONTACT (NO)								
	BREAK 2	MAIN CONTACT								
		PIR CONTACT								
		PIR &MAIN CONT OVERLAP TIME/ PIR								
		OPENING TIME PRIOR TO MAIN CONT								
		AUXILIARY CONTACT (NC)								
Y	BREAK 1	MAIN CONTACT								
		PIR CONTACT								
		PIR &MAIN CONT OVERLAP TIME/ PIR								
		OPENING TIME PRIOR TO MAIN CONT								
		AUXILIARY CONTACT (NO)								
	BREAK 2	MAIN CONTACT								
		PIR CONTACT								
		PIR &MAIN CONT OVERLAP TIME/ PIR								
		OPENING TIME PRIOR TO MAIN CONT								
		AUXILIARY CONTACT (NC)								
B	BREAK 1	MAIN CONTACT								
		PIR CONTACT								
		PIR &MAIN CONT OVERLAP TIME/ PIR								
		OPENING TIME PRIOR TO MAIN CONT								
		AUXILIARY CONTACT (NO)								
	BREAK 2	MAIN CONTACT								
		PIR CONTACT								
		PIR &MAIN CONT OVERLAP TIME/ PIR								
		OPENING TIME PRIOR TO MAIN CONT								
		B-PH AUXILIARY CONTACT (NC)								

* CO Time is to be measured with simultaneous Close-Trip commands. In case provision dose not exist for simultaneous Close/ Trip commands in kit, Trip command to be given at least 10 ms prior to closing of CB contacts.

Details of kit used: (Make & Sl. No.)......./

Format No: SS/MAIN/CB/YEARLY

(b) Checking the Pressure Setting of switches

CB pole	Sf6 Pressures Switch Setting		Sf6 Pressure Switches Actual		Ambient Temp
	ALARM	LOCKOUT	ALARM	LOCKOUT	
R					
Y					
B					

Pressure Switch setting should be within +/- 0.1 Bar of set value.

(c) Checking of Pole Discrepancy Relay (repeat for Y & B poles also

TRIP 'R' ph	Measure Tripping Time of Y & B pole	
	Set Value in sec	Operating Value in sec
PRECOMMG		
ACTUAL		

Close any one pole and observe the tripping of same pole

CLOSE 'R' pole	Measure Tripping Time of R pole	
	Set Value in sec	Operating Value in sec
PRECOMMG		
ACTUAL		

(d) Checking of Anti Pumping relay – by giving continuous Close/ Trip command, Hunting should not take place.

(e) Duty Cycle operation including rapid re-closing

	Timings in msec				
POLE	Break 1		Break 2		
	ALARM	LOCKOUT	ALARM	LOCKOUT	ACTUAL
R					
Y					
B					

* For CO, no delay in Close/ Trip commands.

(f) Check of interlocks (Local Closing Interlock):

(g) Check of Operating Lockouts

Sl. No		Pressure Values					
	Test-Description	A/R Lockout		Closing L/O		Operational Lockout	
		Set value	Actual	Set value	Actual	Set value	Actual
1.	Driving mechanism (Hydraulic /Pneumatic)						

(h) Maintenance of Air Compressor in Pneumatic drive: As per manufacture guideline

DONE / NOT DONE

(i)	Cleaning of Breaker Pole	
	1. Support Insulators	DONE / NOT DONE
	2. PIR and grading capacitor	DONE / NOT DONE
	3. Interrupter Chamber	DONE / NOT DONE
(j)	Spring Operating Mechanism	
	1. Lubrication of Chain and Gears	DONE/ NOT DONE
	2. Checking healthiness and cleaning of rollers	DONE/ NOT DONE
	3. Checking healthiness of springs, Greasing if required	DONE/ NOT DONE
(k)	Healthiness Of Operation Counter	
	R phase..............	OK/NOT OK
	Y phase............	OK/NOT OK
	B phase............	OK/NOT OK
(l)	Maintenance of Control Cabinets	
	1. Checking of tightness of all the terminations in MB.	
	2. Checking of Door Sealing gaskets and replacement there of, if necessary	
	3. Check functioning of space heater/ illumination	

REMARKS

Sign. of Maintenance/Protection Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CB/YEARLY

CIRCUIT BREAKER - 2 YEARLY MAINTENANCE

(i) Measurement of Static Contact Resistance :

(Max. Contact resistance acceptable for all breaks: 75 micro ohm per break for 400 kV CB)

CB POLES	CONTACT RESISTANCE IN MICRO OHMS			
	Interrupter 1(CTSIDE)	Interrupter 2 (Bus side)	Interrupter 3	Interrupter 4
R phase				
Y phase				
B phase				

(i) Dynamic Contact Resistance and Contact Travel Measurement

(10kHz sampling Frequency and minimum 100A d.c. injected current)

CB POLES	BREAK	Remarks on DCRM Signature by Protc/Hub team
R phase	BREAK 1	
	BREAK 2	
Y phase	BREAK 1	
	BREAK 2	
B phase	BREAK 1	
	BREAK 2	

REMARKS -

Dynamic Contact Resistance signature for CO operation for all the breaks of CB to be recorded and compared with the earlier signatures. Minimum delay (TCO time) should be 300ms. Depending on number of Breaks, formats shall be modified.

Sign. of Maintenance/Protection Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CB/ 2 YEARLY

CIRCUIT BREAKER- 4 YEARLY MAINTENANCE

(a) Capacitance & Tan δ Measurement of Grading Capacitor

PTW NO: Date:

DESCRIPTION	INTERUPTER 1			INTERUPTER 2		
	R-PH	Y-PH	B-PH	R-PH	Y-PH	B-PH
	CAPACITANCE					
PRE-COMM VALUE						
MEASURED VALUE						
	Tan δ					
PRE-COMM VALUE						
MEASURED VALUE						

Details of Kit used: (Make & Sr. No) :

Ambient Temp: ^{0}C

Note: Normally Capacitance and Tanδ measurement is to be carried out in UST mode but if interferrence is more then, same may be done in GSTg mode with one side grading capacitor grounded and other side connected to guard, depending on number of Interrupters/ Grading Capacitor, Format shall be modified.

(b) Measurement of dew point in SF6 Gas (For SF6 CB)

Date...........................

CB POLE	DEW POINT MEASUREMENT			
	PRE-COMMISSIONING		ACTUAL	
	DEGREE °C	PRESSURE	DEGREE °C	PRESSURE
R phase				
Y phase				
B phase				

REMARKS -

Sig. of Maintenance/Protection Engineer Sig. of Substation In-charge

Format No.: SS/MAIN/CB/4 YEARLY

CIRCUIT BREAKER – SOS MAINTENANCE ACTIVITY

Date ……..

ACTIVITY	OBSERVATION & REMARKS
(a) SF6 Gas Leakage Test	
(b) Air Leakage Test in ABCB	
(c) Regeneration of Air Dryer	
(d) Repainting of Metallic Surfaces, if required	

REMARKS -

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CB/SOS

CURRENT TRANSFORMER - MAINTENANCE

CURRENT TRANSFORMER MONTHLY MAINTENANCE

Bay Location-
DOC-
Make-
Rating-
Sr No-
Date-
PTW No (if taken)-

(a) Visual inspection of CT for oil leakage and crack in insulators ……………………… DONE/ NOT DONE.

(b) Checking of bellow for expansion/ oil level………………………………………… DONE/ NOT DONE.

(c) Checking of SF_6 gas pressure ………………………………………… DONE/ NOT DONE.

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CT/MONTHLY

CURRENT TRANSFORMER – YEARLY MAINTENANCE

(i) Marshalling Box

1. Cleaning of MB...
2. Checking the tightness of all electrical connections including earthing of MB ....
3. Cleaning and tightness of CT secondary terminals and healthiness of sec terminal bushing..........
4. Checking of Space Heater & Illumination...............................
5. Check for any oil leakage from Secondary Terminal Box.......................
6. Checking of healthiness of gaskets..

(ii) Capacitance & Tan δ Measurement

Make of the Kit...........

Permissible Value: Tan δ= 0.007 at 20° C

CT Details/ Phase	Capacitance		Tan δ	
	Pre-comm Value	Measured Value	Pre-comm Value	Measured Value
R ø				
Y ø				
B ø				

1. Checking of low gas SF_6 pressure (alarm) ....
2. Checking of low gas SF_6 pressure (trip) ....

REMARKS -

Sign. of Maintenance/Protection Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CT/YEARLY

CURRENT TRANSFORMER - 2 YEARLY MAINTENANCE

(i) Nitrogen pressure checking (where ever provision exists)

CT Details	Bay No./ Feeder	R	Y	B	Remarks

Sign. of Maintenance/Protection Engineer

Sign. of Substation In-charge

Format No.: SS/MAIN/CT/2/YEARLY

CURRENT TRANSFORMER – SOS MAINTENANCE

(I) Dissolved Gas Analysis (To be maintained as per formats of the test laboratory)

(II) Oil Parameters

Break Down Voltage (kV)	Moisture (ppm)

(III) Measurement of CT Ratio

Primary Current	Secondary Current	Ratio
100 Amp. 500 Amp.		

(IV) Measurement of Secondary Resistance

Core	Resistance Value			Remarks
	R Phase	Y Phase	B Phase	
1				
2				
3				
4				
5				

REMARKS -

(V) Magnetising Characteristics

Applied Voltage in Secondary (Volts)	Measured Current (mA)	Remarks

(VI) Insulation Resistance Measurement

IR-15	IR-60	IR-600	Absorption Coefficient IR-60/ IR-15	Polarization Index IR-600/ IR-60

Applied Voltage:

Sign. of Maintenance/Protection Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CT/SOS

CAPACITANCE OR POTENTIAL VOLTAGE TRANSFORMER MAINTENANCE

Bay Location-
DOC-
Make-
Rating-
Sr No-
Date-
PTW No (if taken)-

A Checking of Oil Leaks

(i) MONTHLY MAINTENANCE OF CVT – W/SD

Sign. of Maintenance Engineer Sign. of Substation In-charge

Format No.: SS/MAIN/CVT/MONTHLY

B. SIX MONTHLY MAINTENANCE OF CVT /PT

(I) Measurement of secondary output voltage

Name of feeder/bay	Phase	Values Volts			Remarks
		Core-1	Core-2	Core-3	
	R PHASE				
	Y PHASE				
	B PHASE				
	R PHASE				
	Y PHASE				
	B PHASE				

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CVT/6MONTHLY

YEARLY MAINTENANCE OF CVT OR PT (AS APPLICABLE)

	Description	Remarks
1	Visual Checking of Earthing of HF Point. (In case it is not used for PLCC)	
2	Checking of any breakage or cracks in HF bushing.	
3	Checking for any breakage or cracks in cementing joint	
4	Cleaning of CVT (Capacitor Stacks) or PT and tightness of terminal connections	
5	Checking of Neutral Earthing in CVT/PT MB and Tightness of All connections	
6	Cleaning of Marshalling Box & Junction Box (to make vermin proof)	
7	Checking of Space heater & illumination	
8	Checking healthiness of all gaskets	

	Insulation Resistance Values			Remarks
	Description	Y- Phase	B- Phase	
Primary- Earth				
CORE-1(Sec-E)				
CORE-II (Sec-E)				
CORE-III (Sec-E)				

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/CVT/YEARLY

D. FOUR YEARLY MAINTENANCE OF CVT

(I) Capacitance & Tan δ Measurement of CVT

(All Stacks measured together between HV and HF point as well as for each stack)
While measuring Bottom and Middle stack, short middle/Top stack respectively.

STACK	PRE-COMMISSIOING VALUES						MEASURED VALUES					
	CAPACITANCE			TAN δ			CAPACITANCE			TAN δ		
	R Φ	Y Φ	B Φ	R Φ	Y Φ	B Φ	R Φ	Y Φ	B Φ	R Φ	Y Φ	B Φ
TOP												
MIDDLE												
BOTTOM												
TOTAL (Between HV and HF point)												

Note: In case of deviation/ discrepancy in test results w.r.t. Factory/ Pre- commissioning values, the problem could be due to EMU PT insulation in few makes of CVTs. In such case, secondary voltage measurement to be taken for any further decision.

Bay Location-
DOC-
Make-
Rating-
Sr No-
Date-
PTW No (if taken)-

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/CVT/4YEARLY

ISOLATORS AND EARTH SWITCHES - MAINTENANCE

(A) YEARLY MAINTENANCE OF ISOLATORS AND EARTH SWITCHES

Bay Location- DOC- Make- Rating-

Sr No- Date- PTW No (if taken)-

(I) OPERATING MECHANISM

Sl.No.	Description	Remarks
1	Maintenance of Linkages including transmission gears-	
2	Maintenance of stopper bolts	
3	Cleaning of Aux. switch contacts & greasing with silicon grease	
4	Lubrication of operating mechanism hinges, Lock Joints on levers & bearings	
5	Checking & Tightening of all mounting bolts	

(II) ISOLATOR

Sl.No.	Description	Remarks
1	Cleaning and Greasing of Main Contacts	
2	Alignment of contacts/ operating levers	
3	Tightening of Bolts, Nuts and Pins Etc	
4	Cleaning of support insulators and check for insulators cracks , if any	
5	Checking of interlocks (Mechanical & Electrical)	

(III) EARTH SWITCH

Sl.No.	Description	Remarks
1	Checking and Alignment of Earthing Blades	
2	Cleaning of Contacts	
3	Operation of Earth Switch	
4	Checking of Aluminum/ Copper flexible conductor	
5	Checking of earth connections of structure & MOM box	

(IV) MARSHALLING BOXES OF ISOLATORS AND EARTH SWITCHES

Sl.No.	Description	Remarks
1	Checking of space heater & illumination	
2	Checking of healthiness of Rubber Gaskets (make vermin proof)	
3	Visual Check of auxiliary contacts	
4	Cleaning and tightness of all terminations	
5	Cleaning of rust etc or painting required	

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No: SS/MAIN/ISOLATORS/YEARLY

(B) 4 YEARLY MAINTENANCE OF ISOLATORS AND EARTH SWITCHES

Bay Location- DOC- Make- Rating-

Sr No- Date- PTW No (if taken)-

(I) Contact Resistance Measurement-(In Micro Ohm) of Isolators

Test results	Contact Resistance			REMARKS
	R Phase	Y Phase	B Phase	
Pre-comm values				
Test Values				

Note: Contact Resistance is to be measured for total ie, Main/ Transfer Contacts, in case of HCB Isolators and both the Main Contacts in case of HDB Isolators. Individual measurement shall be carried out when the measured values are higher to identify the defect for rectification.

Permissible limit for Main contact Resistance: 300 Micro Ohm (Max.).

(ii) Contact Resistance Measurement-(In Micro Ohm) of Earth Switch

Test results	Contact Resistance			REMARKS
	R Phase	Y Phase	B Phase	
Pre-comm values				
Test Values				

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/ISOLATORS/4YEARLY

LIGHTNING ARRESTER – YEARLY MAINTENANCE

Bay Location- DOC- Make- Rating-

Sr No- Date- PTW No (if taken)-

(a) Checking of Leakage by Current Analyser (µ A) after cleaning the porcelain surface.

Phase	R	Y	B	Remarks
3^{rd} harmonic resistive current (I_3R) in µ A				
Total Current				

(b) Testing by Surge Monitor kit -Counter and meter tests

(c) Cleaning of LA Insulators

I R= upto 150 µ Amp- Normal

For New LA : I_3R Upto 30 micro-Amp

For LA in service:– I_3R upto 150 µ Amp- Normal ; I_3R in range of 150 µ Amp- 300 µ Amp – to be tested for IR Values. If IR Value is low, must be removed from service immediately.

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/LA/4YEARLY

LIGHTNING ARRESTER – SOS MAINTENANCE

(a) Capacitance and Tan Delta Measurement & Insulation Resistance vales

Stack	Insulation Checks for surge arrestors			Remarks after comparing with pre-Commissioning results
	Capacitance	Tan Delta δ	Insulation Resistance	
1				
2				
3				
4				

Bay Location-

DOC-

Make-

Rating-

Sr No-

Date-

PTW No (if taken)-

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/LA/SOS

MAINTENANCE OF BUSBAR AND BUS POST INSULATOR

YEARLY MAINTENANCE OF BUS BAR & BPI

SN	ACTIVITY	MEASURED VALUE	REMARKS
1	MEASUREMENT OF STATION EARTH RESISTANCE (List various measuring locations/points)		
2	CLEANING OF INSULATORS	DONE / NOT DONE	
3	CHECKING OF INSULATORS FOR CRACKS	DONE / NOT DONE	

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/BUSBARS&BPI/YEARLY

MAINTENANCE OF WAVE TRAP

Bay Location-
DOC-
Make-
Rating-
Sr No-
Date-
PTW No (if taken)-

YEARLY MAINTENANCE OF WAVE TRAP

SN	ACTIVITY	REMARKS
1	TIGHTNESS AND CLEANLINESS	
2	GENERAL INSPECTION/ CLEANING OF TUNING UNIT	

Format No: SS/MAIN/WT/YEARLY

TEN YEARLY MAINTENANCE OF WAVE TRAP

SN	ACTIVITY	REMARKS
1	Replacement of LA	

Sign. of Maintenance Engineer　　　　Sign. of Substation Incharge

Format No.: SS/MAIN/WT/ SOS

YEARLY MAINTENANCE OF SUB-STATION ILLUMINATION SYSTEM

DATE OF MAINTENANCE : MTC.DONE BY:

PTW NO: DATE :

SN	JOB DESCRIPTION	REMARKS & OBSERVATION	DATE	SIGNATURE
1	Check healthiness of light fittings in all circuits of the station building. Repair or replace, as required			
2	Check, if all switchyard fittings are in working condition (_______ nos. as record). Repair/ replace, as required.			
3	Check Lighting panel of control room, tightening of terminals etc.			
4	Check OUTPUT SUPPLY after fuse in all panels etc.			

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/ILL/YEARLY

THERMOVISION SCANNING OF SWITCHYARD EQUIPMENTS

NAME OF SUBSTATION: NAME OF BAY:

DATE OF MEASUREMENT: AMBIENT TEMPERATURE:

S.N	Equipment	POINT OF MEASUREMENT	TEMPERATURE IN ^{0}C R Φ	Y Φ	B Φ	Remarks
I. Main Bay Equipments						
01	**Transformer/ Reactor**					
	a)	400kV Bushing Insulators				
	b)	400kV/ 220kV Bushing Connectors				
	c)	400kV/ 220kV Turrets				
	d)	400kV/220kV Bushing Insulators				
	e)	All four sides of Transformer/ Reactor				
	f)	Radiator Bank/ Oil Pipes				
02	**Circuit Breaker**					
	CONNECTOR / CLAMP OF CIRCUIT BREAKER (52)					
	A)	TOWARDS LINE SIDE				
	B)	TOWARDS BUS SIDE				
03	**Current Transformer**					
	CT Insulators					
	Connector Clamp					
	- Line Side					
	- Bus Side					
04	**Capacitive VT /Potential Transformer**					
	Top Stack					
	Middle Stack					
	Bottom Stack					
	Metallic Tank					
05	**ISOLATORS**					
	i) CONNECTOR / CLAMP OF BUS ISOLATOR					
	a) TOWARDS BAY SIDE					
	b) TOWARDS BUS SIDE					
	c) ISOLATOR CONTACT					
	ii) CONNECTOR / CLAMP OF LINE ISOLATOR					
	a) TOWARDS LINE SIDE					
	b) TOWARDS BAY SIDE					
	c) ISOLATOR CONTACT					

Equipment TEMPERATURE IN DEGREE °C

POINT OF MEASUREMENT

iii) CONNECTOR/CLAMP OF ISOLATOR- BUS SIDE (89)

a) TOWARDS BREAKER SIDE

b) TOWARDS BUS SIDE

c) ISOLATOR CONTACT

iv) CONNECTOR/CLAMP OF ISOLATOR- C T SIDE (89)

a) TOWARDS BREAKER SIDE

b) TOWARDS BUS SIDE

c) ISOLATOR CONTACT

II. Tie Bay Equipments

01 CB

CONNECTOR / CLAMP OF CIRCUIT BREAKER (52)

a) TOWARDS LINE SIDE

b) TOWARDS BUS SIDE

02 C.T

Connector Clamp of CT- A

a) Towards Breaker Side

b) Towards Line Side

03 C.T

Connector Clamp of CT- B

a) Towards Breaker Side

b) Towards Line Side

ISOLATOR

04 CONNECTOR / CLAMP OF ISOLATOR (89A)

a) Towards Breaker Side

b) Towards Bus Side

c) Isolator Contact

05 CONNECTOR / CLAMP OF ISOLATOR (89B)

a) Towards Breaker Side

b) Towards Bus Side

c) Isolator Contact

POINT OF MEASUREMENT

III. All Jumpers/ Droppers joints related to

EQUIPMENT	TEMPERATURE IN DEGREE °C			
Jumpers/Dropper Joints	R Φ	Y Φ	B Φ	Remarks
a) Main Bay				
b) Tie Bay				
c) Strung bay				
d) Rigid Bus				
Wave Trap CONNECTOR / CLAMP				
A) TOWARDS LINE SIDE				
B) TOWARDS BUS SIDE				
Bus Bar & BPI				
a) All Conductor Joints				
b) Terminal Connectors/ Clamps				

PERMISSIBLE LIMITS FOR THERMOVISION SCANNING

- TEMP UPTO 15° C (ABOVE AMBIENT)- NORMAL
- TEMP_ABOVE 15- 50° C (ABOVE AMBIENT)- ALERT
- TEMP ABOVE 50°C (ABOVE AMBIENT)- TO BE ATTENDED IMMEDIATELY

Note: This is only a guideline. The format to be modified as per actual site layout

Sign. of Maintenance Engineer   Sign. of Substation Incharge

Format No.: SS/MAIN/TSCAN/STANDARD

MONTHLY /QUARTERLY MAINTENANCE OF SUB-STATION AIR CONDITIONING SYSTEM

DATE OF MAINTENANCE : MTC DONE BY: MTC. DATE:

DATE : AC UNIT NO:

PTW NO:

S.N	EQUIPMENT	JOB DESCRIPTION	REMARKS/ OBSERVATION
		MONTHLY MANINTENANCE SCHEDULE	
1.	COMPRESSORS	Checking of belt tension Leakages checks for refrigerants and oil Checking of oil level.	
2.	CONDENSER UNIT	Checking for water leaks. Operation of inlet/ outlet valve.	
3.	WATER TREATMENT PLANT	Cleaning of Soft water tank and regeneration of chemicals	
4.	COOLING TOWERS	Cleaning of sediments	
		QUARTERLY MANINTENANCE SCHEDULE	
1.	COOLING TOWERS	Cleaning of nozzles for clogging Flow switch performance checking	
2.	AIR HANDLING UNITS	Cleaning of suction air filters	

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/AC.SYSTEM

HALF YEARLY/ YEARLY MAINTENANCE OF SUB-STATION AIR CONDITIONING SYSTEM

DATE OF MAINTENANCE: MTC DONE BY: MTC. DATE:

PTW NO: DATE: AC UNIT NO:

S.N	EQUIPMENTS	JOB DESCRIPTION	REMARKS/ OBSERVATION
		HALF-YEARLY MANINTENANCE SCHEDULE	
1.	COMPRESSOR	Checking of tightness of flywheel, bolted joints, leakage of oil etc.	
2.	CONDENSER UNIT	Checking of water pressure – inlet/ out let & cleaning of side plates	
3.	WATER TREATMENT PLANT	Checking operation of level switch Checking water quality	
4.	ELECTRICAL MOTORS	Lubrication of moving parts Terminal connection tightness checking	
		YEARLY MANINTENANCE SCHEDULE	
1.	COMPRESSORS	Checking of oil pressure switch. LP/HP, cut-out switches, solenoid valve, thermostat, Humidistat etc.	
2.	LT PANELS	Cleaning of Bus Bars, Insulators etc.	
3.	AIR HANDLING UNITS	Tightness of the connections Checking of all interlocks	

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/AC.SYSTEM

SOS MAINTENANCE FORMAT FOR SUB-STATION AIR CONDITIONING SYSTEM

DATE OF MAINTENANCE : MTC DONE BY: MTC. DATE:

PTW NO: DATE: AC UNIT NO:

S.N	EQUIPMENTS	Activities	REMARKS
1.	CONDENSER UNIT	De-scaling of cooling water circuit	
2.	ELECTRICAL MOTORS	ELECTRICAL Overhauling	

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/AC.SYSTEM

MAINTENANCE FORMAT FOR SUB-STATION AC PACKAGE (SPLIT AC)
YEARLY MAINTENANCE ACTIVITIES

1. Maintenance as per manufacture's guidelines

2. Leakage check for refrigerant gas

SOS MAINTENANCE ACTIVITIES

1. Healthiness of Stabilizer

Sign. of Maintenance Engineer   Sign. of Substation Incharge

Format No.: SS/MAIN/AC-SPLIT

MAINTENANCE OF BATTERY SETS

SUB-STATION:	MONTH:
DATE OF INSPECTION:	VOLTAGE: 24/48/220 VOLTS BATTERY
BATTERY SET: I/II	TOTAL ACTUAL BATTERY VOLTAGE (VOLTS):
BB Make:-	BB DOC:

(A) MONTHLY MAINTENANCE – Bank-A or B

(a) Checking of electrolyte level and topping up with DM water, If any

(b) Checking of emergency DC lighting to Control Room

(SWITCH OFF CHARGER TO NOTE TOTAL BATTERY VOLTAGE)

(c) Measurement of Specific gravity and voltage of cell with Charger OFF, in case of flooded cells.

CELL	CELL VOLTS	SP. GRAVITY	CELL TEMP.°C	CELL	CELL VOLTS	SP. GRAVITY	CELL TEMP.°C
1				29			
2				30			
3				31			
4				32			
5				33			
6				34			
7				35			
8				36			
9				37			
10				38			
11				39			
12				40			
13				41			
14				42			
15				43			
16				44			
17				45			
18				46			
19				47			
20				48			
21				49			
22				50			
23				51			
24				52			
25				53			
26				54			
27				55			
28				56			

(SHEET 2 OF 2 FOR 220 VOLT BATTERY SET)

CELL	CELL VOLTS	SP. GRAVITY	CELL TEMP.°C	CELL	CELL VOLTS	SP. GRAVITY	CELL TEMP.°C
57				84			
58				85			
59				86			
60				87			
61				88			
62				89			
63				90			
64				91			
65				92			
66				93			
67				94			
68				95			
69				96			
70				97			
71				98			
72				99			
73				100			
74				101			
75				102			
76				103			
77				104			
78				105			
79				106			
80				107			
81				108			
82				109			
83				110			

- Checking of any Earth fault in DC System wherever E/F relays are not provided.
- In case of VRLA Battery, only Battery Voltage and Cell Temperatures are to be recorded.
- To measure DC Voltage at the farthest point in the switchyard to see the voltage drop.
- To check the output of 84 cells in case of boost charging.

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/BB/MONTHLY

BATTERY CHARGER / DC DISTRIBUTION SYSTEM MAINTENANCE

DCDB Sr No DCDB DOC: PTW No: Date:

Charger Sr No Charger Make Charger DOC

(B) Yearly Maintenance

(i) Checking of charger panel & DCDB for tightness and cleanliness of electrical connections.

(ii) Testing of D.C. E/F & U/V Relays.

(iii) IR measurement of Charger Transformers

(iv) Checking & Cleaning of Battery cell terminals and application of petroleum jelly or spray (if required).

(v) Checking of tightness of VRLA Battery and dusting/ cleaning.

(vi) Servicing of Air Conditioners for VRLA Batteries.

(vii) Working of Charger on boost & trickle

(viii) Auto working of charger

(ix) Working of Volt meter / Ammeter/ DC leakage meter on the charger panel

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/BB/YEARLY

(C) 3 Yearly Maintenance Record - S/D Activity

DISCHARGE AND IMPEDANCE TEST OF BATTERY SET

(i) Connect the load to battery, start the timing and continue to maintain the discharge @ 10% Battery capacity as per standard capacity measurement procedures.

(ii) Record hourly, the temp,the current, the voltage and specific gravity of individual cells along with the battery terminal voltage.

(iii) Charge the battery (in Boost mode) to full capacity and measure the temperature, voltage and specific gravity of individual cell.

Date/Hrs Cell No.. Sp.Gravity Cell Volts Cell Temp. Battery Discharge Current Battery Terminal Voltage

Note: Above test to be carried out after ascertaining the battery capacity (during commissioning or during any of AMP activity). For battery impedance test standard format is provided by manufacturer of testing kit.

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/BB/3YEARLY

A. Monthly Maintenance STATION FIRE PROTECTION SYSTEM

SUB-STATION: DATE OF MAINTENANCE:

S.NO	EQUIPMENTS	ACTIVITIES	REMARKS & OBSERVATION
1	COMPRESSOR	Cleaning/Replacement of Air Filter detectors	
2	FIRE ALARM SYSTEM	(i) Sequence test for annunciation in control room panel (ii) Smoke test Cleaning (iii) Battery Electrolyte level checking	
3	DIESEL ENGINE	(i) Checking of auto starting of diesel engine (ii) Check oil level, top up if required	
4	PUMPS	(i) Checking of operation of Hydrant pumps Sump pumps, Jockey pumps etc Check leakage & lubrication of Jockey Pump	

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/FF.SYS/MONTHLY

B. Quarterly Maintenance

SUB-STATION : DATE OF MAINTENANCE :
PTW NO: DATE :

S.NO	EQUIPMENTS	JOB DESCRIPTION	REMARKS & OBSERVATION
1.	COMPRESSORS	(i) Checking of compressor oil and replacement, if necessary (ii) Maintenance & cleaning of compressor valves, gaskets, valve plates and replacement, if necessary. (iii) Operation check of low oil level switch (iv) Cleaning and checking for seating of the breather valve (v) Checking of V-belt tightness	
2.	HYDRANT SYSTEM	(i) Cleaning of oil strainer	

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/FF.SYS/QUARTERLY

C. Half Yearly Maintenance

SUB-STATION : DATE OF MAINTENANCE :

PTW NO: DATE :

S.NO	EQUIPMENTS	JOB DESCRIPTION	REMARKS & OBSERVATION
1.	MOTORS	Tightness of terminal connections, lubrication of bearings overhauling etc	
2.	PUMPS	Adjustments of glands for leakages and tightening of nuts and bolts	
3.	GENERAL	Greasing of all valves	

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/FF.SYS/HALF YEARLY

D. Yearly Maintenance

STATION: DATE OF MAINTENANCE:

PTW NO:

S.NO	EQUIPMENTS	JOB DESCRIPTION	REMARKS & OBSERVATION
1.	COMPRESSOR DIESEL	(i) Cleaning of NRV /HP tank (ii) Checking/replacement of fuel oil filter, lube oil filter, air filter etc	
2.	ENGINE PUMPS	(i) Checking of alignment of pump set	
3.	HYDRANT SYSTEM	(i) Checking of pressure of hydrant system at the remotest end, auto starting of pumps, diesel engine etc (Pr = - Kg/cm^2) (ii) Checking of pressure gauges and replacement of defective gauges.	
4.	EMULSIFIRE SYSTEM	(i) Operation of emulsifire system, check outlet pressure, check alarm, check starting of diesel/ electrical pump. (Pr = - Kg/cm^2) (ii) Checking of detector bulbs, nozzle angle/ blocking etc	
5.	ELECTRICAL PANELS	(i) Cleaning (ii) Tightning of terminals, (iii) Checking of gaskets	
6.	GENERAL	(i) Painting of pipes, air lines, marshalling box etc	

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/FF.SYS/YEARLY

YEARLY MAINTENANCE FORMAT FOR SUB-STATION FOR FIRE ALARM SYSTEM

SUB-STATION : DATE OF MAINTENANCE : MTC. DONE BY :

PTW NO: DATE :

(i) Check for operation of fire alarm system installed at various location by Agarbati or some smoke device

(ii) Check for alarm in the control panel.

(iii) Check the condition of battery

(iv) Check for cleanliness

NOTE- Initially all the zones for fire alarm should be identified areawise and a list representing the AREA for each zone should be available in the control room.

S.NO	TYPE	LOCATION	QUANTITY	REMARKS & OBSERVATION	DATE	SIGNATURE

Sign. of Maintenance Engineer

Sign. of Substation Incharge

Format No.: SS/MAIN/FF.SYS/ YEARLY

SOS MAINTENANCE FORMAT FOR SUB-STATION FIRE PROTECTION SYSTEM

SUB-STATION : DATE OF MAINTENANCE :

PTW NO: DATE :

S.NO	EQUIPMENTS	JOB DESCRIPTION	REMARKS & OBSERVATION
1	COMPRESSOR	General Overhaul	
2	PUMPS	(i) Replenishment of grease	
		(ii) Overhauling	
3	FIRE EXTINGUISHERS	Re-filling activities of portable fire extinguishers	

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/FF.SYS/SOS

YEARLY/HALF YEARLY PROTECTION TESTING FORMAT OF PROTECTIVE RELAYS IN SUB-STATIONS

S.N	Testing of Control relay Panel (CRP)	Result
1.	Testing of auxiliary relays and circuit for bucholz relay alarm/Trip stage-1	
2.	Testing of auxiliary relays and circuit for bucholz relay Trip stage-II	
3.	Testing of auxiliary relays and circuit for pressure release device (PRD)-1	
4.	Testing of auxiliary relays and circuit for pressure release device (PRD)-II	
5.	Testing of auxiliary relays and circuit for OLTC bucholz Trip	
6.	Testing of auxiliary relays and circuit for OLTC PRV	
7.	Testing of auxiliary relays and circuit for winding temperature alarm/Trip	
8.	Testing of auxiliary relays and circuit for oil temperature alarm/Trip	
9.	Total cooling fans (RTCC panel)	
10.	Auto working of fans (with settings)	
11.	Total cooling pumps (RTCC panel)	
12.	Auto working of pumps (with settings) & thermo-syphon	
13.	Protection signals to NIFPS system (NIFPS panel)	
14.	Trip circuit healthy& supervision relay (TC-1)	
15.	Trip circuit healthy& supervision relay (TC-2)	
16.	Trip circuit healthy& supervision relay (Master trip relay)	
17.	Tripping through over current relay & testing results	
18.	Tripping through over current relay (HSU) & testing results	PS & TMS
19.	Tripping through earth fault relay & testing results	PS & TMS
20.	Tripping through earth fault relay (HSU) & testing results	PS & TMS
21.	Tripping through restricted earth fault relay & testing results	PS & TMS
22.	Tripping through differential relay & testing results	PS & TMS
23.	Tripping through differential relay (HSU) & testing results	PS & TMS
24.	Tripping through distance protection relay (Main-1 & 11) & testing results (Attach separate sheet as per Doc.No.CE/PM/OS/INST-1)	PS & TMS SETTINGS
25.	Alarm & indication circuits of the CRP	& PICKUP
26.	Trip alarm & circuit and facia indications	
27.	Non-trip alarm & circuit and facia indications	
28.	Circuit breaker OPEN/CLOSE operation from CRP & indications	
29.	Isolater/earth switch open/close position/indications on semaphores	
30.	Working of RTCC panel (remote tap changer control panel)	
31.	SF_6/Air pressure low alarm & trip block indications on CRP and circuitry	
32.	Overflux relay- Alarm and trip	
33.	Pole desrepancy circuit & indications on CRP	
34.	Bus bar protection/LBB relay (setting & operation) as per Doc.No.CE/PM/OS/INST-1	PS & TMS
35.	Low oil level Alarm (from MOG)	PS & TMS

Sign. of Protection Engineer

Format No: SS/MAIN/PROT/HALF YEARLY

YEARLY/HALF YEARLY TEST FORMAT FOR 'IN SERVICE'/NEW OIL TESTING FORMAT

OIL & DIAGNOSTIC TESTING LABORATORY, LUDHIANA

TEST REPORT

Sample No- Date of Sample receiving- Report No- ODTL/15-16/11/ Date-

Sample sent by-

Name & designation-	Reference Memo No- Date-
Organization: Address-	Condition of Sample- Remarks- Received in

EQUIPMENT DETAILS-

Sub-Station- Equipment-	Voltage Class- Sr No
Make/YOM- Capacity-	Cooling- Oil Type-

TEST RESULTS

Reference Standard: IS-1866-2000

SN	Parameter	Meas. Unit	Meas. Value	Required for in-service oil	Required for new oil	Test Method & Periodicity
1	Apperance	Color				
2	**Dielectric Strength-** Breakdown Voltage Oil temp during test Frequency (test volt) Type of Electrodes	 KV ^{0}C Hz Brass spherical		Minimum 30 (<72.5 KV) 40(>72.5KV) 50(>170KV)	Minimum 40 (<72.5 KV) 50 (>72.5 KV) 60 (>170 KV)	IEC 60156- 95 (Yearly)
3	Water Content	ppm		(Maximum) 20 (>170 KV) 30 (<170 KV) 40 (<72.5 kV)	(Maximum) 10 (>170 KV) 15 (<170 KV) 15 (<72.5 KV)	IEC-60814 -1997/ ASTM D-1533 (Yearly)
4	Total Acidity	Mg KOH/g		(Maximum) 0.3 (max)	(Maximum) 0.03 (max)	IEC62021-2/ASTM D-974(Yearly)
5	Tan Delta at 90^{0}C	^{0}C DC Volts		(Maximum) 0.2(>170KV) 0.1(<170KV)	(Maximum) 0.015(>170K) 0.01(<170KV)	EC 60247: 2004 (Yearly)
6	Specific Resistance at 90^{0}C	X10^{12} ohm-cm		(Minimum) 1 at 27^{0}C 0.1 at 90^{0}C	(Minimum) 6 at 90^{0}C	IEC 60247: 2004 (Yearly)
7	Flash Point test	^{0}C		125^{0}C (min)	140^{0}C (min)	ISO 2719/ASTM D93 (Yearly)
8	Viscosity	cSt			(Maximum) 27 at 27^{0}C	ASTM D 7483 (Yearly)
9	Pour Point	^{0}C			-6 (Maximum)	
10	Density at 29.5^{0}C	g/cm^2		(Maximum) 0.895 at	(Maximum) 0.895 at	ISO 12185/ ISO 3675
11	**DGA Test** Hydrogen H_2 Carbon dioxide Carbon Monoxide Ethylene C_2H_4 Ethane C_2H_6 Methane CH_4 Acetylene C_2H_2	ppm		Maximum 100 2500 350 50 65 120 1	Maximum 100 2500 350 50 65 120 1	IEEE- C57.104-2008 (once in a year <220 KV & every six months for > 220 KV
12	Inter-facial tension at^{0}C	mN/m		15 mN/m at 27^{0}C (min)	35 mN/m at 27^{0}C (min)	ASTM D-971-91/ IS- 60104 (Yearly)

Remarks :- SUGGESTIONS-

Tested by:- AEE/ODTL Addl. S.E/ POS

Format No: SS/MAIN/ODTL/YEARLY/HLY

TEST FORMAT FOR FRESH OIL IN DRUMS FORMAT BEFORE FILTERATION

Reference Standard: IS-

TEST RESULTS

SN	Parameter	Meas. Unit	Measured Value	Required for fresh oil (In Drums)
1 2	Appearance	Color		Clear, colorless, transparent and free from suspended matter or sediments.
	Dielectric Strength- Breakdown Voltage Oil temp during test Frequency (test volt)	KV ^0C Hz Brass spherical		Minimum 30 kV (New unfiltered)
3	Type of Electrodes	ppm		(Maximum) 50 ppm (New unfiltered)
4	Water Content	mg KOH/g		(Maximum) 0.05 mg KOH/g
5	Total Acidity Tan Delta at 90^0C	^0C DC Volts		(Maximum) 0.002
6	Specific Resistance at 90^0C	$X10^{12}$ ohm-cm		(Minimum) 150 $X10^{12}$ ohm-cm at 90^0C
7	Flash Point test	^0C		148^0C (min)
8	Viscosity	cSt		(Maximum) 40 at 20^0C
9	Pour Point	^0C		-30 (Maximum)
10	Density	g/cm^3		(Maximum) 0.89 at 29.5^0C
11	**DGA Test** Hydrogen H_2 Carbon dioxide Carbon Monoxide Ethylene C_2H_4 Ethane C_2H_6 Methane CH_4 Acetylene C_2H_2	ppm		Maximum 100 2500 350 50 65 120 1
12	Inter-facial tension at 27.0^0C	mN/m		40 mN/m at 27^0C (min)
13	PNA Analysis	Vol. percent Paraffinic Naphthenic Aromatic		Paraffinic <46 Naphthenic>46 Aromatic <8
14	Oxidation Stability Test -164 hr@ 100^oC a)Neutralisation Val b)Total Sludge	KOH %age Weight		0.40Mg KOH/g (Max) 0.10% by weight (Max)
15	Ageing Characteristic Test- (96 hrs with Copper catalyst) a)Sp. Resis. at 90^0C b)Tan Delta at 90^0C c)Total Acidity d)Total Sludge	$X10^{12}$ ohm-cm Mg KOH/g %age Weight		0.2 $X10^{12}$ ohm-cm at 90^0C (Min) 0.20(Max) 0.05 (Max) 0.05% by weight (Max)
16	Corrosive Sulphur			Non- Corrosive

Format No: SS/MAIN/ODTL/FRESH

HALF YEARLY MAINTENANCE FORMAT FOR SUB-STATION FOR FIRE EXTINGUISHERS

SUB-STATION : DATE OF MAINTENANCE : MTC. DONE BY :

PTW NO: DATE :

(i) Check for fully charged Catridge & change if necessary.

(ii) Check for quality of charge & refill if required.- SOS

(iii) Check if ready for operation

(iv) Check for cleanliness.

(v) Seal using lead seal.

S.N	TYPE	LOCATION	QUANTITY	REMARKS & OBSERVATION	DATE	SIGNATURE

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/FE/HALF YEARLY

MONTHLY MAINTENANCE FORMAT FOR SUB-STATION DG SET

DG SET NO :	DATE OF MAINTENANCE :	MTC. DONE BY:
DG SET CAPACITY:	PTW NO/DATE:	RUNNING HOURS OF DG SET -:

S.NO	EQUIPMENTS	JOB DESCRIPTION	REMARKS & OBSERVATION
1	LUBRICATING SYSTEM	Checks for oil leaks	
2	COOLING SYSTEM	Checks for radiator air blocking and coolant level	
3	AIR INTAKE SYSTEM	Checks for air leaks	
4	MAIN GENERATOR	Checks for air inlet restrictions	
5	GENERAL	Battery Voltage & Specific Gravity Measurement.	

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/DG SET/MONTHLY

YEARLY/ 2 YEARLY/ SOS MAINTENANCE FORMAT FOR SUB-STATION DG SET

DG SET NO :	DATE OF MAINTENANCE :	MTC. DONE BY:
CAPACITY:	PTW NO/DATE:	RUNNING HOURS OF DG SET:

SN EQUIPMENTS	JOB DESCRIPTION	REMARKS & OBSERVATION
	YEARLY	
1. COOLING SYSTEM	Check for Fan hub, Drive pulley and Water pump Replacement of Air Cleaning Element	
2.AIR INTAKE SYSTEM	Checks for governor linkages, fuel transfer pump, fuel line connections	
3. FUEL SYSTEM	Drain sediments from fuel tank, change fuel filter and clean fuel tank breather.	
4. MAIN GENERATOR	Checking for electrical connections for tightness. Stator winding IR measurement Checking / cleaning of slip ring & its brushes.	
5. EXHAUST	Check for air leaks & exhaust restriction	
6. GENERAL	Tight Exhaust Manifold and Turbo charger Cap screw Check for rusting and package casing and rectification	
	2 YEARLY	
1.MAIN GENERATOR	Testing of protection/ control relays and alarms	
2.LUBRICATING SYSTEM	SOS	
3. AIR INTAKE SYSTEM	Replacement of oil filter after recommended running hours	
4 GENERAL	Cleaning of air filter Overhauling of DG set as per manufacture's recommendations	

Sign. of Maintenance Engineer   Sign. of Substation Incharge

Format No.: SS/MAIN/DG SET/YEARLY

YEARLY/ 2YEARLY/ SOS MAINTENANCE RECORD FOR LT/HT SWITCHGEAR

Bay Location- DOC- Make/Model- Rating-
Cabinet Sr No- Date- PTW No (if taken)-
1). Section-I/II/Bus Coupler...................... 2). L.T. TRF No......................................
I. YEARLY

A. LT/HT PANELS
a) Cleaning of Panels, Bus Bars Insulators etc.
b) Checking of indicating meters
c) Checking for change over facility

B. LT TRANSFORMER/TERTIARY TRANSFORMER
(Details-Sr. No:- Make:- DOC: YOM:-
a) Test oil of LT Transformer for BDV

C. LT/HT SWITCHGEARS
a) Tightness of all electrical Power & Control Cable connection
b) Cleaning of insulators of CT/PT/Isolators / MV CBs and Tightness of Terminal Connection.
c) Checking of alignment of isolators
d) Functional Checks (Trip/Close).

II. YEARLY
A. LT/HT PANELS
1. Relay Checking and TRIP TEST

MAKE/TYPE	Setting Values		Actual operating Values	
SR. NO.	Volt/Current	Time delay (TMS)	Volt/Current	Time delay (TMS)

(a) O/C Relay
(b) E/C Relay
(c) U/V Relay

B. LT TRANSFORMER/ TERTIARY TRANSFORMER
a) IR measurement check
b) Testing of OTI/WTI & Buchholz relay for L.T. Transformer (where ever applicable)

III SOS
1. Measurement of operating timings of 33/11kV Cbs.

Sign. of Maintenance Engineer Sign. of Substation Incharge

Format No.: SS/MAIN/LT SWGR/YEARLY

PLCC EQUIPMENT MAINTENANVE RECORD

Bay Location- DOC- Make/Model- Rating-
Cabinet Sr No- Date- PTW No (if taken)-
Name of Line/Direction................................

(A) YEARLY MAINTENANCE - S/D Activity

(a) General Cleaning of Cabinets.
(b) Checking of healthiness of ventilation fans in Cabinet.
(c) Level Measurements

TEST POINTS (T.P.)	SPEECH		PROTECTION-I		PROTECTION-II	
OF MESUREMENTS	Tx	Rx	Tx	Rx	Tx	Rx

S.N.	MAINTENANCE ACTIVITY
1.0	POWER SUPPLY MEASUREMENTS
1.1	INPUT VOLTAGES
1.2	STABILISED DC VOLTAGES
2.0	TRANSMITTER CHECKS
2.1	FM OSCILLATOR- Frequency measurement
2.2	AM OSCILLATOR- Time measurement
2.3	OUTPUT LEVEL MEASUREMENT
3.0	RECEIVER CHECKS
3.1	Receiver level FM
3.2	Receiver level AM
4.0	ALARM CHECKS Check Alarm Contacts with Buzzer/ Ohm meter after inserting test plug ”IN POSITION”
5.0	TRANSMISSION OF PROTECTION CODE
	CODE I
	CODE II
	CODE III
6.O	RECEIPT OF PROTECTION CODE
	CODE I
	CODE II
	CODE III
7.O	LOOP TEST/REFLEX TEST

Note: This is only a guide line. The format to be modified as per actual PLCC system available at site.

Sign. of PLCC/(T&C) Engineer Sign. of Substation Incharge

Format No: SS/MAIN/PLCC/YEARLY

Subject- Formulation of standard procedure for reporting to NRLDC by Punjab STU under section 5.9 of IEGC

In the 30th Protection Committee Meeting of NRPC held on 21st September 2015 at New Delhi, the Member Secretary/NRPC & NRLDC had taken a serious view of non-compliance of sections 5.2.r and 5.9.6.c (VI) and CEA grid connectivity standards 15.3 by Punjab STU. NRLDC had cautioned that in case of repeated violations, matter will be taken to CERC. As per their suggestion PSTCL (i.e Punjab STU) has framed a standard reporting procedure, so that timely inputs are available to NRLDC for proper fault analysis.

In case of all trippings at 400 KV sub-stations, the *indication on relays along with DR& EL* records should be sent to centralized e-mail address by concerned Sr XEN/P&M for further transmission to NRLDC within 24 hours as per section 5.9.5 of IEGC. The detailed report as per section 5.9.6 of IEGC will be submitted to NRLDC by ASE, POS, Ludhiana within 15 days.

In case of 220 KV elements (i.e transmission lines & Transformers), the *indication on relays* along with preliminary report should be sent to centralized e-mail address by Sr XEN/P&M for giving preliminary information to NRLDC within 24 hours as per section 5.9.5 of IEGC. But if it is a case of multiple element trippings, mal-operation or non-operation of required relays or delayed clearance of faults as per section 5.9.5 of Indian Grid Code, the *detailed report* should be send by the concerned Sr XEN/Protection to centralized e mail address of ASE/POS for onward submission to NRLDC as per section 5.9.5 of IEGC.

The centralised e-mail addresses for sending such information is srxen-prot2-ldh@pstcl.org & xenprotectionludhiana@yahoo.in as already intimated by C.E/P&M vide probable memo no- 3430/37/DRP-23, Dated 23-4-14 to all Dy C.E's/P&M and NRLDC, New Delhi.

REPORT FORMAT DEVISED BY NRLDC FOR FINAL TRIPPING ANALYSIS IN CASE OF MULTI-ELEMENT TRIPPINGS- TO BE SUBMITTED BY SR XEN/PROTECTION OR SR XEN/P&M

1. Confirm the actual load loss
2. Reason of bus fault
3. Action being taken to prevent such incident in future
4. Reason of delayed clearance of fault as per IEGC
5. Detailed report from Sr XEN/Protection in following format of IEGC-
    a. Time and date of event (GPS Sync time)
    b. Location
    c. Plant and/or Equipment directly involved
    d. Single line diagram showing the connection (isolators) of various 220 KV lines, bus coupler, ICT's etc
    e. Description and cause of event
    f. Antecedent conditions of load and generation, including frequency, voltage and the flows in the affected area at the
    g. Time duration of tripping including Weather Condition prior to the event
    h. Duration of interruption and Demand and/or Generation (in MW and MWh) interrupted
    i. All Relevant system data including copies of records of all recording instruments including Disturbance Recorder, Event Logger, DAS etc of DPR's of affected lines at Ablowal end
    j. Sequence of trippings with time.
    k. Details of Relay Flags
    l. Remedial measures

Sign. of Sr XEN/Protection Engineer

Format No: SS/MAIN/NRLD REPORT/GEN/FAULT REPORT

EQUIPMENT FAILURE REPORT (EFR)

The need was felt for standardisation of reporting of equipment failure, to be followed uniformly by all sub-stations and transmission line S/D's. Equipment failure report (EFR) has been introduced for reporting of any type of failure in equipments and is the first information of failure to be reported by S/S or TL Unit to circle, zone or OS.

FILLING PROCEDURES FOR EQUIPMENT FAILURE REPORT

When to fill EFR

Each EFR to be given a specific report no, first abbreviated name of S/S (five letters) & Circle (three letters) , then failed equipment and then year of manufacture eg. for Ablowal S/S (Patiala circle) Report NO. may be 1/ABLOW/PAT/CT/96, dated- Date of failure.

Whenever there is a failure of any sub-station main equipments or part of any equipment during operation and maintenance which leads to outage of said equipment, EFR are to be filled up.

Report no: Date of report:

Date of failure:

Reporting S/S or TL unit

Division:

Circle:

Name of station (where equipment failure occurred):.

Date and time of occurrence/discovery:

Fault discovered during

Appropriate box to be marked X during which fault was discovered.

TESTING

COMMISSIONING

OPERATION

MAINTENANCE

RE-COMMISSIONING

Subsystem (station part)

Appropriate box to be marked X in which sub-system, fault has occurred/discovered. Specify the name of equipment in others, if not specifically mentioned: .

A/C & VENTILATION	D.C.SYSTEM	L T SWITCHGEAR
AUX. POWER	FIRE PROTECTION	PLCC
RELAY PANEL	ILLUMINATION	TELEPHONE EXCHANGE
CONTROL PANEL	OTHERS	YARD EQUIPMENT

Main equipment type

Put a X mark in appropriate base, representing main equipment, If not covered, then specify.

ARRESTER	CURRENT TRANSF.	EVENT LOGGER
BREAKER	COUPLING CAPACITOR	FAULT LOCATOR
BATTERY	CVT/PT	ISOLATOR
BUS BAR	EARTH SWITCH	METERING EQUIPMENT
CHARGER	DIST.RECORDER	REACTOR
CABLING	D G SET	TRANSFORMER
OTHERS		WAVE TRAP

Manufacturer/supplier:-

Faulty Unit:

Type of faulty unit/equipment as given by manufacturer to be specified eg. In Breakers, it could be SF6 3AT3/3AT2; SF6 HPL, ABCB DLF 245 NC2 etc.

- Item designation is bay name in which faulty equipment was located/erected.
- Sr.No. & Batch No. as given on equipment name plate to be given.

Faulty component in unit

Appropriate box to be marked X.

ACCUMULATOR	PORCELAIN INS	REACTOR
BUSHING	MOTOR	SUPPORT STRUCTURE
CABLE	OIL	SWITCH
CAPACITOR	FUSE	WINDING
CONTACT	GAS	CLAMPS& CONNECT RELAY
EARTHING SYSTEM	PCB	RESISTOR
OTHERS		

Part No. as per part list/O&M manual of manufacturer to be given and name of faulty item to be described in brief.

Type of failure

Appropriate box to be put X mark. Specify, if not covered by type of failure given.

FLASH OVER	MAL OPERATION	OPERATOR ERROR
BURNED	MECHANICAL	SETTING
LEAKAGE	FAULT	SHORT CIRCUIT
OTHERS	OPEN CIRCUIT	UNKNOWN

Action taken

Appropriate box to be marked X.

RESET	REPLACED	REPAIR	
PENDING	DEFFERED MAINTENANCE		DESIGN CHANGE

Description of fault

Short/Brief description of occurrence of fault and cause thereof may be given.

Ref to documents

Reference of document from which part no. or fault diagnosis has been done, to be specified so that it may help in analysis of fault. It could be manufacturer part list manual, O&M manual or P Manual, as the case may be.

Tripping/Outage report no.

Equipment failure may occur during tripping due to suspected fault/malfunctioning of some other equipment. Report no. thereof to be specified.

General Remarks

The document should be signed by Maintenance Engineer and countersigned by substation in charge. It is AAE & SSE for all 220 or 132 kV stations & AEE & sr XEN for 400 kV stations.
Distribution of EFR to be done as per list on the format.

Sign. of Maintenance Engineer (AAE or SSE)	Sign. of Substation Incharge (AEE or Sr XEN)

Copy to:
1. CE/P&M (OS Wing), Ludhiana
2. Dy CE/P&M (O&M), respective circle
3. ASE/P&OS, Ludhiana
4. Sr XEN/P&M (concerned)

PRE-COMMISSIONING PROCEDURES AND FORMATS FOR SUBSTATION BAY EQUIPMENT

Volume IV

Doc.No.CE/PM/OS/INST-4

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

Head office- The Mall, Patiala








CONTENTS

1.0 PRE-COMMISSIONING PROCEDURES FOR SUB-STATION EQUIPMENT

1.1 Introduction

Pre-commissioning checks/ tests are the activities carried out to ascertain the correctness, completeness of installation and healthiness of the equipment before its energization. These checks/ tests are to be carried out by protection and T&C teams of PSTCL.

1.2 Constitution of commissioning team

1.2.1 A Commissioning team should be constituted to oversee/coordinate for the pre-commissioning tests and charging of the equipment. In case of Substation/power transformer or bay erected by costruction wing, commissioning team shall consist of following:

(i) ASE/Sr XEN/ Grid Construction or TLSC (executing the work)
(ii) ASE/Sr XEN/ P&M (concerned) (iii) ASE/Sr XEN/Protection (concerned)
(iv) ASE/Sr XEN/T&C (Communication) (v) ASE/P&OS (except 66 KV bays)

1.2.2 The responsibilities of the commissioning team are to review the pre-commissioning test results and clear the equipment for energization, go through statutory clearances and standing instructions before initial charging of new equipment, witness final commissioning tests and test charging, investigate failure of equipment during test charging, if any, to list out deviations/exception/incomplete work, for acceptance or rejection. Proper documentation should also be ensured by the commissioning team for future reference.

1.2.3 The results of all pre-commissioning tests after erection of individual equipment as per guidelines issued by company in line with manufacturer's recommendation, carried out jointly by the execution agency in association with Protection team shall be put up to the Commissioning Team for its acceptance and clearance for charging.

1.2.4 The commissioning team shall examine the following statutory and other clearances obtained for test charging of the equipment/transmission line at rated voltage:

Statutory Clearances:

a) Chief Electrical Inspector's clearance (provisional or final) for charging transmission line/bay equipment as per I.E. rules.
b) Written clearance by concerned Sr XEN/ Protection
c) Written clearance by Sr XEN/POS for EHV line bays and power transformers (related to testing by ODTL and OS wings).
d) Sub station I/C of P&M to give clearance regarding isolation from earthing, men & material

Other Clearances:

a) Charging instruction from SLDC.

b) Relay setting details from OS wing.

1.2.5 The team shall also go through the factory test reports. If such tests have been repeated during pre-commissioning, the team shall list out deviations, if any, in the results of re-commissioning tests with respect to the factory tests.

1.2.6 After all pre-commissioning checks and tests are found to be acceptable taking into account permissible deviation limits, the commissioning team, in consultation with S.E/ Dy C.E/P&M, shall give clearance for commissioning as per Doc. No. CE/PM/ OS/INST-1 & Doc. No. CE/PM/OS/INST-5.

1.2.7 In case of deviation in commissioning test results beyond permissible limit as per guidelines/standards in vogue, the commissioning team shall submit its report along with recommendations to C.E/P&M. In such an event, the test charging will be carried out only after obtaining approval of Head of P&M organization as per Doc. No. CE/PM/OS/INST-1 & Doc. No. CE/PM/OS/INST-5.

1.3 Safety

All measures and precautions should be undertaken to prevent occurrence of unsafe acts. All the personnel involved should be thoroughly apprised about the safe procedures to be adopted while performing various activities including carrying out tests in the switchyard. Instructions as per PSTCL safety manual should be complied.

Warning signs and safety barriers should be positioned in conformity to IE rules as amended from time to time.

1.4 General Procedures during Pre-commissioning of Substation Bay Equipment

All the equipment after erection/assembly at site, should be tested in order to check that it has not been damaged during transportation, erection or assembly to such an extent that its future operation is risky. The significance of various tests with brief procedure has been elaborated in the subsequent sections of this document. Regarding the detailed testing methods/procedures for conducting various pre-commissioning tests refer to all the documents in this manual.

1.5 Documentation

The results of the test shall be documented on the test record formats as mentioned below, which are also part of this documentation:

FORMAT	EQUIPMENT
No. CP/CT/01/PCT	CURRENT TRANSFORMER
No. CP/CVT/02/PCT	CVT
No. CP/BAY/03/PCT	BAY/FEEDER
No. CP/SA/04/PCT	SURGE ARRESTOR
No. CP/CB/05/PCT	CIRCUIT BREAKER
No. CP/ICT/06/PCT	ICT
No. CP/SR/07/PCT	SHUNT REACTOR
No. CP/ISO/08/PCT	ISOLATOR/GROUND SWITCH
No. CP/WT/09/PCT	WAVE TRAP

These formats have all the possible testing procedures & documentation to be performed at site before charging. Switching and operational activities will be recorded in regular manner in the operator's logsheet. Copies of this log, notes on special observations from inspections and other measurements will constitute the test records. The test records had to be signed by the responsible officer of the testing team.

2.0 TRANSFORMER AND REACTOR

2.1 Following points to be checked after Receipt of transformer/reactor at site:

2.1.1 N_2 pressure and dew point to be checked after receipt of transformer at site. It should be within permissible band (as per graph provided by manufacturer as per Fig-1)

2.1.2 The data of impact recorder shall be analyzed jointly in association with the manufacturer wherever it is installed. In case the impact recorder indicates some serious shocks during shipment, further course of action for internal inspection, if necessary shall be taken jointly. Impact recorder should be detached from the transformer/reactor preferably when the main unit has been placed on its foundation.

2.1.3 Oil samples shall be taken from oil drums/tanker received at site and sent to oil testing Lab (ODTL) for oil parameter testing. The copy of test certificates of routine testing at supplier should be available at site for comparison of test results.

2.1.4 Unpacking and inspection of accessories should be carried out taking all precautions so that the tools used for opening do not cause damage to the contents. Fragile instruments like oil level gauge, temperature indicators, etc. are to be inspected for breakage or other damages. Any damaged or missing components should be reported to equipment manufacturer, so that the same can be investigated or shortage made up as per the terms/conditions of the contract.

2.1.5 Core Insulation Test shall be carried out to check insulation between Core (CC & CL) and Ground. (Not applicable for Air Core Reactors).

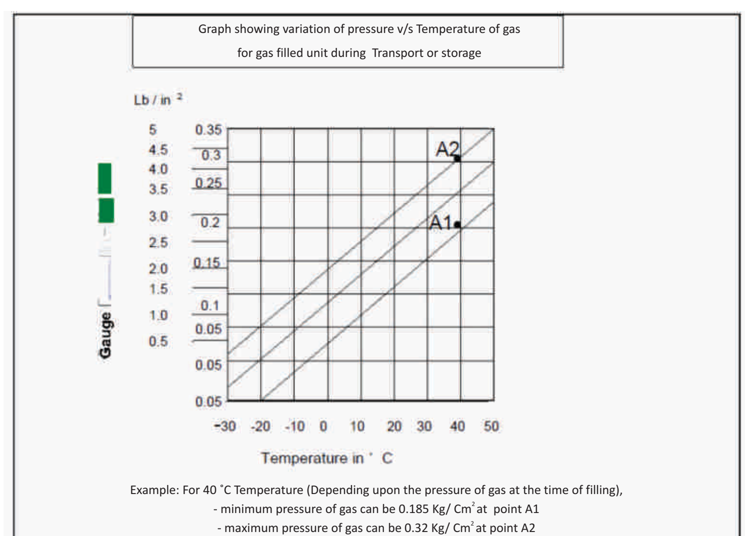


Figure-1 : Graph depicting variation of N_2 gas pressure w.r.t temperature

After receiving the accessories at site same should be inspected and kept ready for immediate erection:

- If erection work can not start immediately due to some reasons, then accessories should be repacked into their own crates properly and packing list should be retained.
- All packings should be kept above ground by suitable supports so as to allow free air flow underneath. The storage space area should be such that it is accessible for inspection and water does not collect in that area and handling/transport is easy. Proper drainage arrangement in storage areas to be ensured so that in no situation, any component get submerged in water due to rain, flooding etc.
- Immediately after the receipt of main unit and accessories, same should be inspected & if found satisfactory, the unit should be erected completely and filled with dry transformer oil as per the instructions.
- It is preferable to store the main unit at its original location/foundation. Only, if the foundation is not likely to be ready for a long time, then suitable an action plan has to be taken from the manufacturer regarding proper storage of the Main Unit.
- If the transformer/reactor is to be stored up to three (3) months after arrival at site, it can be stored with N_2 filled condition. N_2 pressure should be monitored on daily basis by construction personnel so that chances of exposure of active part to atmosphere are avoided. In case of drop in N_2 pressure, dew point of N_2 has to be measured to check the dryness of the transformer/reactor.
- In case of storage of transformer in oil-filled condition, the oil filled in the unit should be tested for BDV and moisture contents, once in every three months. The oil sample should be taken from bottom valve. If BDV is less and moisture contents are more than the prescribed limits, then oil should be filtered.

2.1.7 During erection, the exposure of active part of transformers should be minimized. Further either dry air generator should be running all the time or dry air cylinders may be used to minimize ingress of moisture. The transformer should be sealed off after working hours. It is practical to apply a slight over-pressure overnight with dry air or N_2 inside– less than 300 mbar (30 kPa or 0.3 atmospheres). Next day the pressure be checked and suspected leaks should be detected with leakage detection instruments, soap water or with plastic bags tightened around valves (being inflated by leaking air)

For oil filled units whenever oil is drained out below the inspection covers, job will be treated as exposed. Other exposure activities are as below:

- Bushing erections
- Internal jumper connections of Bushings
- Fixing bushing turrets on side
- Fixing bushing turrets on cover
- Core insulation checking
- Buchholz relay pipe work fixing on cover
- Gas release pipes/equaliser pipe fixing
- Entering inside the tank for connections/inspection etc

For transformers with a gas pressure of 2.5- 3 PSI, the acceptable limits of dew point shall be as under: (Source: Courtesy BHEL, Bhopal)

Temperature of insulation in °C	Maximum permissible dew point in °C
-17.77	-61.11
-15.0	-58.88
-12.22	-56.66
-9.44	-54.44
-6.66	-52.22
-3.33	-49.99
-1.11	-47.22
+1.66	-44.44
+4.44	-42.22
+7.44	-39.39
+9.99	-37.22
12.77	-34.99
15.55	-32.77
18.33	-29.99
23.11	-27.77
23.88	-25.55
26.66	-23.33
29.44	-21.11
32.22	-18.33
34.99	-16.11
37.75	-13.88
43.33	-8.88
48.88	-3.88
54.44	+0.55
59.99	+5.55

TABLE-1: Variation of dew point of N_2 gas filled in transformer tank w.r.t temperature

2.2 Insulating Oil

Oil is dispatched to site or store separately in sealed steel drums. The oil to be used for filling or topping up must comply with oil specification prescribed by PSTCL. Technical specification for acceptance criteria, before oil is accepted, should be complied. samples have to be taken and checked with respect to dielectric strength & dielectric losses. The latter is very important because dirty transportation vessels can significantly contaminate the oil. High dielectric losses cannot be removed by filter treatment and such lots have to be rejected. If the oil is supplied in railroad or trailer tanks, one or two samples are sufficient. If the oil is delivered in 200 litres drums, the following scheme for checking is recommended.

Number of drums delivered	No. of drums to be checked
2 to 5	2
6 to 20	3
21 to 50	4
51 to 100	7
101 to 200	10
201 to 400	15

However, before filling oil, each drum has to be physically checked for free moisture and appearance. In case of any doubt, the number of drums to be checked should be increased. A site register should be maintained to indicate the number of drums supplied in each lot as per PO and the number of drums of each lot used in filling a particular Transformer/Reactor. The oil test results carried out should also be recorded in register.

2.2.1 Samples from Oil Drum

Check the seals on the drums. Each drum should first be allowed to stand with bung (lid) vertically upwards for at least 24 hours. The area around the bung should be cleaned & clean glass or brass tube long enough to reach upto 10 mm of the lower most part of the drum should be inserted, keeping the uppermost end of the tube sealed with the thumb while doing the activity. Remove the thumb, thereby allowing oil to enter the bottom of the tube. Reseal the tube and withdraw an oil sample. The first two samples should be discarded. Thereafter, the sample should be released into a suitable container.

2.2.2 Parameters of Transformer Oil

The oil as received at site for filling and topping up in the transformer must comply with oil specification given in PSTCL document Doc.No.CE/PM/OS/INST-4 for acceptance.

The oil sample from the transformer tank, after filling in tank before commissioning should meet the following specifications as per IS:1866–2000 (latest Revision):

Table-2

SN	Property	Highest Voltage of Equipment		
		<72.5 kV	72.5 – 170 kV	>170 kV
1.	Breakdown Voltage (BDV) (kV rms)-Minimum	40	50	60
2.	Moisture content – (ppm) Max	15	15	10
3.	Dielectric Dissipation Factor (Tan δ) at 90ºC and 40-60Hz -Max	0.015	0.015	0.01
4.	Resistivity at 90 ºC-Min (x 10^{12} ohm-cm	6	6	6
5.	Interfacial Tension (mN/m) -Min	35	35	35
6.	Viscosity at 27ºC-Max – cSt	27	27	27
7.	Density at 29.5ºC gm/cm (Max)	0.89	0.89	0.89
8.	Flash point ºC – Min	140	140	140
9.	Pour point ºC – Max	-6	-6	-6
10.	Neutralization Value mg KOH/gm of oil (Max)	0.03	0.03	0.03
11.	Oxidation Stability of Uninhibited Oil			
a.	Neutralization Value mg KOH/gm of oil –Max	0.4	0.4	0.4
b.	Sludge percent by mass – Max	0.1	0.1	0.1
12.	Oxidation Stability for Inhibited Oil	Similar values as before filling		

2.3 Oil Filling

Introduction:

For transformers dispatched with gas filled, from the works of manufacturer, the filling of oil inside the tank is done under vacuum. Transformers of high voltage ratings and their tanks are designed to withstand full vacuum. Manufacturer's instructions should be followed regarding the creating of full vacuum during filling the oil in the tank.

<u>Final tightness test with vacuum</u> (i.e. leakage test or Vacuum Drop Test):

Before the oil filling is started, final check is made of the tightness of the transformer tank by applying vacuum. When any vacuum is applied to a transformer, without oil, a leakage test must be carried out to ensure that there are no leaks on the tank which can result in wet air being drawn into the transformer. The procedure is as follows:

a. Connect the vacuum gauge to a suitable valve of the tank (vacuum application and measurement should be performed only on top of the main tank).
b. Connect the vacuum pump to another opening and apply vaccum.
c. Evacuate the transformer/reactor tank until the pressure is below 3 mbar (0.3 kPa or about 2 mm of Hg)
d. Shut the vacuum valve and stop the pump.
e. Wait for an hour and take a first vacuum reading–say P1
f. Take a second reading 30 minutes later-say P2
g. Note the quantity of oil required, according to the rating plate, and express as volume 'V' in m^3.

The maximum permitted leakage is 20 bar x litres/ second.

Take the difference between P2 and P1, and multiply this with the oil quantity V. If the pressures are expressed in kPa, and the oil quantity is in m^3, then the product shall be less than 3.6.

$(P2 – P1) \times V < 3.6$

The transformer is then considered to be holding sufficient vacuum and is tight.

Continued readings (at least 2 to 3) at successive 30 minutes intervals may be taken to confirm the results.

If the leak test is successful, the pumping will be continued, until the pressure has come down to 0.13 kPa or less. The vacuum shall then be held for the time specified by manufacturer before the oil filling is started. If the specified vacuum cannot be reached, or if it does not hold, the leak in the transformer system shall be located and rectified. This vacuum should also maintained during the subsequent oil filling operations by continuous running of the vacuum pumps.

When filling a transformer with oil it is suggested that the oil should be pumped from the bottom of the tank through a filter press or any other reliable oil drying & cleaning device should be interposed between the pump and the tank. In case the transformer has an On Load Tap Changer (OLTC), then while evacuating the main transformer tank, the diverter switch compartment may also be evacuated simultaneously so that no undue pressure is allowed on the tap changer chamber. While releasing vacuum, the tap changer chamber vacuum should also be released simultaneously. For this one pressure equalizer pipe should be connected between main tank and the tap changer. Manufacturer's instruction manual should be referred to protect the air cell/diaphragm in the conservator during evacuation.

The oil must pass from the oil tanker or settling tanks, through an oil conditioning plant to the top oil filter valve (please refer Figure-2) and the oil must conform to the PSTCL- transformer oil specifications.

The oil flow at the entry valve must be controlled to maintain a positive pressure above atmospheric and to limit the flow rate if necessary to 5000 litres/hour or a rise in oil level in the tank not exceeding one metre/hour (as measured on the oil level indicator). Continue oil filling until the level reaches approximately 200 mm above the ambient oil level indicated on the magnetic oil level gauge in the expansion vessel. Then, release the vacuum, with dry air of dew point -40^0 C or better.

The diverter tank can now be topped up at atmospheric pressure. Reconnect oil outlet hose to valve on flange on tap changer diverter head. Reinstate breather and very slowly top up the diverter switch such that the correct level is reached in the diverter expansion vessel. In the event the expansion vessel is overfull drain oil from flange into a suitable container until the correct level is reached.

When the vacuum filling of the transformer and diverter tank is complete, the cooling system/radiator bank can be filled (WITHOUT VACUUM) at atmospheric pressure, via an oil processing plant. Oil must be entered, very slowly, through the bottom cooler filter valve, with the cooler vented at the top and the top cooler filter valve unblanked and open to atmosphere. As the oil level reaches the vents and open valve, close off and shut down the processing plant.

Note: Care must be taken not to pressurise the coolers/ radiators

On completion, open the top cooler isolating valve in order to equalise the pressure in the cooler with the transformer tank. This will also allow contraction or expansion of the oil as the ambient temperature changes.

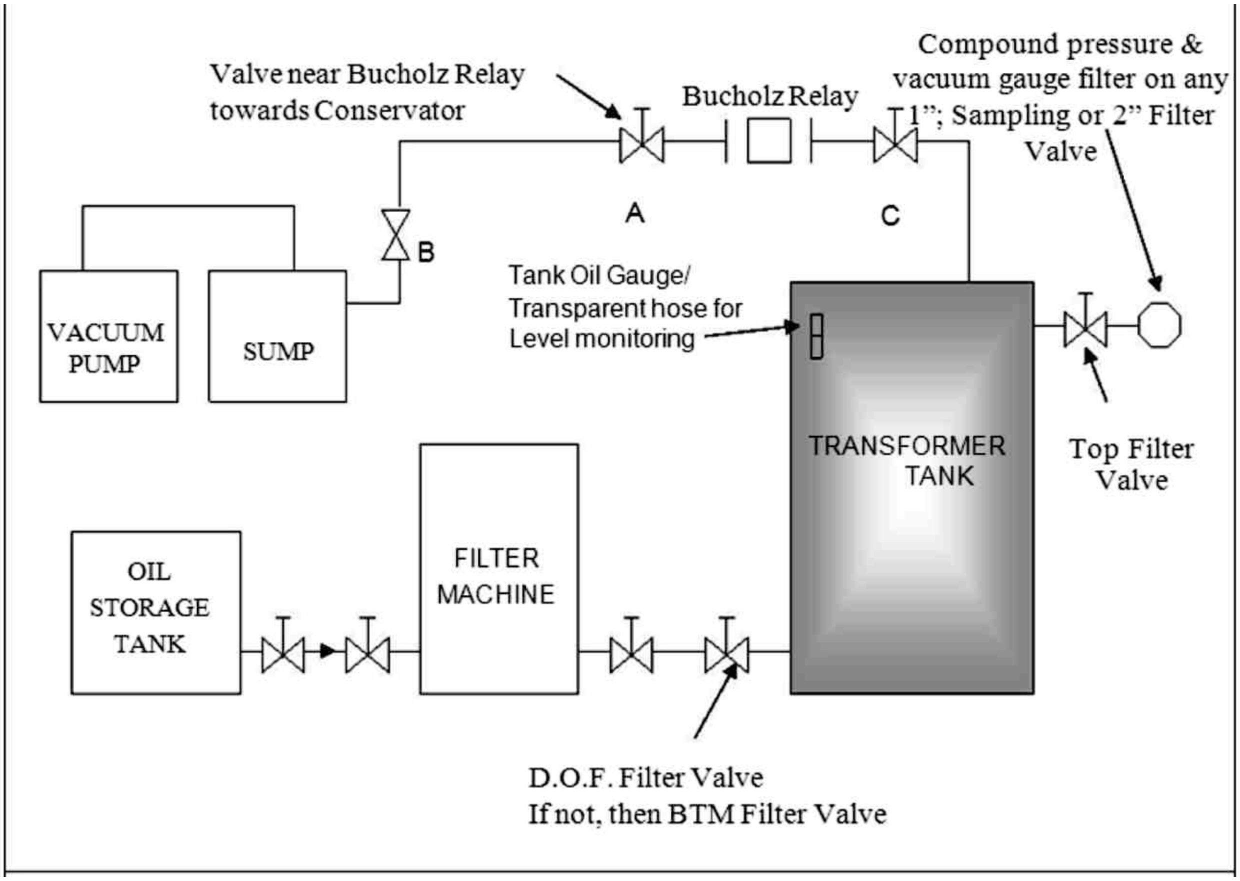


Figure-2 :Arrangement for Evacuation and Oil filling upto tank Oil gauge & Conservator

Before oil filling into conservator inflate the air cell to 0.5 PSIG i.e 0.035 kg/cm^2 maximum slightly by applying pressure (N^2/Compressed dry air) so that it can take shape. Release pressure. Fit breather pips but do not fit breather in position, instead put wire mesh guard over and flange of the pipe. This will ensure free air movement from the air cell to the atmosphere. Use flow meter/indicator on outlet of the filter machine and regulate the flow using the valve to limit oil filling rate to 2000 litres/hour (max.).

In case filter capacity is more push oil slowly into conservator through the transformer via valve No.5 as shown in fig-3 (valve 2, 3 & 4 to remain open) till the oil comes out first through valve Nos.2 & 3 (then close these valves) and then through valve No.4. Allow some oil to come out freely through valve No.4 to the atmosphere. This will ensure that air inside the conservator is expelled out and the space surrounding the air cell is full of oil. Then close valve No.4. During all these operations let valve No.1 to be in closed position.

For draining out oil, drain oil from the conservator by gravity only through valve No. 1 or through drain valve of the transformer via valve No. 5. Do not use filter machine to drain out oil from the conservator tank. Also do not remove buchholz relay and its associated pipeline, fitted between the conservator and the transformer tank while draining oil. Stop draining oil till indicator of magnetic oil level gauge reaches position-2 on the dial, which corresponds to 30°C reading on the oil temperature indicator

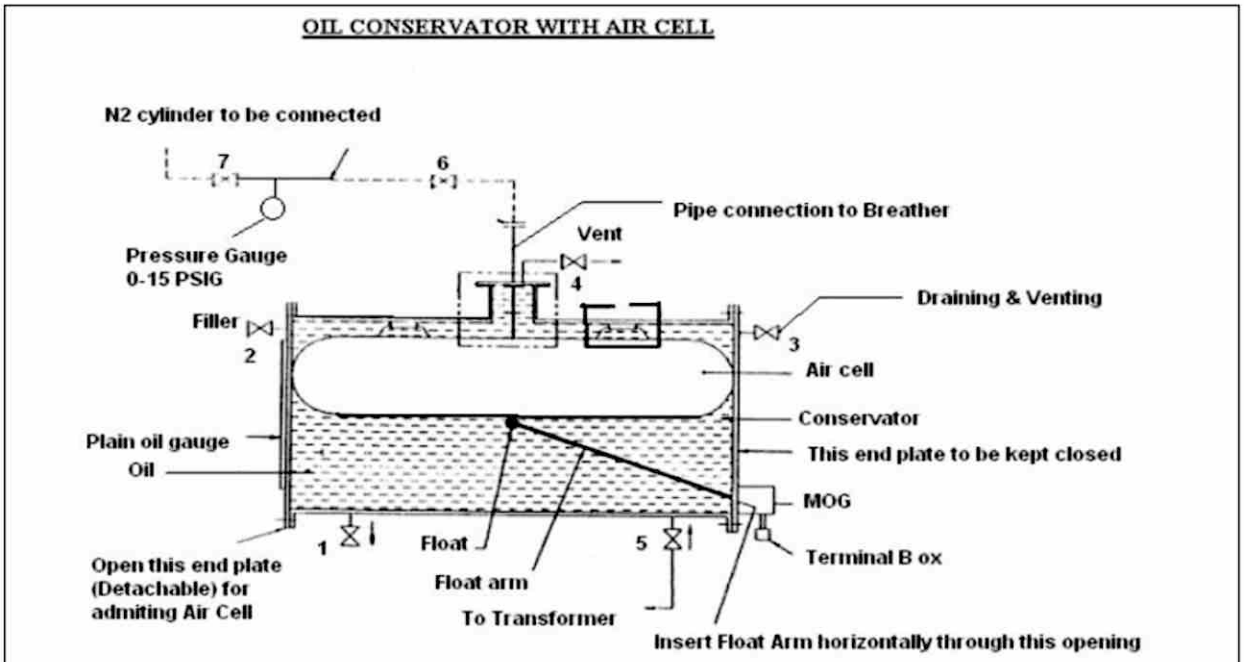


Figure-3 : General Arrangement For Oil Conservator

After oil filling, hot oil circulation has to be applied to all the transformers/reactors except under the circumstances when active part of transformer/reactor gets "wet". Following conditions can be considered to define the "Transformer/Reactor as wet":

1. If Transformer/ Reactor is received at site without positive N^2 pressure.
2. If dry air not used during exposure while doing erection activities
3. Overexposure of active part of transformer/reactor during erection
4. Overexposure(i.e when exposure > 12 Hrs)

Under above mentioned conditions, manufacturer shall take necessary action for effective dry out of the transformer/reactor.

2.4 HOT OIL CIRCULATION USING HIGH VACUUM OIL FILTER MACHINE

To ensure total impregnation and absorption of possible trapped gas bubbles, the oil in the tank should be circulated through the vacuum filter and with circulation direction as shown in Fig- 4.

The circulation procedure for the main tank is as follows:

2.4.1 The transformer/Reactor is connected to the filter in a loop through the upper and lower filter valves. The direction of circulation shall be from the filter to the transformer at the top and from the bottom of the transformer to the filter.

2.4.2 The temperature of the oil from the filter to the transformer should be around 60˚C and in no case it should go beyond 70˚C otherwise this may cause oxidation of oil.

2.4.3 The circulation shall proceed until a volume of oil has passed through the loop corresponding to 2 times the total oil volume in the tank. (At freezing ambient temperature, the circulation time is increased: circulate 3 times the volume at temperature down to minus 20˚C, increase to 4 times below that temperature).

The oil will be circulated through a vacuum filtration machine till the parameters are attained as per IS 1866 - 2000, Table-3 below:

KV CLASS	B.D.V (KV) (Min)	Moisture (Max) * (ppm)	Tan Delta (MAX) * (90 Deg C)	Resistivity (Min) * (Ohm-Cm)	IFT at 27 Deg. (Min)* N/m
> 170 KV	60	10	0.010	6×10^{12}	0.035
< 170 KV But > 72.5 KV	50	15	0.015	6×10^{12}	0.035
< 72.5 kV	40	20	0.015	6×10^{12}	0.035

Table-3

* The limiting values given in the above table-3 to be revised as per revision in IS 1866

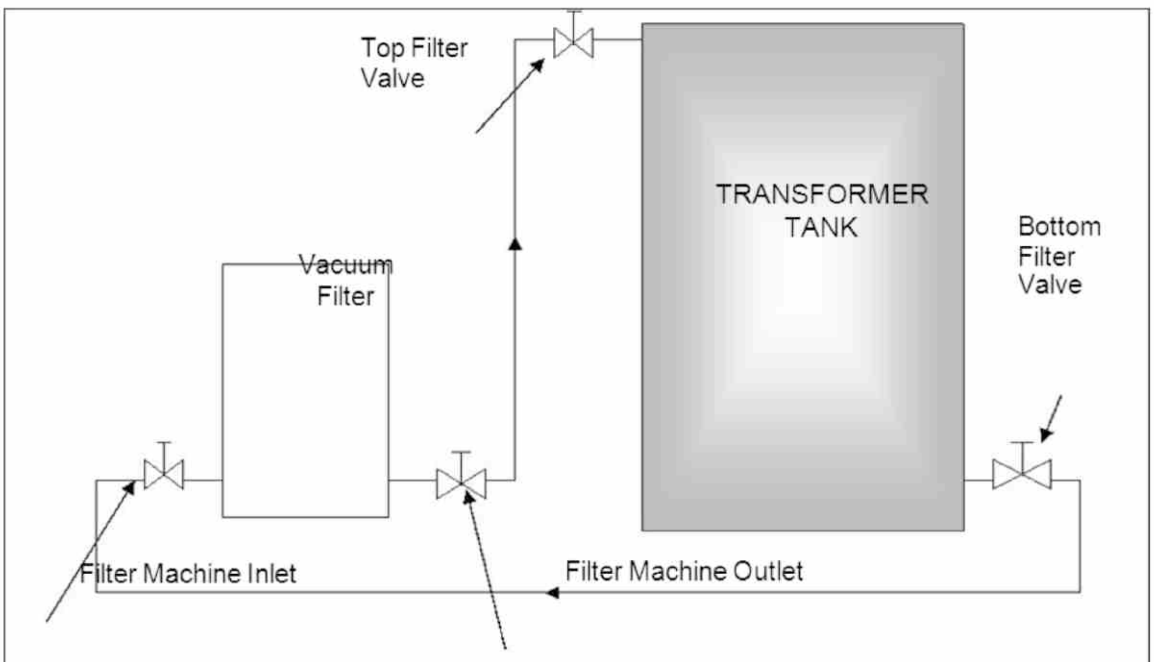


Figure-4: Arrangement for Hot Oil Circulation and Filteration

2.5 PROCEDURE FOR DRY OUT OF WET WINDING OF TRANSFORMER/REACTOR BY VACUUM PULLING, N_2 FILLING AND HEATING

The dry out of a new transformer/reactor is required when the moisture get absorbed by the solid insulation used in transformers/reactors due to various reasons. The process of dry out of a transformer requires utmost care and fine judgment. If the dry out process is handled carelessly or performed improperly, it can result in a irreparable damage to the transformer insulation by over heating, etc. In no case shall a transformer be left unattended during any part of the dry out period. The transformer should be carefully watched through out the dryout process and all observations shall be carefully recorded. When transformer has dried out, it is necessary to ensure that the fire fighting equipment is available near the transformer.

2.5.1 Isolation Required: All the openings of the transformer main tank like- openings for coolers/radiators, conservator, OLTC etc. should be properly isolated and totally blanked.

2.5.2 Procedure:

a. Fill the main transformer/reactor tank with Nitrogen (use only dry N_2 gas as per IS:1747 with 50 ppm moisture and 1% oxygen by volume) until it comes to a positive pressure of 0.15 Kg/cm^2 for at least 48 hours. At the end of 48 hours, dew point of N_2 at outlet is measured. If the dew point is not within acceptable limits as per table-I, dry out method should be continued.

b. Heating from outside: While N_2 circulation is in progress, the heaters are to be installed around the transformer tank. The heaters are to be kept ON until a temperature of about 75–80^{0}C of the core & winding is achieved.

c. Vacuum Pulling: After ascertaining that there is no leakage, pull out vacuum and keep the transformer/reactor under absolute vacuum (nearly 1-5 torr) for about 96 hours by running the vacuum pump continuously. The duration of vacuum can vary between 48 to 96 hours depending upon the dew point being achieved. Keep vacuum machine ON and collect condensate for measurement. Observe the rate of condensate collection on hourly basis. Depending on the value of rate of condensate, continuation of further vacuum should be decided.

d. Nitrogen Circulation: After this, the vacuum is broken with dry nitrogen. The dew point of nitrogen at the inlet is to be measured and should be of the order of -50°C or better. When the nitrogen comes to the positive pressure of 0.15 kg/cm^2, it is stopped and kept still for 24 hours. Heating from outside is to be continued while N^2 circulation is in progress. Then the nitrogen pressure is released and the outlet nitrogen dew point is measured. If the dew point is within acceptable limits as per Table-I then the dryness of transformer is achieved. If not again the transformer is taken for vacuum treatment and then nitrogen is admitted as mentioned above and tested again. The cycle to be continued till desired dew point as per Table -I is achieved.

e. Periodicity: Periodicity of vacuum cycle may vary between 48 to 96 hours. Initially two N_2 cycles may be kept for 24 hours. After that it may be repeated for 48 hrs depending upon dew.

After completion of dryout process, oil filling and hot oil circulation should be carried out before commissioning. Please ensure a standing time as given below before charging.

Transformer HV rated Voltage (kV)	Application of vacuum & holding time (before oil filling) (in hours)	Standing time after Oil circulation and before energising (in hours)
Up to 145 kV	12	12
145 kV and up to 420kV	24	48
Above 420 kV	36	120

Table-4

After the expiry of this time, air release operation should be carried out in Buchholz relays and other release points given by the manufacturer before charging.

2.6 RELATION BETWEEN DIFFERENT UNITS (CONVERSION OF UNITS):

Pressure:

1 bar = 10^5 Pa = 750 Torr = 14.5 psi = 1.02 kg/cm^2

1 Torr = 1.33 mbar = 0.133 kPa

1 kPa(kilo-Pascal) = 10^3 Pa = 10 mbar = 7.501 Torr (mm of mercury)

1 MPa = 10^6 Pa

1 atmosphere=0.1 MPa= 1.02 kg/cm^2 = 14.5 psi

FORCE

1 kp = 9.807 N

WEIGHT

1 ton=1000 kg=2200 lbs

Temperature

°C = 5/9 X (°F - 32)

°F = 9/5 X (°C + 32)

VOLUME

1m^3 = 1000 litres = 260 US gallons = 220 Imp gallons

1 litre = 0.26 US Gallons

1 US Gallons = 3.78 litres

1 litre =0.22 Imp Gallons

BENCH MARKS

1-mm mercury (Torr) is about 1 millibar or 0.1 kPa

1 m^3 of oil weights 0.9 tons –say 1 ton

1000 US gallons of oil weights 3.5 tons

2.7 CHECK LIST FOR ENERGISATION OF TRANSFORMER/ REACTOR

2.7.1 PRELIMINARY CHECKS

a. Release air at the high points, like oil communicating bushings, buchholz petcock, tank cover and the cooling devices including headers, radiators, pumps, expansion joints etc. of the transformer. Air release should be started from low points to high points.

b. Check the whole assembly for tightness and rectify where necessary

c. Check the general appearance and retouch the paint work if need be

d. Check that the valves are in the correct position:
   - i. Tank : valves closed and blanked
   - ii. Cooling circuit : valves open
   - iii. Conservator connection : valves open
   - iv. By-pass: valves open or closed as the case may be
   - v. On-load tap changer : valves open

e. Check that the silica gel in the breather is blue and that there is oil in the breather cup

f. Check that tan delta points of bushing's & core points are shorted with ground.

g. Check the oil level in the main & OLTC conservator tanks, bushing caps, flanges, turrets, expansion bellows as per manufacturer's recommendation. Level should correspond to 35º C mark on oil level gauges.

h. Check the bushings for:
   - i. Oil level (bushings fitted with sight-glasses)
   - ii. Adjustment of spark-gaps/arcing horn–gaps, if provided
   - iii. Conformity of connection to the lines (There should be no tensile stress on the terminal heads)
   - iv. Bushing CT secondary terminals must be shorted and earthed, if not in use.
   - v. Neutral bushing should be effectively earthed

i. Check the on-load tap changer for :
   - i. Conformity of the positions between the tap changer control cubicle and the tap changer head
   - ii. Adjustment of the tap-changer control cubicle coupling
   - iii. Electric and mechanical limit switches and protective relays
   - iv. Step by step operation- local and remote electrical operation as well as manual operation and parallel operation, if any

j. Check the quality of the oil:
   - i. Take a sample from the bottom of the tank & Carry out DGA and oil parameters test (i.e. BDV, Moisture content, resistivity & tan δ at 90°C and IFT) before charging

k. Check the oil of OLTC chamber, if not good, drain and fill with filtered oil upto level desired

l. Check that the (if there) equalising link between OLTC tank and Main tank is removed .

m. Extraneous materials like tools, earthing rods, pieces of clothes, waste etc. should be removed before energisation.

2.7.2 CHECKING OF AUXILIARY AND PROTECTIVE CIRCUITS

1. Check the temperature indicator readings and their calibrations
2. Check the settings and working of the mercury switches of winding and oil temperature indicators and presence of oil in the thermometer pockets
3. Follow the same procedure for the thermal replicas
4. Check the direction of installation of buchholtz relay
5. Check the operation of the buchholz relay and the surge protective relay of the tap-changer for tripping (stage 1& stage 2) and protection signals interlocked with these relays.
6. Check the insulation of the auxiliary circuits in w.r.t to the ground by 500 V megger for 1 minute
7. Check the earthing of the tank and auxiliaries like cooler banks at atleast two places
8. Measure the supply voltages of the auxiliary circuits
9. Check the cooling system for :
   i. The direction of installation of oil pumps
   ii. The direction of rotation of the pumps and fans
   iii. The working of the oil flow indicators
   iv. The setting of the thermal overload relays, if provided
   v. Go through the starting up sequences, control and adjust, if necessary, the relay time delays
10. Ensure efficient protection of the electric circuit supply to the accessories and tightness of all electrical connections. Also check the heating and lighting in the cubicles
11. Check that the differential protection, over-current protection, restricted earth fault, over-fluxing protection etc. are in service and settings are as per guidelines or settings or recommendations issued by OS group

After the inspection /tests are completed, the transformer may be energised on NO LOAD. 1st charging of 400/220 kV auto transformers on NO LOAD should be done from the incoming side only. The initial magnetising current at the time of switching will be very high, depending upon the particular moment in the cycle or core material. The transformer should always be soaked for few hours under constant care i.e. keep it energised for atleast twelve hours. Excessive vibrations of radiator parts etc. should be located and corrected. The transformer humming should be observed for any abnormality. After that it may be checked for gas collection. Should the gas prove to be inflammable, try to detect the cause which may probably be an internal fault. If the breaker trips on differential/REF, buchholz or any other protective device, the cause must be investigated thoroughly before re-energizing the transformer/reactor. After successful charging, performance of transformer/rector should be checked under loading. OTI/WTI readings should be monitored for 24 hours and ensured that they are as per loading.

DGA samples may be sent as per standard practice (after 24 hours of energisation, one week, 15 days, 1 month and 3 months after charging & thereafter as per normal frequency of 6 months). Data may be forwarded to ODTL, design, construction and manufacturer (if requested by them) if there is any abnormality.

2.8 PRE-COMMISSIONING CHECKS/TESTS FOR TRANSFORMERS & REACTORS

Once oil filling is completed, various pre-commissioning checks/tests are performed to ensure the healthiness of the Transformer/Reactor prior to its energisation. Various electrical tests to be performed and their significance are given below:-

SN	Check point	Name of the test/Purpose of test/check
1	Core insulation tests	To check the insulation between Core (CC&CL) and Ground
2	Operational checks on protection System	Operational checks on cooler bank (pumps & fans), MOG, breathers (silica gel/drycol), temperature gauges (WTI/OTI), gas actuated relays (Buchholz, Pressure Release Device, SPR, OSR etc.) and simulation tests of protection system.
3	Insulation Resistance Measurement (IR)	Test reveals the condition of insulation (i.e degree of dryness of paper insulation), presence of any foreign contaminants in oil and also any major defect inside the transformer (e.g failure to remove the temporary transportation bracket on the live portion of OLTC part) etc.
4	Capacitance and Tan δ measurement of bushings	Measurement of capacitance and Tanδ in UST mode. Changes in the normal capacitance of an insulator indicate abnormal conditions like presence of moisture layer, short-circuits or open circuits in the capacitance network etc.
5	Capacitance and Tan δ measurement of windings	Dissipation factor/Loss factor & capacitance measurement of winding is carried out to ascertain the general condition of the inter-winding insulation & w.r.t Ground
6	Turns ratio (Voltage ratio) measurement	To determine the turns ratio of transformers to identify any abnormality in tap changers/ shorted or open turns etc
7	Vector group & Polarity	To determine the phase relationship and polarity of transformers
8	Winding resistance measurement	To check for any abnormalities due to loose connections, broken strands and high contact resistance in tap changers
9	Magnetic balance test	This test is conducted only in three phase transformers to check the imbalance in the magnetic circuit
10	Floating Neutral point measurement	This test is conducted to ascertain possibility of short circuit in a winding.
11	Measurement of short circuit current	This test is used to detect winding movement which occurs due to heavy fault current or mechanical damage during transportation or installation after dispatch from the factory.
12	Exciting/Magnetising current measurement	To locate defect in magnetic core structure. Shifting of windings, inter turn insulation failure or problem in OLTC change the effective reluctance of the magnetic circuit & affects the current required to establish flux in core.

SN	Check point	Name of the test/Purpose of test/check
13	Vibration easurement of oil- immersed reactor	To measure the vibrations of core/coil assembly in the tank of the reactor. Movement of the core-coil assembly and shielding structure caused by the time–varying magnetic forces results in vibration of the tank and ancilliary equipment. These vibrations have detrimental effects such as excessive stress on the core-coil assembly
14	Operational checks on OLTC's	To ensure smooth & trouble free operation of OLTC during operation continuity test & dynamic resistance measured
15	Stability of circuit of differential, REF relays of transformer / reactor	This test is performed to check the proper operation of differential & REF protection cicuit of transformer & reactor by simulating actual conditions. Any problem in CT connection, wrong cabling, relay setting can be detected by this test.
16 17	Tests/ checks on bushing current transformers (BCTs) Frequency Response	To ascertain the healthiness of bushing current transformer's at the time of erection. To asess the mechanical integrity of the transformer.
	Analysis measurement (FRA)	Transformers while experiencing severity of short circuit current looses its mechanical property by way of deformation of winding or core. During pre-commissioning, this test is required to ascertain that active part transformer has not suffered any severe impact/ jerk during transportation.
18	Dissolved Gas Analysis (DGA) of oil sample	Oii sample for DGA should be taken from transformer main tank before commissioning to have a base data and after 24 hours of charging & subsequently to ensure that whenever fault gas develop after first charging. DGA analysis helps the user to identify the reason for gas formation & material involved in the process. It also indicates the urgency of corrective action to be taken
19	Thermovision scanning (IR thermography	A thermo-vision camera determines the temperature distribution on the surface of the tank as well as in the vicinity of the jumper connection to the bushing. The information obtained is useful in predicting the temperature profile within the inner surface of tank and is likely to provide approximate details of heating mechanism. Thermovision scanning of transformer to be done at least after 24 hrs. of loading and repeated after one week

2.8.1 CORE INSULATION TEST

This test is recommended after receipt at site & before the unit is put in service or following modifications to the transformer that could affect the integrity of its core insulation and at other times, when indicated by DGA (key gases being ethane and/or ethylene and possibly methane) or usually during a major inspection.

For core-insulation to ground test, remove the cover of the terminal block, disconnect the closing link that connects the two terminals CL-G. Apply 2.0 kV direct voltage between CL and CC+G (core grounding strap). The tank shall be grounded during the test. The insulation value after 1 minute test-time should be minimum 10 MΩ for new transformers at the time of commissioning. Core insulation resistance is generally more than 100 MΩ for new assembled transformer when tested at factory.

2.8.2 OPERATIONAL CHECKS IN PROTECTION SYSTEM

1. Operational Checks on breathers (conventional Silcagel or drycol which ever is supplied with the transformers)
2. Visual check of MOG of main conservator , Marshalling Boxes , Kiosk Checks, Valve Operational Checks etc
3. Checks on cooling System- checks on cooling fans-rotation, speed & control (Manual/ auto/with temperature/load) setting checks.
4. Checks on Cooling pumps- rotation, vibration/noise, oil flow direction
5. Checks on temperature Gauges (OTI/WTI-Calibration and Cooler Control , alarm & trip setting tests.
6. Checks on gas actuated (SPRs/PRDs/Buchholz) relays– operational checks by simulation as well as shorting the respective contacts, as applicable
7. Checks on tightness of terminal connectors- micro-ohm measurement of each connection
8. Checks on transformer/reactor protection (differential, REF, Over-current & stability tests etc.)

2.8.3 INSULATION RESISTANCE (IR) MEASUREMENT

IR measurements should be taken between the windings collectively (i.e. with all the windings being connected together) and the tank earthed (Earth) and between each winding and the tank, with rest of the windings being earthed. Before taking measurements the neutral should be disconnected from earth. Following table gives combinations of IR measurements for auto-transformer, three -winding transformer & Shunt Reactor. Where HV-High voltage, IV-Intermediate voltage, LV-Low voltage/Tertiary voltage windings & E- Earth

For Auto-transformer	For 3 winding transformer	For shunt reactor
HV + IV to LV	HV/IV to LV	HV to E
HV + IV to E	HV/ LV to IV	
LV to E	HV/ IV/LV to E	

Unless otherwise recommended by the manufacturer the following IR values as a thumb rule may be considered as the minimum satisfactory values at 30°C (one minute measurements) at the time of commissioning.

Rated Voltage class of winding	Minimum desired IR value at 1 minute (Mega ohm)
11kV	300 MΩ
33kV	400 MΩ
66kV & above	500 MΩ

Insulation resistance varies inversely with temperature and is generally corrected to a standard temperature (usually 20°C) using table (Source: BHEL instruction Manual) as given below:

Difference in temperatures (°C)	Correction Factor (k)
10	1.65
20	2.60
30	4.20
40	6.60
50	10.50

The ratio of 60 second insulation resistance to 15 second insulation resistance value is called di-electric absorption coefficient or Index (DAI). For oil filled transformers with class A insulation, in a reasonably dried condition the absorption coefficient at 30°C will be more than 1.30. Polarization Index Test is ratiometric test, insensitive to temperature variation and may be used to predict insulation system performance. The polarization index test is performed generally by taking Megaohm readings at a constant DC voltage after 1minute and then after 10 minutes. The polarization index is the ratio of the 10 minute to the 1 minute Megaohm readings.

PI= R_{10}/R_1 (dimensionless), Where PI is Polarisation Index and R is resistance

The following are guidelines for evaluating transformer insulation using polarization index values:

Polarization Index	Insulation Condition
Less than 1	Dangerous
1.0-1.1	Poor
1.1-1.25	Questionable
1.25-2.0	Fair
2.0 – 4.0	Good
Above 4.0	Excellent

PI of more than 1.25 and DAI of more than 1.3 are generally considered satisfactory for a transformer, when the results of other low voltage tests are found in order. PI less than 1 calls for immediate corrective action. For bushings, an IR value of above 10,000 MΩ is considered satisfactory.

2.8.4 CAPACITANCE AND TAN δ MEASUREMENT OF BUSHINGS

Capacitance & tan δ measurement of bushings should be done at 10 kV with test kit to have reliable test results.

a) For 3-Ph auto-transformer, short (together) all 400kV, 220kV and Neutral (isolated from earth) bushings. Also short all 33 kV Bushings and earth them.

b) Measurement of C1 capacitance and Tanδ: Connect the crocodile clip of the HV cable to the top terminal of the shorted HV/IV bushings. Unscrew the test tap cover, Insert a pin in the hole of the central test tap stud by pressing the surrounding contact plug in case of 245 kV OIP bushing and remove the earthing strip from the flange by unscrewing the screw (holding earth strip to the flange body) in case of 420 kV OIP bushing. Connect the LV cable to the test tap (strip/central stud) of the bushing under test to the C & TAN δ KIT through a screened cable and earth the flange body. Repeat the test for all bushings by changing only LV lead connection of the kit to test tap of the bushing under test

c) Measurement of C2 Capacitance and Tanδ : HV lead to be connected to the test tap of the bushing under test (if required additional crocodile type clip may be used) and LV of the kit to be connected to the ground. HV of the bushing is to be connected to the Guard terminal of the test kit. Test to be carried out in GSTg mode at 1.0 kV

d) For measurement of 33 kV bushing tan delta, earth HV/IV Bushings (already shorted). Apply HV lead of the Test kit to shorted 33 kV bushings and connect LV lead of the test kit to test tap of the bushing under test.

e) Measurements be be made in a fashion similar to the previous measurement. The oil-paper insulation combination of bushings exhibit fairly constant tan delta over a wide range of operating temperatures. Hence, effort should be made to test at temperature near to previous test and application of correction factor should be avoided.

f) Do not test a bushing (new or spare) while it is in its wood shipping crate or when it is ying on the wood. Wood is not a good insulator un comparison to porcelain and will result in inaccurate readings. Save the test results as a baseline record to compare in future.

g) It may be ensured that C & Tan δ measurement of bushings and testing of turrets be carried before installation. This will prevent installation of bushings having C & Tan δ values beyond permissible limits.

h) It may also be ensured that test tap points are earthed immediately after carrying out the measurements for a particular bushing and earthing of test tap must also be ensured by carrying out the continuity test.

2.8.5 CAPACITANCE AND TAN δ MEASUREMENT OF WINDINGS

The combination for C & tanδ measurement of winding is same as that of measurement of IR value. The probable combination may be-

Auto-transformer (Two winding)	Test Mode	Shunt Reactor	Test Mode	3 winding transformer	Test Mode
HV + IV to LV	UST	HV to E	GST	HV to LV	UST
HV + IV to E	GSTg			HV to IV	UST
LV to E	GSTg			LV to IV	UST
				HV to Ground	GSTg
				LV to Ground	GSTg
				IV to Ground	GSTg

Combination for C & tan δ measurement of winding for various transformers/ Shunt Reactor

- Ensure that the test specimen is isolated from other equipment. Removal of Jumpers from bushings is pre-requisite for C & tan δ measurement of windings.
- For ICT's (Auto-transformers): shorting of all the three phase bushings (400 kV & 220 kV) and neutral be done. In case of single phase, 400kV, 220kV and neutral bushings are to be shorted. C & Tanδ measurement of windings should be done in following combinations:

Test No.	Winding Combination	Test Mode	Cap Symbol	Test lead Connection	Remarks
1.	HV-IV/LV	UST	CHL	HV lead of test kit to HV/IV bushings	
2.	HV-IV/LV+G	GST	CHL+CHG	of transformer & LV lead of test kit to LV bushing of transformer	
3.	HV-IV/LV with guard	GSTg	CHG	-do-	LV be guarded
4.	LV/HV-IV	UST	CHL	LV lead of test kit to HV/ IV bushings of transformer	
5.	LV/ HV-IV+G	GST	CHL+CLG	HV lead of test kit to LV bushing of transformer	
6.	LV/HV-IV with guard	GSTg	CLG	-do-	HV be guarded

Winding combination for C & tan δ measurement for auto transformer

- Measurement inter-check can be done by calculating C1= C2-C3 & C4= C5- C6 & $DF_1 = C_2DF_2 - C_3DF_3/C_2 - C_3 = C_4DF_4 - C_5DF_5/C_4 - C_5$, Where C stands for capacitance and DF for dissipation factor or tan δ and attached suffix (1...6) denotes the sr. no. of test in above table

For Reactors: All 400kV and neutral Bushings to be shorted. HV of the test kit to be connected to shorted bushings and LV of the test kit to be connected to earth connection. Measure the capacitance and tan delta in GST mode. Neutral connection with earth/ NGR to be isolated before the test.

2.8.6 TURNS RATIO (VOLTAGE RATIO) MEASUREMENT

Ratio measurements must be made on all taps to confirm the proper alignment and operation of the tap changers. The pre-commissioning test should be performed by automatic transformer turns ratio (TTR) meter already provided to protection teams of PSTCL. Open turns in the excited winding will be indicated by very low exciting current and no output voltage. Open turns in the output winding will be indicated by normal levels of exciting current, but no or very low levels of unstable output voltage.

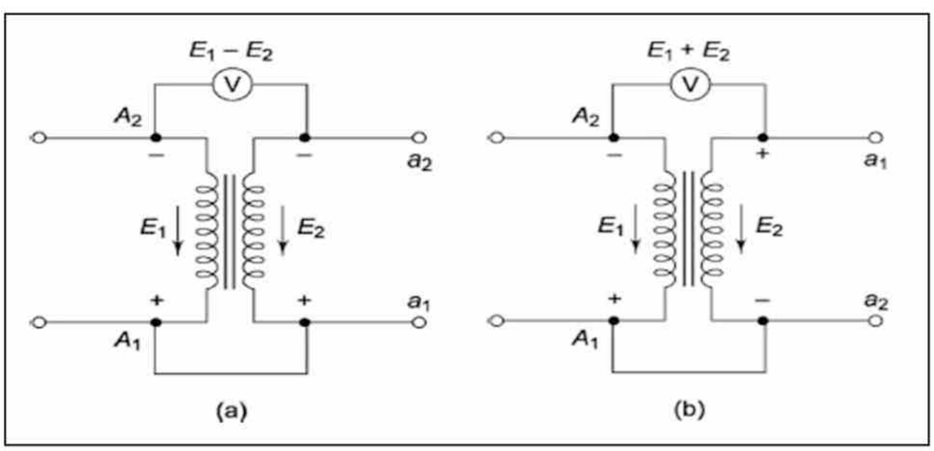
The turns ratio test also detects high-resistance connections in the lead circuitry or high contact resistance in tap changers by higher excitation current and a difficulty in balancing the bridge

.

Results of the transformation turns or voltage ratio are absolute, and may be compared with the specified values measured during factory testing. The turns ratio tolerance should be within 0.5 % of the name plate specifications. For three phase Y connected winding this tolerance applies to phase to neutral voltage. If the phase-to-neutral voltage is not explicitly indicated in the nameplate, then the rated phase-to-neutral voltage should be calculated by dividing the phase-to-phase voltage by √3.

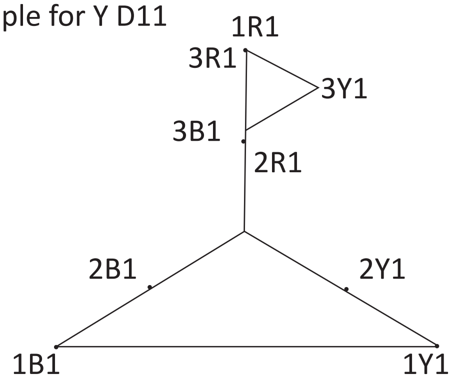
2.8.7 VECTOR GROUP & POLARITY

Polarity and phase-relation tests are of interest mainly because of their bearing on paralleling of two or more transformers. Phase-relation tests are made to determine angular displacement and relative phase sequence. Phase-relation or vector group verification test is performed on a three phase transformer or on a bank of three single-phase transformers. The details of Additive and Subtractive polarity are given in IS: 2026-Part-1 and IEC 60076-1. For a single-phase transformer having a ratio of transformation of 30 to 1 or less, the polarity test shall be done as following. The line terminal of high voltage winding (A1) shall be connected to the adjacent line terminal low-voltage winding (a1) as shown in figure below



Any convenient value of alternating voltage shall be applied to the full high-voltage winding and readings shall be taken of the applied voltage and the voltage between the A2 & a2 leads. When the later reading is greater than the former, the polarity is additive. When the later reading is less than the former (indicating the approximate difference in voltage between that of the high-voltage and low-voltage windings), the polarity is subtractive. The test shall be conducted with 3 phase, 415V supply. By the measured voltage data, it should be verified that the desired conditions of vector group and polarity are fulfilled

Example for Y D11



- Connect neutral point and LV phase with Earth

- Join 1R1 & 3R1 Terminals
- Apply 415 , 3 ϕ supply to HV
- Ensure 2R1-N=2Y1-N=2B1-N=Constant
- If 3R1-N>3Y1-N>3B1-N, and 3Y1-1B1 >3Y1-1Y1 Vector group Yna0d11 is confirmed and polarity verified.

Fig 5: For HV-Star / LV-Delta Transformer

2.8.8 WINDING RESISTANCE MEASUREMENT- (with automatic test kit)

To reduce the high inductive effect, it is advisable to use a sufficiently high current to saturate the core. This will reduce the time required to get a stabilized reading. It is essential that temperatures of the windings are accurately measured. Care should be taken so that self inductive effects are minimized. Care must also be taken to ensure that direct current circulating in the windings has settled down before the measurement is done. In some cases this may take several minutes depending upon the winding inductance.

The winding resistance shall preferably be done when the difference in the top and bottom temperature of the winding (temperature of oil in steady-state condition) is equal to or less than 5°C. The winding resistance should preferable be carried out at the end i.e after completion of all other LV tests, as after this test core gets saturated and If the core is not de-magnetized, test results of tests like magnetizing current, magnetic balance etc. may indicate a misleading picture. For star connected auto-transformers the resistance of the HV side is measured between HV terminal and IV terminal, then between IV terminal and the neutral at all taps.

The tap changer should be changed from contact to contact so that contact resistance can also be checked in a dynamic state. Measurement of winding resistance is to be carried out from tap position 1 to 17 and again back from 17 to 1. During tap changing operation, continuity check between HV to neutral to be carried out in all the phases by analog multimeter while changing tap. For delta connected windings, such as tertiary winding of auto-transformers, measurement shall be done between pairs of line terminals and resistance per winding shall be calculated as per the following formula:

Resistance per winding = 1.5 x Measured value

Take the winding temperature reading while doing the resistance measurement. Calculate the resistance at 75°C as per the following formula

$$\mathbf{R_{75} = R_t\,(235+75)/(235+t)},$$

Where **Rt** = Resistance measured at winding temperature t

The resistance value obtained should be compared with the factory test values. Results are compared to other phases in star-connected transformers or between pairs of terminals on a delta–connected winding to determine if a resistance is too high or low. Because field measurements make it unlikely that precise temperature measurements of the winding can be made, the expected deviation for this test in the field is 5.0 % of the factory test value.

2.8.9 MAGNETIC BALANCE TEST

This test is a low voltage test conducted at factory and site by applying single phase voltage between phase and neutral of a winding and measuring voltage induced in other two phases of the same winding. Keep the tap in nominal tap position. Disconnect transformer neutral from ground. Apply single phase 230 V across one phase of the Highest Voltage (HV) winding terminal and neutral (call it v1) then measure voltage in other two HV terminals/phases wrt neutral across neutral (call them v2 and v3 respectively). Repeat the test for each of the three phases. Repeat the above test for Intermediate Voltage (IV) or the LV winding (LV) winding, as the case may be. The identical results confirm that there is no damage in transportation. The following points may be kept in mind while performing the test-

i. Transformer neutral should be disconnected from ground
ii. No winding terminal should be grounded, otherwise results would be erratic.
iii. Zero voltage or very negligible voltage induced in any of the other two phases shall be investigated
iv. It is proposed that a set of readings should be taken for information and comparison later on during the In-service period of the transformer.

Also the applied voltage may be expressed as 100% voltage and the induced voltage may be expressed as percentage of the applied voltage. This will help in comparison of the two results when the applied voltages are different. The voltage induced in the centre phase shall be 50 to 90% of the applied voltage. However, when the centre phase is excited then the voltage induced in the outer phases shall be 30 to 70% of the applied voltage.

Zero voltage or very negligible voltage induced in the other two windings should be investigated

2.8.10 FLOATING NEUTRAL POINT MEASUREMENT

This test is conducted by applying 3 phase 415 volt supply across HV windings or IV winding as the case may be after disconnecting the transformer neutral from the ground. For a healthy transformer, when 3 phase balance voltage is applied, the voltage between neutral and ground is zero or otherwise a negligible voltage will appear. But in case there is a short circuited winding, the voltage between the neutral and the ground is appreciable. This test will also help in detecting the gradual deterioration or development of fault in the winding during service.

2.8.11 MEASUREMENT OF SHORT CIRCUIT IMPEDANCE

This test is used to detect winding movement that usually occurs due to heavy fault current or mechanical damage during transportation or installation after dispatch from
the factory. Ensure the isolation of transformer from high voltage & low voltage side with physical inspection of open condition of the concerned isolators/disconnectors. In case tertiary is also connected, ensure the isolation prior to commencement of testing. The measurement is performed in single phase mode.

This test is performed for the combination of two winding. The one of the winding is short circuited and voltage is applied to other winding. The voltage and current readings are noted. The test shall be conducted with variac of 0-280 V, 10 A, precision RMS voltmeter and ammeter. The conductors used for short-circuiting one of the transformer windings should have low impedance (less than 1m-ohm) and short length. The contacts should be clean and tight. The acceptable criteria should be the measured impedance voltage having agreement to within 3% of impedance specified on rating & diagram nameplate of the transformer. Variation in impedance voltage of more than 3% should be considered significant and investigated further.

2.8.12 EXCITING/ MAGNETISING CURRENT MEASUREMENT

This test should be done before DC measurements of winding resistance to reduce the effect of residual magnetism. Magnetising current readings may be effected by residual magnetism in the core. Therefore, transformer under test may be de-magnetised before commencement of magnetising current test.

Three-phase transformers are tested by applying single-phase 230 V or line to line 415 V volltage to one phase (HV terminals) w.r.t to neutral and keeping other winding open circuited and then measuring the current at normal, minimum and maximum tap positions.

Keep the tap position in normal position and keep HV and LV terminals open. Repeat the procedure for IV winding or LV winding as the case may be.

The set of readings for current measurement at each of the tap position should be more or less equal. Highly unequal currents indicate possible problem in winding. Results between similar single-phase units should not vary more than 10%. The test values of the outside limbs should be within 15 to 25 % of each other, and values for the centre leg should not be more than either of the outside limbs in case of a three-phase transformers. Results compared to previous tests made under the same conditions should not vary more than 25%. If the measured exciting current value is about 50 times higher than the value measured during pre-commissioning checks, then there is likelihood of a fault in the winding which needs further analysis. The identical results confirm no damage due to transportation. The availability of test data of normal condition and faulty condition can help us to analyze the problem.

2.8.13 VIBRATION MEASUREMENT OF OIL-IMMERSED REACTOR

Movement of the core-coil assembly and shielding structure caused by the time–varying magnetic forces results in vibration of tank and ancillary equipment. These vibrations have detrimental effects such as excessive stress on the core-coil assembly.

The shunt reactor under test shall be completely assembled in normal operating condition with cooling equipments, gauges and accessories. The shunt reactor shall be energised at rated voltage and frequency. Three phase excitation for 3-ph units. The shunt reactor should be mounted on a level surface that will provide proper bearing for the base, in order to eliminate the generation of abnormal tank stresses.

The vibration of shunt reactor shall be measured by transducers, optical detectors or similar measuring devices. The measuring equipment should be accurate within ±10% at 2nd harmonic of the exciting frequency. The peak-to-peak amplitude shall be determined by direct measurement or calculated from acceleration or velocity measurement. The average amplitude of all local maximum points shall not exceed 60 µm (2.36 mils) peak to peak. The maximum amplitude within any individual reading shall not exceed 200 µm (7.87 mils) peak to peak.

2.8.14 OPERATIONAL CHECKS ON OLTC

Following checks should be carried out during pre-commissioning. Before applying voltage to the transformer, the mechanical operation of tap changer and motor drive for step by step operation should be checked as follows:

¾ Manual Operation: The tap changer has to be run manually by the hand crank through the total operating cycle. In each operating position, the position indicators of motor drive and tap changer (On TC head) show the same position.

¾ Motor drive for step by step tap changing operation: Push button to be kept pressed till the motor stops i.e. driving motor should be automatically switched off when the tap changer has performed one switching operation.

(Note: At the time of change over selector operation (i.e 9b to 10 & vice-versa), higher torque is required. Tap changer end position should be checked that the same is not over run to avoid any failure during operation. Same can be seen through the inspection glass in the tap changer head cover. With the tap-changer fully assembled on the transformer the following sequence of operations shall be performed:

a. With the transformer un-energised, one complete cycles of operations (a cycle of operation goes from one end of the tapping range to the other, and back again). Check continuity of winding during this test. Ensure that the voltmeter needle does not deflect to zero.
b. With the transformer un-energised, and with the auxiliary voltage reduced to 85% of its rated value, one complete cycle of operation.
c. With the transformer energized at rated voltage and frequency at no load, one complete cycle of operation.

The following additional check points/guidelines for OLTC are recommended in consultation with OLTC manufacturer to ensure the smooth operation:

a. Function of control switches
b. OLTC stopping on position
c. Fastening/tightness
d. Signs of moisture such as rusting, oxidation or free standing water and leakages
e. Mechanical clearances as specified by manufacturer's instruction booklet
f. Operation & condition of tap selector, changeover selector and arcing transfer switches
g. Drive mechanism & its operation
h. Counter operation, tap position indicator working and its co-ordination with mechanism and tap selector positions
i. Limit switch operation
j. Mechanical lock integrity at extreme taps
k. Proper operation of hand-crank and its interlock switch
l. Physical condition of tap selector
m. Freedom of movement of external shaft assembly
n. Extent of arc erosion on stationary and movable arcing contacts
o. Inspect barrier board for tracking and cracking
p. After filling with oil, manually crank throughout entire range of operation
q. Oil BDV and Moisture content (PPM) should be as per specifications of main body oil

2.8.15 STABILITY OF DIFFERENTIAL, REF OF TRANSFORMER/ REACTOR

This test is performed to check the correctness of CT polarity, CT secondary core connections, connections at relay terminals and operation of relay under fault conditions.

2.8.15.1 REF STABILITY TEST FOR ICT

1. After opening the C.B & isolators of both sides (HV and LV side) of transformer, use "Primary Test Tap (M point or PI1/PI2)" provided in the BUSHING TURRET CTs to bypass the Transformer with the help of Primary current injection leads. Now, after ensuring completion of all CT wiring & normal polarity, inject current with the help of Primary Injection kits in the relevant Turret CTs of R phase & Neutral, subject to the maximum rating of Primary Test Tap.
2. Measure the spill current in REF relay which should be nearly zero.
3. Switch off Current Injection.
4. Reverse the polarity of R phase Bushing CT and again start current Injection.
5. Appreciable spill current will appear in REF relay.
6. Normalize the CT circuit which was reversed in step no. (4), after switching off the current injection.
7. Repeat the same procedure for Y and B phases and note down the results in formats.
8. Normalise the connections of CT.
9. This test has to be performed from both HV side & LV side w.r.t. Neutral.

However, if Primary Test Tap is not available in the Turret CTs, adopt following procedure;

1. After opening the C.B. and isolators of both sides (HV and LV side) of transformer, apply 440V three phase voltage at three phase bushing of H.V side with the help of three phase variac or normal supply.
2. Earth the R-phase of the LV side (through isolator/earth switch/discharge rod).
3. Measure the spill voltage (in mV)/spill current (in mA) of REF relay which should be nearly zero.
4. Switch off 440V supply.
5. Reverse the polarity of R-phase Bushing CT and again switch on 440 V supply.
6. Appreciable spill voltage/ current will appear in REF relay.
7. Normalize the CT circuit which was reversed in step no. (5), after switching off 440V supply.
8. Repeat the same procedure for Y and B phases and note down the results in formats.
9. Normalise the connections of CT and remove feeding of three phase supply.

2.8.15.2 REF STABILITY TEST FOR REACTOR

1. After opening the C.B and isolators of Reactor, use "Primary Test Tap (M point or PI1/PI2)" provided in the BUSHING TURRET C.Ts to bypass the Reactor with the help of Primary current injection leads. Now, after ensuring completion of all CT wiring & normal polarity, inject Current with the help of Primary Injection kits in the relevant Turret CTs of R-phase of Reactor & earth side CT of NGR, subject to the maximum rating of Primary Test Tap.

2. Measure the spill current in REF relay which should be nearly zero.
3. Switch off Current Injection.
4. Reverse the polarity of R phase bushing CT and again start Current Injection.
5. Appreciable spill current will appear in REF relay.
6. Normalize the CT circuit which was reversed in step no. (4), after switching off the current injection.
7. Repeat the same procedure for Y and B phases and note down the results in formats.
8. Normalise the connections of CT.

However, if primary test tap is not available in the turret CTs, adopt following procedure;

1. After opening the C.B and isolators of reactor, remove the jumpers of three phase bushings. Reactor neutral will remain connected to NGR, however earth connection of NGR bushing will be opened.
2. Apply 415 volts, phase to phase voltage across R phase bushing of Reactor & earth side bushing of NGR, after ensuring completion of all CT wiring & normal polarity.
3. Measure the spill voltage (in mV)/spill current (in mA) in REF relay which should be nearly zero.
4. Switch off 415V supply to Reactor / NGR Bushing.
5. Reverse the polarity of R phase bushing CT.
6. Switch on 415V supply to Reactor / NGR Bushing.
7. Appreciable spill voltage/ current will appear in REF relay.
8. Now normalize the polarity of the Bushing CT which was reversed in step (5).
9. Repeat the same procedure for Y & B phase and note down the results in formats.
10. After completing the test for all three phases normalize the reactor CT connection and jumpers & Earth connection of NGR Bushing.

2.8.16 TESTS/ CHECKS ON BUSHING CURRENT TRANSFORMERS (BCTS)

Continuity, polarity & secondary winding resistance tests of individual cores of bushing CT's

2.8.17 FREQUENCY RESPONSE ANALYSIS (FRA) MEASUREMENT

Frequency Response Analysis (FRA) is conducted to assess the mechanical integrity of the transformer which may get disturbed due to transportation shocks or short circuit forces experienced while in service. FRA signatures will be taken after assembly and oil filling and compared with factory testing to ensure the healthiness of core /coil assembly during transportation. These signatures will be benchmark for future reference. The FRA signatures should be analysed in conjunction with impact recorder readings. Report of Impact recorder readings is to be obtained from manufacturer. It is recommended to follow the standard procedure for the SFRA measurement as per the Table-7. It should be done on maximum, normal and minimum tap.

Auto Transformer

Test Type	Test	3 Φ	1 Φ
Series Winding (OC)	Test 1	H1-X1	H1-X1
All Other Terminals Floating	Test 2	H2-X2	
	Test 3	H3-X3	
Common Winding (OC)	Test 4	X1-H0X0	X1-H0X0
All Other Terminals Floating	Test 5	X2-H0X0	
	Test 6	X3-H0X0	
Tertiary Winding (OC)	Test 7	Y1-Y3	Y1-Y2
All Other Terminals Floating	Test 8	Y2-Y1	(Y1-Y0)
	Test 9	Y3-Y2	
Short Circuit (SC)	Test 10	H1-H0X0	H1-H0X0
High (H) to Low (L)	Test 11	H2-H0X0	Short (X1-H0X0)
Short (X1-X2-X3)	Test 12	H3-H0X0	
Short Circuit (SC)	Test 13	H1-H0X0	H1-H0X0
High (H) to Tertiary (Y)	Test 14	H2-H0X0	Short (Y1-Y2)
Short (Y1-Y2-Y3)	Test 15	H3-H0X0	
Short Circuit (SC)	Test 16	X1-H0X0	X1-H0X0
Low (L) to Tertiary (Y)	Test 17	X2-H0X0	Short (Y1-Y2)
Short (Y1-Y2-Y3)	Test 18	X3-H0X0	

Table-7: Various combinations for FRA measurement in Auto Transformer

Shunt Reactor: In case of Shunt Reactor, SFRA to be done in following combinations:

- H1-H0
- H2-H0
- H3-H0

2.8.18 DISSOLVED GAS ANALYSIS (DGA) OF OIL SAMPLE

Dissolved Gas Analysis (DGA) is a powerful diagnostic tool to detect any incipient fault developing inside the oil-filled equipment. The oil sample is to be taken after oil filling (before commissioning) as a benchmark and there after 24hrs of charging, 7 days, 15 days, one month and three months after charging or as per Doc.No.CE/PM/OS/INST-1
to monitor the gas formation, if any. The oil samples are to be sent to ODTL for DGA and first two samples for oil parameter testing also.

2.8.19 THERMOVISION SCANNING (IR THERMOGRAPHY)

Once the transformer/reactor is charged and loaded, thermovision scanning is to be carried out to see any hotspots by HOTLINE STAFF.

3.0 PRE-COMMISSIONING CHECKS /TESTS FOR OTHER SWITCHYARD EQUIPMENTS

Once erection is completed, various pre-commissioning checks/tests are performed to ensure the healthiness of the switchyard equipment prior to their energisation. Various major electrical tests to be performed along with their significance are given below:-

SN. Name of test/check and purpose of the test

3.1 Tan δ & Capacitance measurement of CT, each stack of CVT & total capacitance, CB voltage grading capacitor & each stack of Surge Arrester's

The purpose of the dissipation factor measurement of high voltage insulation is to detect incipient weakness in HV insulation. The most important benefit of this measurement is to get a "benchmark reference reading" on a HV equipment when the equipment is new and insulation is clean, dry and free from impurities. Tan delta & Capacitance values shall be comparable with factory test results.

3.2 **Checks/ Tests applicable for Cts**

3.2.1 Polarity test for CT -To check the polarity markings as per drawing.

3.2.1 Magnetization characteristics of CT

To check that the turns of CTs secondary windings are not short circuited and also to check healthiness of CT cores. The magnetizing currents at KPV (Knee point voltage) shall be less than the specified value. The ratio of secondary and primary voltage shall also be measured.

3.2.3 Ratio test for CT

The ratio errors of the primary to the secondary currents should be within limits

3.2.4 IR measurement of CT (Primary & Secondary windings)

Changes in the normal IR value of CT indicate abnormal conditions i.e presence of moisture, dirt, dust, crack in insulator of CT and degradation of insulation.

3.2.5 DGA test of CT oil

To be conducted on 400 kV CT's after 30 days of commissioning to identify evolving faults in the CT. DGA values should be comparable with factory values (if available)

3.3 **Checks/Tests applicable for Circuit Breakers**

3.3.1 Dew point measurement of SF6 gas

Dew point of SF_6 gas is to measure moisture content in SF_6 gas which indicates whether CB evacuation is done properly or not. This test shall be carried out preferably at rated pressure of SF_6 gas.

3.3.2 Measurement of CB operating timings including PIR

To measure closing/ tripping/CO timings. These timings should be within permissible limits and shall be comparable with factory values. Pole discrepancies and Break to Break discrepancies shall be less than specified values.

3.3.3 DCRM contact travel measurement/ DC injected and trip/ close coil currents.

DCRM is the technique for measuring contact resistance during operation (Close/ Trip) of a circuit breaker with a delay TCO of 300 ms. A D.C current of at least 100 ampers is injected through the circuit breaker. The current and voltage drops are measured and resistance is calculated. The resistance and travel versus time data provides useful information on the condition of the circuit breaker contacts and is used as a diagnostic tool. DCRM test signatures shall be approved by OS wing.

3.3.4 Operational lockout checking of CB's

To ensure various lockout operations of C.B by simulating the actual conditions at the specified pressure of oil/air/operating medium.

3.3.5 Measurement of static contact resistance

This test is conducted to evaluate the healthiness of main contacts..100 Amp DC is is injected and voltage drop is measured across each CB contact to compute contact resistance.

3.3.6 Checking the Anti-Pumping feature

By giving simultaneous close/ trip commands, CB hunting shall not take place by operation of mechanical/ electrical anti pumping feature.

3.3.7 Checking the Anti-Condensation Heaters

To check correct operation of thermostat provided for anti- condensation heaters.

3.3.8 Pole discrepancy relay testing

To test tripping of CB in case of pole discrepancy more than specified value.

3.4 **Checks/ Tests applicable for CVTs /PT's**

3.4.1 CVT /PT polarity, Ratio test :- This test is conducted in the same manner as for CT to determine correct CVT/PT polarity, ratio and phasor group.

3.4.2 IR measurement of CT (Primary & Secondary windings)

Changes in the normal IR value of CT indicate abnormal conditions i.e presence of moisture, dirt, dust, crack in insulator of CVT/PT and degradation of insulation.

3.4.3 **Checks/ Tests applicable for Isolators**

3.4.4 Contact resistance test

It gives a measure of resistance of current carrying parts and the contacts by injecting minimum 100 A DC current.

3.4.5 Operation tests

To test operation of contacts and other moving parts etc with jumpers connected and to check various electrical and mechanical interlocks.

3.4.6 **Checks/ Tests applicable for Surge Arrestors**

3.4.7 Third Harmonic Resistive Current (THRC)

To monitor healthiness of surge arrestors by monitoring 3rd harmonic resistive current from the leakage current. This test is to be conducted after charging.

3.4.8 IR measurement of each stack of LA -

Changes in the normal IR value of LA indicates abnormal conditions such as presence of moisture, dirt, dust, crack in insulator of LA and degradation of insulation.

3.4.9 Checking of operation of LA counter-

This test is done to check the healthiness of LA counter.

3.5 Checks/tests for other areas/equipments

3.5.1 Earth resistance measurement-

To ensure that the value of earth resistance of all equipment in a sub-station is below 1 ohm.

3.5.2 Secondary current injection test

Conducted for testing of protecting devices, circuit breakers, trip coils, motor overloads etc.

3.5.3 Contact tightness check of bay contacts by primary injection method-

Since complete bay contact resistance measurement is practically not possible because DC current may not be injected in CT primary, hence contact tightness check by primary injection method has been introduced to check overall contact tightness.

3.5.4 Stability check for Bus Bar-

This test is performed to check the proper operation of Bus-Bar protection scheme by simulating actual conditions. Any problem in CT connection, wrong cabling, relay setting can be detected by this test.

4. TAN DELTA & CAPACITANCE MEASUREMENT OF CT, CVT, CB, VOLTAGE GRADING CAPACITORS AND LA STACKS

To measure dissipation factor/loss factor (Tan delta) and Capacitance measurement of EHV class CTs, CVTs, CB Voltage Grading Capacitors & LA stacks by applying test voltages upto 10kV as per procedure mentioned in Doc.No.CE/PM/OS/INST-2 & CE/PM/OS/INST-5

4.1 SURGE ARRESTORS- Testing procedure for Top, Middle and Bottom Stacks:

4.1.1 Apply 10 KV between flanges of Top/Middle/ Bottom stacks (whichever is being tested)

4.1.2 Carry out measurements in UST mode at 10.0 KV with test kit

4.1.3 While measuring Middle/ Bottom stacks, the stacks above the HV lead to be shorted.

4.1.4 Standard procedure (as specified by kit supplier) for measuring capacitance and an delta in charged switchyard/ induced voltage conditions should be followed.

4.1.5 While doing measurement of bottom stack the earth connection to be removed.

4.2 CHECKS/ TESTS APPLICABLE FOR CTs

4.2.1 IR measurement as per procedure mentioned in Doc.No.CE/PM/OS/INST-2

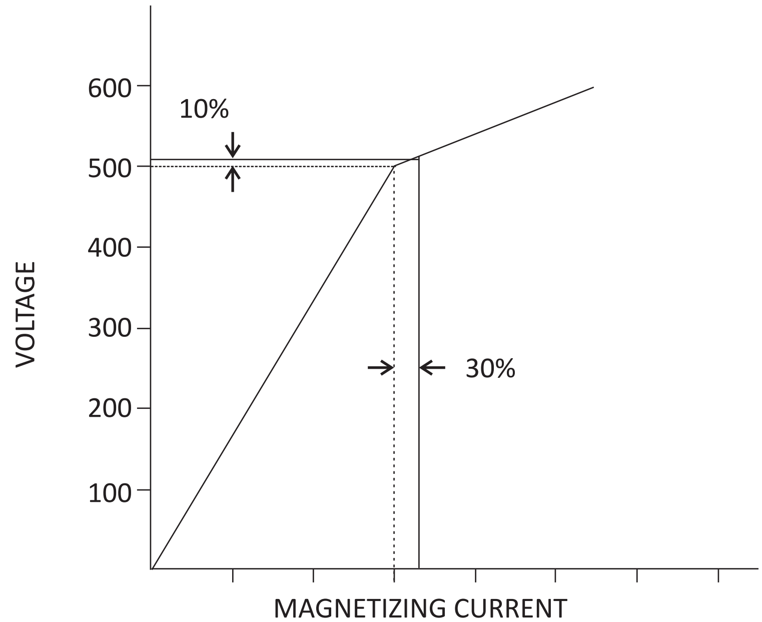
4.2.2 Measurement of secondary winding resistance of CT's as per procedure mentioned in Doc.No.CE/PM/OS/INST-2

4.2.3 Polarity test- To check whether polarity markings by manufacturer is correct or not. A centre zero voltmeter is connected across CT secondary. A 1.5 Volt cell or battery is touched to primary of CT. The deflection of pointer should be similar in case of each CT core. At any instant current entering the primary from P1 should leave secondary from the terminal marked S1.

4.2.4 Ratio test- Primary should be fed from a primary injection set & measurement of secondary current be noted with ammeter. Calculated current ratio should match the actual CT rating as per name plate.

4.2.5 DGA test- 1^{st} test shall be conducted after 30 days of energisation and results should be compared with manufacturer's test report to identify any evolving fault in 400 KV & above class C.T's.

4.2.6 Measurement of magnetizing characteristics of CT's as per procedure mentioned in Doc.No.CE/PM/OS/INST-2



TYPICAL MAGNETIZATION CURVE

Figure - 12

From the curve it can be implied that up to rated KPV (Knee Point Voltage), the VI curve should be almost a straight line. However, if this line is not linear, this indicates that the magnetizing characteristics are not desirable. If the slop of the curve starts increasing, it indicates that magnetizing induction becomes low and total primary current is utilized in exciting the core alone. Consequently, out put of CT secondary disappears.

It is customary to conduct this in conjunction with the primary injection test. Current is passed through the primary circuit with the secondary winding circuit to its normal circuit load. The ratio of the primary to the secondary currents should approximately be close to the stamped ratings/ratio as per CT (under tet) identification plate.

4.3 CHECKS/ TESTS APPLICABLE FOR CIRCUIT BREAKERS

4.3.1 Dew point measurement of SF_6 gas for Circuit Breaker- as per procedure mentioned in Doc.No.CE/PM/OS/INST-2

4.3.2 Measurement of Circuit Breaker operating timings including Pre-Insertion resisitor timings- as per procedure mentioned in Doc.No.CE/PM/OS/INST-2

4.3.3 Dynamic contact resistance measurement (DCRM) & contact travel measurement of EHV (≥ 400 KV) Circuit Breakers- as per procedure mentioned in Doc.No.CE/PM/OS/INST-2

4.3.4 Static Contact Resistance of Circuit Breakers- as per procedure mentioned in Doc.No.CE/PM/OS/INST-2

4.3.5 Operational lock out checking for EHV Circuit Breakers- as per procedure mentioned in Doc.No.CE/PM/OS/INST-2

4.3.6 Measurement of IR values of Circuit Breaker in all possible combinations.

4.3 Contd-

4.3.7 Checking the the anti-pumping feature- When the breaker is in open position and closing and opening commands are given simultaneously, the breaker first closes and then opens, but does not reclose even though the closing command is maintained.

4.3.8 Checking the anti-condensation heaters- Check the supervisory circuit of the anti-condensation heaters for the correct functioning. With the heaters switched ON, measure their current outputs.

4.3.9 Pole discrepancy testing- Pole Discrepancy is defined as the difference in closing & opening timings of different poles of CB.

4.3.9.1 WHEN CB IN OPEN POSITION- When closing command is extended to close one pole, say R-Pole, of CB. After closing the R-Pole of CB, this pole should automatically open after 3 seconds (or as per pole discrepancy timer settings). Repeat the test for remaining two poles of CB.

4.3.9.2 WHEN CB IN CLOSED POSITION- when tripping command is extended to trip one pole, say R-Pole, of CB. Remaining Y and B- Poles of CB should automatically open after 3 seconds (or as per set time). Repeat the same test for remaining two poles of CB.

4.3.9.3 Evaluation of test results- Permissible value of pole discrepancy between two poles of CB is 3.33 milli- seconds from system point of view and it should not be confused with the setting of pole discrepancy timer which is generally 1.0 or 3 seconds depending on auto-reclose scheme.

4.

4.4 CHECKS/ TESTS APPLICABLE FOR CVT's/PT's

4.4.1 CVT/PT Polarity test & ratio test- CVT or PT polarity is checked in the same manner as in the case of CT by ensuring that the battery is connected to the primary winding. In case of star/star winding configuration care has to be taken to ensure that the primary and secondary neutral points are not connected together. It is necessary to verify that the phase rotation sequence of the 3 phase CVT is correct. The secondary voltage between phases and neutral are measured and then phase rotation meter is connected across the three phase terminal. Similarly ratio of CVT/ Pt should also be checked in a similar fashion as is done in case of CT's.

4.4.2 Insulation resistance measurement of primary & secondary winding- IR values should be measured in all possible combinations.

4. Contd-

4.5 **CHECKS/ TESTS APPLICABLE FOR ISOLATORS**

4.5.1 MILLI VOLT DROP TESTS-

The milli volt drop across the isolator is measured using DC current. The voltage drop gives a measure of resistance of current carrying parts and the contacts.

The DC current should be equal to or more than 100 A. The resistance of isolator should be measured at ambient air temperature. The temperature of specimen/ environmental temperature should be recorded. The value of measured resistance should be converted to the value of temperature at which factory test results are taken. Temperature corrected value of resistance should be comparable to the factory value.

4.5.2 50 OPERATION TESTS- To test operation of contacts etc, with jumpers connected, the contact resistance should be again measured after 50 operations and there is should not be any deviation from previous value.

4.6 **CHECKS/TESTS APPLICABLE FOR SURGE ARRESTORS**

4.1.1 Measurement of 3rd harmonic resistive current (THRC) as per per procedure mentioned in Doc.No.CE/PM/OS/INST-2

4.6.1 Checking of leakge current monitor

4.6.2 Insulation resistance values

4.7 **EARTH RESISTANCE MEASUREMENT** - Normally Earth tester is used for measuring-

4.7.1 Soil resistivity

4.7.2 Earth resistance

4.7.3 Prior to the testing of soil resistivity and earth resistance the operation manual of the testing instrument available at site may be referred for procedures to be adopted for measurement of soil resistivity and earth resistance.

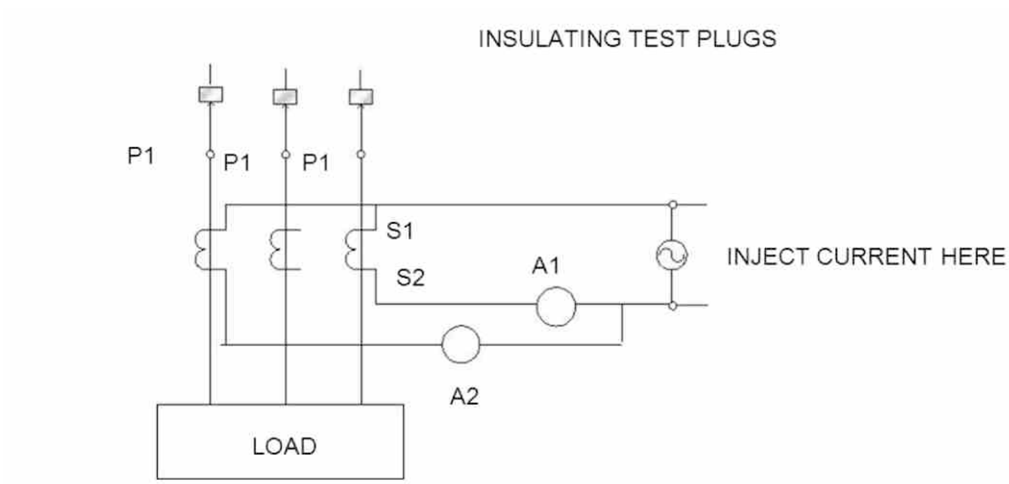
A typical earth tester has 4 terminals i.e C1, P1, C2, P2 and 4 similar electrodes are driven in the ground at equal distances and connected to the instruments in the order of C1, P1 and P2, C2. Then button is pressed and the reading of the resistance is read on the scale of the instrument. If R is the resistance measured then, Specific Resistivity = $2\pi aR$, where- 'a' is the distance between the electrode & R is the resistance in ohms measured on the earth tester.

4.8 In order to measure the earth resistance of the electrode of the substation, it could be connected to C1 and the value of R could be read in the scale with the pressing of button of the tester. This will give the earth resistance. The value as far as possible should be around 1 ohm. To improve the value, water should be spread at the earth pit.

4. Contd-

4.6 **SECONDARY CURRENT INJECTION TEST SETS**-

4.6.1 The primary test is essential when commissioning a new installation to test the protection system as a whole and to detect the current transformer connections for any incorrect polarity or relays that have been connected in wrong sequence or polarity for a differential scheme. The secondary current injection sets are also very useful in conducting these tests. The standard secondary current injection test set consists of a 1/5 A current injection equipment with a separate wave form filter unit. The equipment is designed in a portable box for on site testing of protecting devices, circuit breakers trip coils etc or a similar apparatus. The typical test setup is shown in the figure below-



4.7 **CONTACT TIGHTNESS TEST OF BAY CONTACTS**

4.7.1 Isolate the Bay from Bus–Side and line side as shown in figure.

4.7.2 Ensure that all the secondary cores are connected or short if not in use.

4.7.3 Inject the current at Point-1 (200A) with a primary injection kit (w.r.t earth) and return current via earth point at 2 as shown in figure.

4.7.4 Check that current is injected at point 1 and measured at point 2.

4.7.5 Proper Injection of current indicates the contact tightness.

4.7.6 Repeat the procedure for point 1 & 3.

4.7.7 Repeat the procedure for point 1 & 4

4.7.8 Above tests can be aborted if individual contact resistances are within satisfactory limit and physical phase checking is satisfactory.

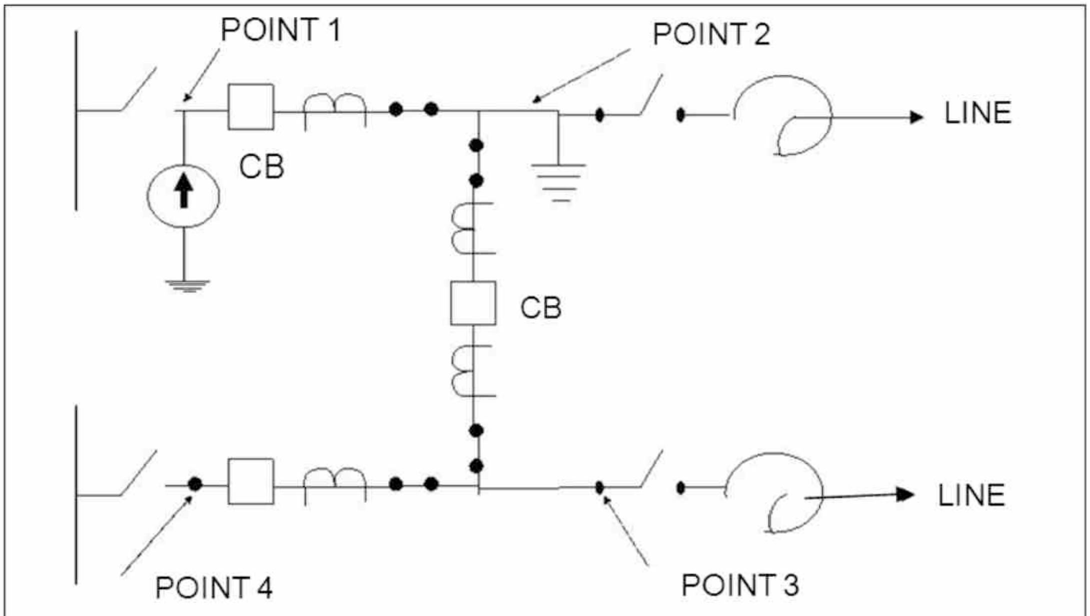


Figure: Primary injection test to check contact tightness of Bay/ feeders

4.8 **STABILITY TEST FOR BUSBAR**: Procedure given below be adopted phase wise

4.8.1 Isolate all the bays connected to the bus bar from line side and then close bus CBs and bus isolators

4.8.2 Inject the Primary current of 200 A from point 1 to point 4 with bus earth switch open as shown in Fig and check the spill current in check zone/bus zone in bus-bar protection panel.

4.8.3 Measured value will be nearly zero (for 2000/1 CT's ratio & secondary current will be around 100 mA with spill current around 1 mA or below) .

4.8.4 If spill current is more than 10%, checking of CT bus bar wiring is required.

4.8.5 THEN IN NEXT STEP- Inject the Primary current of 200A from point 1 to point 4 with bus earth switch close as shown in Fig. and check the spill current in check zone/bus zone in bus-bar protection panel.

4.8.6 The measured value should be be around full secondary current (for 2000/1 CT's ratio secondary current will be around 100 mA and spill current will be nearly 100 mA).

4.8.7 If no spill current found then checking of the CT bus-bar wiringt.

4.8.8 Repeat the above test for all remaining CT combination i.e 1-3, 1-5, 1-2 etc

4.8.9 If a new bay is added to the BUS, check only new CT's in reference with any old bay CT's of that particular BUS-BAR.

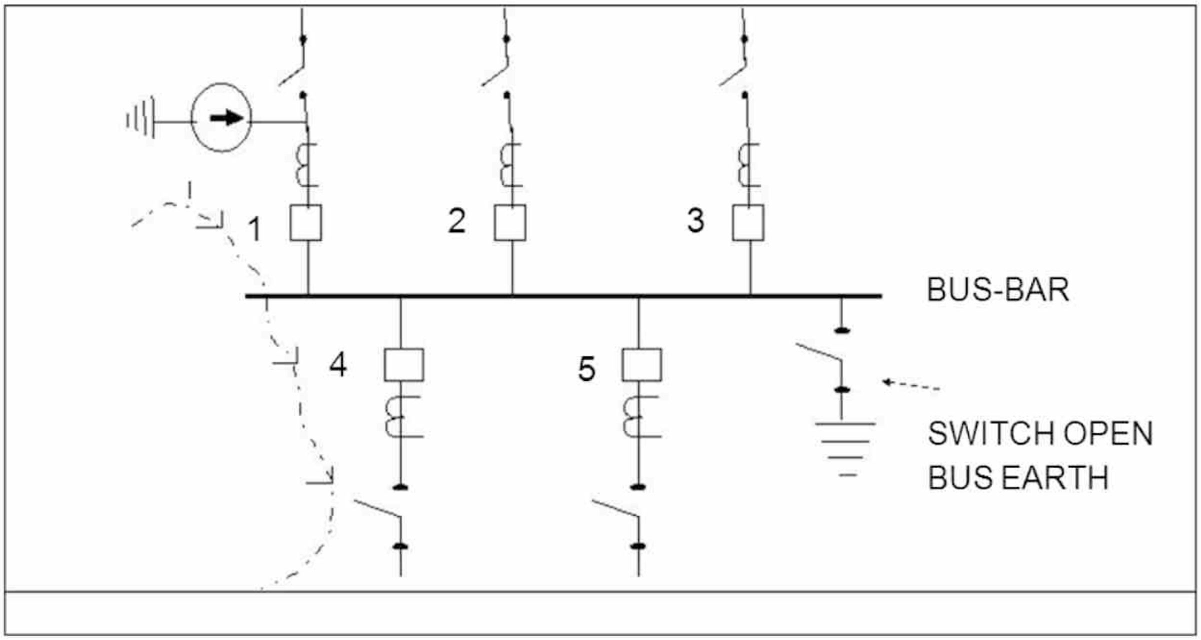


Figure-1: Primary injection with Bus Earth Switch Open

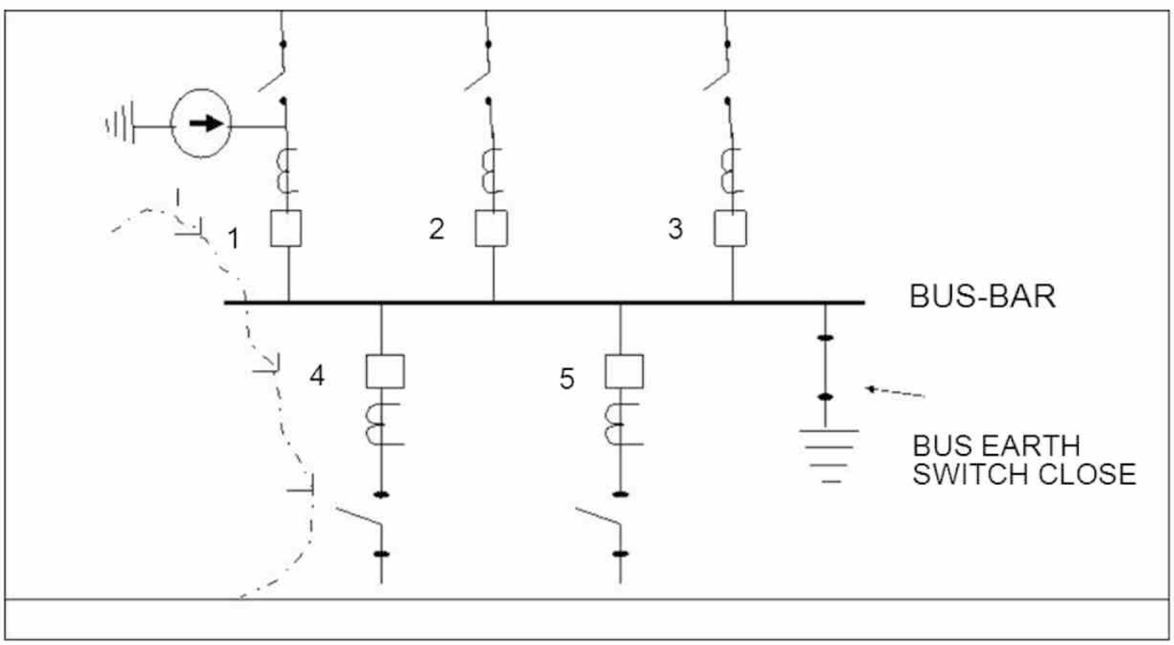


Figure-2: Primary injection with Bus Earth Switch Closed

DOC NO. : CP/CT/01/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

PRE-COMMISSIONING OF CURRENT TRANSFORMER COMMISSIONING FORMATS

P&M CIRCLE: P&M DIVISION sub-station

DATE OF TESTING DATE OF ENERGISATION

DETAILS OF EQUIPMENT :

PO NO:

MAKE:

TYPE:

R - PHASE: ____________ Y - PHASE : ____________ B - PHASE : ____________

SL NO.
YEAR OF MANUFACTURE ____________ ____________ ____________

FEEDER NAME :
RATED DATA AND DUTY ____________ ____________ ____________

CORE	RATIO	CLASS	BURDEN	KVP	PROTECTION/METERING
WINDING I					
WINDING II					
WINDING III					
WINDING IV					
WINDING V					

Kvp : KNEE POINT VOLTAGE IN VOLTS
DETAILS :

	DESCRIPTION	STATUS YES	STATUS NO	REMARK RECORD DEFICIENCIES, IF ANY
1.	EQUIPMENT IS CLEANED AND FREE FROM DUST/ DIRT/FOREIGN MATERIALS ETC.			
2.	EQUIPMENT IS FREE FROM ALL VISIBLE DEFECTS ON PHYSICAL INSPECTION			
3.	CHECK CT TANK HAS BEEN PROVIDED WITH DOUBLE EARTHING (DEAD TANK CT's)			
4.	CHECK THAT CT JUNCTION BOX IS EARTHED			
5.	ALL NUTS AND BOLTS ARE TIGHTENED			
6.	CHECK TIGHTNESS OF TERMINAL CONNECTOR			
7.	ALL FITTINGS AS PER OUTLINE GENERAL ARRANGEMENT DRAWING			
8.	LEVELLING AND ALIGNMENT OF STRUCTURE AND BASE FRAME			
9.	ANY PAINT REMOVED/SCRATCHED IN TRANSIT HAS BEEN TOUCHED UP			
10.	PRIMARY POLARITY OF CT'S ERECTED			
11.	CHECK HERMETICALLLY SEALING IS INTACT			
12.	CHECK THE OIL LEVEL AND LEAKAGE THROUGH ANY JOINTS/SEC. TERMINALS			
13.	CHECK OIL DRAIN VALVE IS PROPERLY CLOSED AND LOCKED			
14.	N2 PRESSURE CHECKED (WHEREVER APPLICABLE)			
15.	OIL LEVEL ON TOP CHAMBER GAUGE GLASS			
16.	ALL THE CABLE IDENTIFICATIONS AND ALL CORES ARE PROVIDED WITH FERRULES AT M.B FOR IDENTIFICATION			

17.	ENSURE CABLE ENTRY POINTS ARE PROPERLY FIXED		
18.	CHECK SECONDARY CABLE END BOX IS AT THE BOTTOM AND UNUSED HOLES SEALED		
19.	ENSURE INTERPOLE CABLING IS COMPLETED AND CHECK THE CONTINUTY		
20.	CHECK THE IR VALUE OF SECONDARY CABLE		
21.	CHECK EXTERNAL CABLING FROM JUNCTION- BOX TO RELAY/CONTROL PANEL COMPLETED		
22.	ENSURE UNUSED SECONDARY CORES, IF ANY, HAS BEEN SHORTED		
23.	CHECK STAR POINT HAS BEEN FORMED PROPERLY AND GROUNDED AT ONE END ONLY		
24.	CHECK SPARK GAP SETTING IN P1 TERMINAL (WHEREVER PROVIDED/ POSSIBLE), PERMANENT POLE LABELLING AND IDENTIFICATION MARKINGS MADE		
25.	CHECK TAN DELTA TEST TAP IS PROPERLY EARTHED		
26.	CHECK THAT LUGS USED IN SECONDARY CIRCUIT ARE OF RING TYPE		
27.	CHECK DIRECTION OF PRIMARY (P1/ P2) W.R.T BUS/ LINE ON ERECTION		
28.	PROVISION OF BIMETALLIC STRIPS (Cu +Al) SHOULD BE ENSURED WHEREVER APPLICABLE		

INSULATION RESISTANCE MEASUREMENT : (USING 5 KV MEGGER/INSULATION TESTER)

NOTE : A) REMOVE THE CONNECTED EARTHING TO SYSTEM INVOLVING CT UNDER TEST

B) DISCONNECT THE CONNECTED TERMINALS OF CT M.BOX

C) PERMISSIBLE VALUES IS 1000 MOHMS

DETAILS OF TEST KIT:

CORE	PHASE			
	R	Y	B	
PRIMARY - CORE I				M OHM
PRIMARY - CORE II				M OHM
PRIMARY - CORE III				M OHM
PRIMARY - CORE IV				M OHM
PRIMARY - CORE V				M OHM
PRIMARY – CORE VI				M OHM
PRIMARY - EARTH				

INSULATION RESISTANCE MEASUREMENT : (USING 500 V MEGGER)

DETAILS OF TEST KIT:

PERMISSIBLE VALUES IS 50 M OHMS

BETWEEN	PHASE			
	R	Y	B	
SECONDARY CORE I - EARTH				M OHM
SECONDARY CORE II - EARTH				M OHM
SECONDARY CORE III - EARTH				M OHM
SECONDARY CORE IV - EARTH				M OHM
SECONDARY CORE V - EARTH				M OHM

BETWEEN	PHASE			
	R	Y	B	
CORE I - CORE II				M OHM
CORE I - CORE III				M OHM
CORE I - CORE IV				M OHM
CORE I - CORE V				M OHM
CORE II - CORE III				M OHM
CORE II - CORE IV				M OHM
CORE II - CORE V				M OHM
CORE III - CORE IV				M OHM
CORE III- CORE V				M OHM
CORE IV - CORE V				M OHM

CHECK IR VALUE BETWEEN TAN DELTA POINT AND EARTH AT 1 KV IN SECONDARY BOX R -PHASE Y -PHASE B -PHASE

SECONDARY WINDING RESISTANCE (IN OHM) (BY DIGITAL MULTIMETER)

CORE	TERMINAL	R -PHASE		Y -PHASE		B -PHASE		
		FACTORY	SITE	FACTORY	SITE	FACTORY	SITE	
CORE I	1S1 - 1S2							OHM
	1S1 - 1S3							OHM
	1S1 - 1S4							OHM
CORE II	2S1 - 2S2							OHM
	2S1 - 2S3							OHM
	2S1 - 2S4							OHM
CORE III	3S1 - 3S2							OHM
	3S1 - 3S3							OHM
	3S1 - 3S4							OHM
CORE IV	4S1 - 4S2							OHM
	4S1 - 4S3							OHM
	4S1 - 4S4							OHM
CORE V	5S1 - 5S2							OHM
	5S1 - 5S3							OHM
	5S1 - 5S4							OHM

POLARITY TEST : WITH 1.5 VOLT DC SUPPLY : (CONNECT +VE AT P1 AND - VE AT P2)

CORE	BETWEEN		PHASE		
			R	Y	B
CORE I	1S1 (+VE)	1S2 (-VE)			
	1S1 (+VE)	1S3 (-VE)			
	1S1 (+VE)	1S4 (-VE)			
CORE II	2S1 (+VE)	2S2 (-VE)			
	2S1 (+VE)	2S3(-VE)			
	2S1 (+VE)	2S4 (-VE)			
CORE III	3S1 (+VE)	3S2(-VE)			
	3S1 (+VE)	3S3(-VE)			
	3S1 (+VE)	3S4(-VE)			
CORE IV	4S1 (+VE)	4S2(-VE)			
	4S1 (+VE)	4S3(-VE)			
	4S1 (+VE)	4S4(-VE)			
CORE V	5S1 (+VE)	5S2(-VE)			
	5S1 (+VE)	5S3(-VE)			
	5S1 (+VE)	5S4(-VE)			

TAN DELTA AND CAPACITANCE MEASUREMENT (WITH TAN DELTA KIT)

DETAILS OF TEST KIT:

VOLTAGE	CAPACITANCE (MEASURED VALUE)						REMARKS
	R--PHASE		Y--PHASE		B--PHASE		
	SITE	FAT	SITE	FAT	SITE	FAT	
2 KV							
10 KV							

VOLTAGE	TAN DELTA (MEASURED VALUE)						REMARKS
	R--PHASE		Y--PHASE		B--PHASE		
	SITE	FAT	SITE	FAT	SITE	FAT	
2 KV							
10 KV							

CURRENT RATIO TEST- PRIMARY INJECTION THROUGH PRIMARY INJECTION KIT AT PRIMARY TERMINAL P1 - P2, MEASURE CURRENT ON THE SECONDARY TERMINALS

DETAILS OF TEST KIT:

R/Y/B – PHASE (Repeat for All the phases)

CORE S1 - S2	PRIMARY %	CURRENT ACTUAL	SECONDARY CURRENT	THEORETICAL RATIO	ACTUAL RATIO	% ERROR
CORE I	20 %					
(1S1 - 1S2)	40 %					
	80 %					
CORE II	20 %					
(2S1 - 2S2)	40 %					
	80 %					
CORE III	20 %					
(3S1 - 3S2)	40 %					
	80 %					
CORE IV	20 %					
(4S1 - 4S2)	40 %					
	80 %					
CORE V	20 %					
(5S1 - 5S2)	40 %					
	80 %					
CORE I	20 %					
(1S1 - 1S3)	40 %					
	80 %					

CORE II	40 %
(2S1 - 2S3)	80 %
	20 %
CORE III	40 %
(3S1 - 3S3)	80 %
	20 %
CORE IV	40 %
(4S1 - 4S3)	80 %
	20 %
CORE V	40 %
(5S1 - 5S3)	80 %
	20 %
CORE I	40 %
(1S1 - 1S4)	80 %
	20 %
CORE II	40 %
(2S1 - 2S4)	80 %
	20 %
CORE III	40 %
(3S1 - 3S4)	80 %
	20 %
CORE IV	40 %
(4S1 - 4S4)	80 %
	20 %
CORE V	40 %
(5S1 - 5S4)	80 %

Y & B – PHASES- Repeat for all the phases

MAGNETISING CURVES PERFORMANCE (except metering core)

KNEE POINT VOLTAGE (KVp) ________________ VOLT

DETAILS OF TEST KIT:

VOLTAGE		CURRENT MEASUREMENT			
TO BE	ACTUAL	CORE – I	CORE - II	CORE - IV	CORE - V
APPLIED	VALUE	1S1-1S2	2S1 - 2S2	4S1 - 4S2	5S1 - 5S2
O.25 X KVp					mA
O.50 X KVp					mA
O.75 X KVp					mA
1.O0 X KVp					mA
1.10 X KVp					mA

NOTE :

1. CT SHOULD NOT SATURATE AT 110% OF KNEEPOINT VOLTAGE KVp
2. IF KNEEPOINT VOLTAGE IS NOT MENTIONED THEN KNEE POINT CURRENT MAY BE TAKEN INTO CONSIDERATION
3. If CT ANALYSER IS USED, AUTOMATED REPORTS WILL BE GENERATED
4. MAGNETISATION OF METERING CORE IS NOT DONE.

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION :
(SUPPLIER REPRESENTATIVE)
(WHEREVER APPLICABLE)

DOC NO. : CP/CT/01/PCT/2
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

CONTACT RESISTANCE MEASUREMENT (WHEREVER POSSIBLE/ ACCESIBLE):
DETAILS OF TEST KIT:

CONTACT RESISTANCE	R-PHASE	B-PHASE	
ACROSS TERMINAL P1			MICRO OHM
ACROSS TERMINAL P2			MICRO OHM

NOTE: THE VALUE OF CONTACT RESISTANCE SHOULD NOT BE MORE THAN 10 MICRO-OHMS PER JOINT / CONNECTOR

TESTS FOR SF6 FILLED 765 KV CTs
DETAILS OF TEST KIT:

PARTICULARS	PHASE		
	R	Y	B
DEW POINT (DEG C) SF6 LOSS ALARM (KG)			
SF6 LOCK OUT (KG)			

DGA TEST OF CT OIL (AFTER ONE MONTH OF COMMISSIONING) FOR 400 KV & ABOVE VOLTAGE LEVEL

DISSOLVE GASES				
TOTAL GAS (%)	R PHASE	Y PHASE	B PHASE	REMARKS
H2				
CH4				
C2H4				
C2H6				
C2H2				
CO CO2				
O2				
N2				

FINAL DOCUMENTATION REVIEW :

A. FINAL DOCUMENT OFPRE-COMMISSIONING CHECKS REVIEWED AND APPROVED — YES NO

B. DOCUMENTS REGARDING SPARES, EQUIPMENT MANNUALS ETC AVAILABLE AT SITE FOR O&M PURPOSE — YES NO

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION :
(SUPPLIER REPRESENTATIVE)
(WHEREVER APPLICABLE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

DOC NO. : CP/CVT/PT/02/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

PRE-COMMISSIONING OF CAPACITIVE VOLTAGE OR POTENTIAL TRANSFORMER COMMISSIONING FORMATS

P&M CIRCLE: P&M DIVISION sub-station
DATE OF TESTING DATE OF ENERGISATION

DETAILS OF EQUIPMENT :
PO NO:
MAKE:
TYPE:

	R - PHASE	Y - PHASE	B - PHASE
SL NO.			
YEAR OF MANUFACTURE			
FEEDER NAME :			
RATED DATA AND DUTY			
PRIMARY VOLTAGE :	KV		
SECONDARY DETAILS :	V		

	WINDING 1	WINDING 2	WINDING 3	
VOLTAGE :				VOLTS
VA BURDEN :				VA
CLASS				
PURPOSE				

DETAILS OF CHECKLIST :

S.N.	DESCRIPTION	STATUS YES	NO	REMARK RECORD DEFICIENCIES, IF ANY
1.	EQUIPMENT IS CLEANED AND FREE FROM DUST/ DIRT/FOREIGN MATERIALS ETC.			
2.	EQUIPMENT IS FREE FROM ALL VISIBLE DEFECTS ON PHYSICAL INSPECTION			
3.	CHECK CVT/PT TANK HAS BEEN PROVIDED WITH DOUBLE EARTHING			
4.	ALL NUTS AND BOLTS ARE TIGHTENED			
5.	CHECK TIGHTNESS OF TERMINAL CONNECTOR			
6.	LEVELLING AND ALIGNMENT OF STRUCTURE AND BASE FRAME			
7.	ANY PAINT REMOVED/SCRATCHED IN TRANSIT HAS BEEN TOUCHED UP			
8.	SECONDARY POLARITY OF CVT's/PT's ERECTED			
9.	CHECK HERMETICALLLY SEALING IS INTACT			
10.	CHECK THE OIL LEVEL AND LEAKAGE THROUGH ANY JOINTS/SEC. TERMINALS			
11.	CHECK OIL DRAIN VALVE IS PROPERLY CLOSED AND LOCKED			
12.	OIL LEVEL ON TOP CHAMBER GAUGE GLASS			

S.N.	DESCRIPTION	STATUS YES	NO	REMARK RECORD DEFICIENCIES, IF ANY
13.	LABELLING AND IDENTIFICATION MARKING IS CARRIED OUT			
14.	OUTSTANDING ACTIVITIES REVIEWED			
15.	SL. NO OF HV CAPACITOR IDENTICAL TO THE SL.NO MENTIONED ON RATING & DRG. PLATE			
16.	ENSURE BRASS VENT PLUG BETWEEN STACKS OF CVT'S IS REMOVED			
17.	BDV OF OIL SAMPLE TAKEN FROM TANK BOTTOM DRAIN VALVE FOR 400 KV & ABOVE VOLTAGE			
18.	CHECK WHETHER SECONDARY CABLE END BOX IS PROPERLY FIXED AND ALSO ENSURE PROPER CABLE ENTRY AT THE BOTTOM.			
19.	ENSURE H.F TERMINAL OF UNUSED PHASES HAS BEEN EARTHED AND THRE IS NO LOAD ON H.F TERMINAL BUSHING			
20.	CHECK RATING/ HEALTHINESS OF FUSES IN CVT/PT M.B AND CVT/PT TERMINAL BOX.			
21.	CHECK THAT THE NEUTRAL POINT IS EARTHED			
22.	ALL THE CABLE IDENTIFICATIONS AND ALL CORES ARE PROVIDED WITH FERRULES AT M.B FOR IDENRTIFICATION			
23.	ALL FITTINGS AS PER OUTLINE GENERAL ARRANGEMENT DRAWING			
24.	CHECK THAT CVT/PT JUNCTION BOX IS EARTHED			
25.	ENSURE INTERPOLE CABLING IS COMPLETED AND CHECK THE CONTINUTY			
26.	CHECK THE IR VALUE OF SECONDARY CABLE WITH 500 V MEGGAR (> 50 M OHMS FOR CONTROL CABLES)			
27.	ENSURE INTERPOLE CABLING IS COMPLETED AND CHECK THE CONTINUTY			
28.	CHECK THE CONTINUITY OF WINDING			

INSULATION RESISTANCE MEASUREMENT WITH A MEGGER OF 5KV/10 KV
MINIMUM VALUE : 1000 M OHMS

BETWEEN	MEASURED VALUE R-PHASE	Y-PHASE	B-PHASE	
PRIMARY - SECONDARY CORE 1				MOHM
PRIMARY - SECONDARY CORE 2				MOHM
PRIMARY - SECONDARY CORE 3				MOHM
PRIMARY - EARTH				MOHM

INSULATION RESISTANCE MEASUREMENT WITH 500 V MEGGER
MINIMUM VALUE : 50 M OHMS

BETWEEN	MEASURED VALUE R-PHASE	Y-PHASE	B-PHASE	
SECONDARY CORE 1 - EARTH				M OHM
SECONDARY CORE 2 - EARTH				M OHM
SECONDARY CORE 3 - EARTH				M OHM
CORE 1 - CORE 2				M OHM
CORE 1 - CORE 3				M OHM
CORE 2 - CORE 3				M OHM

VOLTAGE RATIO TEST

PHASE	PRIMARY VOLTAGE	SECONDARY VOLTAGE BETWEEN	VALUE	THEORATICAL RATIO	ACTUAL RATIO FACTORY	SITE	% ERROR
R		1a - 1 n					
R		2a - 2 n					
R		3a - 3 n					
Y		1a - 1 n					
Y		2a - 2 n					
Y		3a - 3 n					
B		1a - 1 n					
B		2a - 2 n					
B		3a - 3 n					

NOTE :

A. APPLY VOLTAGE OF THE ORDER OF 10 KV / 5 KV ACROSS LINE CAPACITOR (TOP FLANGE) TO EARTH LINK
B. ENSURE ALL EARTH LINKS CONNECTED
C. VOLTAGE RATIO TEST LIMITS ARE- ±5% FOR PROTECTION CORE & ±0.5% FOR METERING CORE

SECONDARY WINDING RESISTANCE IN OHMS

PHASE	CORE-1	CORE-2	CORE-3
R			
Y			
B			

ALL TERMINAL BLOCKS CLOSED IN THE SECONDARY SIDE AFTER ALL TESTING-

PHASING (PHASE RELATIONSHIP OR PHASE SEQUENCE) OF CVT BY MEASURING VOLTAGE BETWEEN R-PHASE, Y-PHASE AND B-PHASE AT INCOMING TERMINAL IN CONTROL CUBICLE,FOR ONE CIRCUIT OF THE CHECKED CVT / PT AND OUTPUT TERNINALS R-PHASE, Y-PHASE AND B-PH OFA REFERENCE CIRCUIT (EXISTING CVT/PT) WITH KNOWN PHASING

REFERENCE CIRCUIT	MEASURED VALUE R-PHASE	Y-PHASE	B-PHASE
R-PHASE			
Y-PHASE			
B-PHASE			

DETAILS OF TEST KIT:

ACROSS STACK	PRE- COMMISSIONING VALUES					
	CAPACITANCE			TAN DELTA		
	R- PHASE	Y -PHASE	B -PHASE	R- PHASE	Y -PHASE	B -PHASE
TOP						
MIDDLE						
BOTTOM						
TOTAL						
	FACTORY VALUES					
	CAPACITANCE					
	R- PHASE	Y -PHASE	B -PHASE	R- PHASE	Y -PHASE	B -PHASE
TOP						
MIDDLE						
BOTTOM						
TOTAL						

FINAL DOCUMENTATION REVIEW :

A. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED

B. DOCUMENTS REGARDING SPARES,EQUIPMENT, O&M MANNUALS ETC AVAILABLE AT SITE FOR O&M

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DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
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ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION :
(SUPPLIER REPRESENTATIVE) (WHEREVER APPLICABLE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

DOC NO: CP/BAY/03/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

PRE-COMMISSIONING OF BAY/ FEEDER
COMMISSIONING FORMATS

NAME OF BAY

CHECK OF BAY MARSHALLING KIOSK

DETAILS	IDENTIFICATION NUMBER	REMARKS , IF ANY
1. ILLUMINATION AND HEATER		
2. 5/15 A SOCKETS		
3. ALL SPECIFIED FUSES IN POSITION		
4. EARTHING AT DIFFERENT LOCATIONs		
5. ALL CABLES TIGHTNESS		
6. ALL CABLES ARE PROPERLY GLANDED		
7. ALL CABLES HAVE IDENTIFICATION NO		
8. ALL CORES HAVE IDENTIFICATION NO		
9. SHIELDING WIRES ARE EARTHED		
10. FREE FROM DUST AND DAMAGE		
11. DOOR HINGES AND LOCKING		
12. PAINTS		
13. UNUSED HOLES ARE SEALED		

AVAILABILITY OF THE FOLLOWING

DETAILS	STATUS YES/NO	REMARKS TEMPORARY ARRANGEMENT,IF ANY
1. FIRE FIGHTING SYSTEM COMMISSIONED		
2. FIRE PROTECTION INCLUDING ALARMS (NIFPES)		
3. FIRE HYDRANT SYSTEM (400 KV S/S)		
4. FIRE DELUGE (SPINKLER) SYSTEM 400 KV S/S's		
5. PORTABLE FIRE EXTINGUSHERS ARE IN POSITION		
6. FIRE TENDERS CAN BE MADE AVAILABLE FOR ANY EVENTUALITY		TEL NO:
7. ALL EQUIPMENT ERECTION AS PER GENERAL ARRANGEMENT DRAWING ISSUED BY DESIGN		
8. EQUIPMENT IDENTIFICATION & NAME PLATES ARE PROPERLY FIXED		
9. ALL EARTHING POINTS HAVE BEEN EARTHED		
10. ALL BUSPOST INSULATORS ARE CLEANED AND FREE FROM DUST/DIRT FOREIGN MATERIALS ETC.		
11. ALL NUTS AND BOLTS OF BUS-BAR ARE TIGHTENED		
12. ALL CLAMPS AND CONNECTORS ARE AS PER THE DRAWINGS		
13. ANY PAINT REMOVED OR SCRATCHED IN YARD EQUIPMENTS HAS BEEN RE-TOUCHED		

AVAILABILITY OF THE FOLLOWING

DETAILS	STATUS YES/NO	REMARKS TEMPORARY ARRANGEMENT,IF ANY
1. BAY IDENTIFICATION AND DESIGNATION PLATE ARE FIXED WITH R,Y, B PHASE MARKING		
2. GRAVEL FILLING IN THE YARD HAS BEEN DONE		
3. THE LADDERS/TOOLS/VEHICLES/WORK-BENCH / TEMPORARY EARTHINGS ETC HAVE BEEN.REMOVED FROM THE AREA WHICH IS TO BE ENERGIZED		
4. DC EMERGENCY LIGHT IS IN OPERATION AND IN AUTO-MODE		
5. DG SET IS AVAILABLE AND IN OPERATION (FOR 400 KV SUB-STATIONS)		
6. FOR 220 KV S/S's DUAL AC SUPPLY SHOULD BE AVAILABLE		
7. SWITCHING SEQUENSES WITH PROCEDURES ARE DOCUMENTED AND AVAILABLE IN THE CONTROL ROOM ALONG WITH SAFETY MANUAL		
8. REGULAR OPERATION IN THE CONTROL ROOM IS MANNED ROUND THE CLOCK WITH REGULAR OPERATION STAFF		
9. ALL PTW ISSUED EARLIER ARE CANCELLED AND NONE ARE PENDING		
10. OPERATION DATA LOG SHEETS, PTW AND OTHER STANDARD FORMATS OF PSTCL ARE AVAILABLE FOR REGULAR OPERATION		
11. CONFIRM COLOR CODING OF ALL EQUIPMENTS ALONG WITH THE PHASE MARKINGS		
12. CHECK STAR POINTS OF CT & CVT SECONDARY AND ASSOCIATED LINKS, IF ANY		
13. CHECK THAT EARTH PITS ARE COVERED		
14. CHECK THE TIGHTNESS OF THE CONNECTING LINKS OF TREATED EARTH PITS		
15. CORE WISE SECONDARY INJECTION TEST FOR BOTH CTs AND PTs INPUTS FROM SECONDARY TERMINAL BOX OF CT/ PT DONE TO DETECT ANY MIXING/INTE-RCHANGING OF CORES/ PHASES		
16. FUSE FAIL PROTECTION CHECKED FOR M1, M2, BACKUP IMPEDANCE ETC		
17. NECESSARY CLEARANCES AS APPLICABLE HAVE BEEN OBTAINED		
18. CHARGING CLEARANCE HAS BEEN RECEIVED FROM GRID CONSTRUCTION/ P&M /PROTECTION/ OPERATION SERVICES/VIDE MSG NO :		
19. CEI CLEARANCE RECEIVED		
20. CHARGING CODE APPLIED TO SLDC		

DOC NO: CP/BAY/03/PCT/2
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

CHECKING OF INTERLOCKS :

PLEASE REFER THE RELEVENT PLANT CIRCUIT DIADRAM FOR CHECKING THE INTERLOCKS OF VARIOUS EQUIPMENTS TO BE ENERGIZED. ALL ISOLATORS AND EARTH SWITCH INTERLOCKINGS HAVE BEEN CHECKED AS PER THE DRAWINGS- IF NO, GIVE REASONS

YES	NO

TRIP TEST
ALL BREAKERS HAVE BEEN TESTED AND TRIP-TEST PERFORMED AS PER THE ENGINEERING DRAWINGS & APPROVED SCHEMES-

YES	NO

MEASUREMENT OF EARTH RESISTANCE
THE EARTH RESISTANCE ARE TABULATED AS BELOW

SL. NO	LOCATION DESCRIPTION	DISTANCE BETWEEN ELECTRODES	RESISTANCE
LOCATION - 1			
LOCATION - 2			
LOCATION - 3			
LOCATION - 4			
LOCATION - 5			
LOCATION - 6			

CONTACT TIGHTNESS CHECK BY PRIMARY CURRENT INJECTION

CURRENT INJECTION AT	CURRENT MEASURED AT	CURRENT INJECTED	CURRENT MEASURED	REMARKS ON CONTACT HEALTHINESS

MEASUREMENT OF SOIL RESISTIVITY DONE EARLIER PRIOR TO COMMISSIONING MAY ALSO BE TABULATED-
DATE : DISTANCE BETWEEN ELECTRODE SOIL RESISTIVITY REMARK
CHECK THE MINIMUM CLEARANCE BETWEEN LIVE PARTS W.R.T GROUNG AND BETWEEN LIVE PARTS

VOLTAGE	PHASE TO GROUND	PHASE TO PHASE	REMARKs , IF ANY
132 KV	1270 mm	1473 mm	
220 KV	2082 mm	2368 mm	
400 KV	3065 mm	5750 mm	
765 KV	6400 mm	9400 mm	

NOTE :ALL THE CLEARANCES BETWEEN PHASE—PHASE & PHASE--GROUND ARE CHECKED AS PER THE DRGS. ISSUED BY DESIGN DEPTT.
STABILITY TEST FOR BUSBAR (TO BE DONE IN LINE WITH APPROVED SCHEME)
DETAILS OF KIT USED -
<u>CONDITION 1: BUS EARTH SWITCH OPEN</u>

PHASE	PRIMARY INJECTION BETWEEN CTs	CURRENT VALUE	SPILL CURRENT VALUE	REMARKS
R				
Y				
B				

<u>CONDITION 2: BUS EARTH SWITCH CLOSED</u>
Performa same as above

DOC NO: CP/BAY/03/PCT/3
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

FINAL TRIP TEST-

THE TRIP TEST MUST BE REPEATED IMMEDIATELY BEFORE ENERGIZATION AS PER APPROVED SCHEME/DRAWING. TRIPPING OPERATION SHOULD BE CHECKED FOR BOTH THE TRIP COILS FROM LOCAL/ REMOTE/ PROTECTION

DC SOURCE-1 (OFF)

	PROTECTION TYPE	SIMULATION METHOD	CB TRIP RESPONSE MAIN	TIE	REMARKS
1.	MAIN- I				
2.	MAIN – II				
3.	OVER VOLTAGE				
4.	CARRIER INTER-TRIPPING				
5.	LBB				
6.	BUS-BAR				
7.	TEE-DIFFERENTIAL				
8.	DIFFERENTIAL				
9.	RESTRICTED EARTH FAULT				
10.	BACK UP O/C & E/F				
11.	OVER-FLUXING				
12.	OTI TRIP				
13.	WTI TRIP				
14.	BUCHHOLZ TRIP (MAIN)				
15.	BUCHHOLZ TRIP (OLTC)				
16.	PRD/PRV				
17.	AUTO-RECLOSE R- Ø				
18.	AUTO-RECLOSE Y- Ø				
19.	AUTO-RECLOSE B Ø				

DC SOURCE 2 (OFF)
SAME PERFORMA AS GIVEN ABOVE TO BE USED
This is applicable only in case where both sources are being used parallel i.e trip circuit-1 is on 1st source and trip circuit-2 is on 2nd source.

IN CASE, IF ONLY ONE SOURCE CATERS TO BOTH TRIP CIRCUITS, ONLY ONE PERFORMA is REQUIRED TO BE FILLED
OPERATIONAL CONSTRAINTS IF ANY

FINAL DOCUMENTATION REVIEW :

A. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED | YES | NO |

B. DOCUMENTS REGARDING SPARES, EQUIPMENT, O&M MANNUALS ETC AVAILABLE AT SITE FOR O&M

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DOC NO: CP/LA/04/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

P&M CIRCLE: P&M DIVISION SUB-STATION
DATE OF TESTING DATE OF ENERGISATION
DETAILS OF EQUIPMENT :
PO NO:
MAKE:
TYPE:

	R - PHASE	Y - PHASE	B - PHASE
SL NO.			
YEAR OF MANUFACTURE			

FEEDER NAME :
RATED DATA AND DUTY
PRIMARY VOLTAGE : KV
DETAILS : CHECKLIST/TESTING

SL. NO	DESCRIPTION	STATUS YES	STATUS NO	REMARK RECORD DEFICIENCIES, IF ANY
1.	EQUIPMENT IS FREE FROM DIRT/DUST FOREIGN MATERIALS ETC.			
2.	EQUIPMENT IS FREE FROM ALL VISIBLE DEFECTS ON PHYSICAL INSPECTION			
3.	SUPPORT STRUCTURES HAVE BEEN PROVIDED WITH DOUBLE EARTH			
4.	ALL NUTS & BOLTS ARE TIGHTENED			
5.	EQUIPMENT ERECTION IS COMPLETE IN ALL RESPECTS			
6.	PERMANENT LABELLING AND IDENTIFICATION IS DONE			
7.	LEVELLING AND ALIGNMENT OF STRUCTURE AND BASE FRAME IS CHECKED			
8.	ALL INSULATORS & SURGE COUNTER ARE FREE FROM ANY PHYSICAL DEFECTS			
9.	TIGHTNESS OF NUTS BOLTS OF TERMINAL CONNECTORS ARE CHECKED			
10.	REVIEW OF OUTSTANDING ACTIVITIES			
11.	CHECK THAT ONE END OF SURGE COUNTER IS CONNECTED TO THE BOTTOM OF LA STACK AND THE OTHER END OF SURGE COUNTER HAS BEEN EARTHED			
12.	OPERATION OF LA COUNTER CHECKED BY APPLYING APPROPRIATE VOLTAGE			
13.	TO CHECK SEQUENCE OF LA PARTS FOR ERECTION IN MULTI -STACK LA's			
14.	TO CHECK THE ALIGNMENT OF CORONA RING			
15.	TO CHECK ON CHARGING THAT THE SURGE COUNTER POINTER IS IN GREEN ZONE			
16.	TO CHECK THAT CLEARANCE FROM THE ARRRESTOR TO EARTHED OBJECTS AND FROM THE ARRESTOR POLE TO ADJACENT ARRESTER POLE IS MAINTAINED			

SURGE COUNTER READING

SL. NO	READING	PHASE		
		R-PHASE	Y-PHASE	B-PHASE
1	COUNTER MAKE			
2	COUNTER SR. NO.			
3	COUNTER READING			

CAPACITANCE & TAN DELTA MEASUREMENT

STACK	CAPACITANCE	TAN DELTA	REMARKS
TOP			
MIDDLE 1			
MIDDLE 2			
BOTTOM			

CHECKING OF HEALTHINESS OF SURGE MONITOR : YES / NO

REFER MANUFACTURER'S CATALOGUE FOR DETAIL CHECKING OF SURGE MONITOR

THIRD HARMONIC RESISTIVE CURRENT MEASUREMENT

AMBIENT TEMPERATURE

SYSTEM VOLTAGE

PH	TOTAL CURRENT	3^{rd} HARMONIC RESISTIVE CURRENT (I3R) in μA	REMARKS
R			
Y			
B			

THE VALUE OF 3^{rd} HARMONIC CURRENT AFTER COMPENSATION SHALL BE LESS THAN 30 μA.

INSULATION RESISTANCE MEASUREMENT : (USING 5KV MEGGER)

SN	BETWEEN	PHASES			MIN VALUE. 1 G OHM
		R-PHASE	Y-PHASE	B-PHASE	
1	1^{st} STACK & EARTH				
2	2^{nd} STACK & EARTH				
3	3^{rd} STACK & EARTH				
4	4^{th} STACK & EARTH				
5	5^{th} STACK & EARTH				
6	6^{th} STACK & EARTH				

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A. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED: YES/NO

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ORGANISATION : (SUPPLIER REPRESENTATIVE)
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FINAL DATE OF TESTING

P&M CIRCLE: P&M DIVISION SUB-STATION
DATE OF TESTING DATE OF ENERGISATION
DETAILS OF EQUIPMENT :
PO NO:
MAKE:
TYPE:

	R - PHASE	Y - PHASE	B - PHASE
SL NO.			
YEAR OF MANUFACTURE			

FEEDER NAME :
RATED DATA AND DUTY:
RATED BREAKING CAPACITY in kA:
PRIMARY OPERATING VOLTAGE KV:
DC CONTROL VOLTAGE (Volts):

DETAILS : CHECKLIST/TESTING

SL. NO	DESCRIPTION	STATUS		REMARK
		YES	NO	RECORD DEFICIENCIES, IF ANY
1.	EQUIPMENT IS FREE FROM DIRT/DUST FOREIGN MATERIALS ETC.			
2.	EQUIPMENT IS FREE FROM ALL VISIBLE DEFECTS ON PHYSICAL INSPECTION			
3.	SUPPORT STRUCTURES HAVE BEEN PROVIDED WITH DOUBLE EARTH			
4.	ALL NUTS & BOLTS ARE TIGHTENED			
5.	EQUPIMENT ERECTION IS COMPLETE IN ALL RESPECTS			
6.	PERMANENT LABELLING AND IDENTIFICATION IS DONE			
7.	LEVELLING AND ALIGNMENT OF STRUCTURE AND BASE FRAME IS CHECKED			
8.	ALL INSULATORS ARE FREE FROM ANY PHYSICAL DEFECTS			
9.	TIGHTNESS OF NUTS BOLTS OF TERMINAL CONNECTORS ARE CHECKED			
10.	REVIEW OF OUTSTANDING ACTIVITIES			
11.	CONTROL BOX/MARSHALLING KIOSK IS FREE FROM ANY PHYSICAL DEFECTS			
12.	AUXILLARY CONTACTS AND RELAYS HAVE BEEN CLEANED AND ARE FREE FROM RUST/DAMAGE.			
13.	OPERATING SYSTEM TYPE (CLOSING)- PNEUMATIC / SPRING / OTHERS			
14.	OPERATING SYSTEM TYPE (OPENING)- PNEUMATIC / SPRING / OTHERS			
15.	CHECKING SAFETY VALVE (OPEN/CLOSE)			
16.	AUTO RECLOSING LOCKOUT			
17.	GENERAL LOCKOUT			
18.	ANTI- PUMPING CONTACTOR			
19.	POLE DESCREPANCY TIMER			
20.	AUXILLARY POWER CONTACTOR			
21.	CLOSING/TRIPING LOCKOUT			
22.	AIR MONITOR/GAS MONITOR			

DOC NO: CP/CB/05/PCT/2
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

PRESSURE SWITCH SETTING

CIRCUIT REFERENCE	FACTORY SETTING VALUE		SITE SETTING VALUE		REMARKS
	BLOCK	DE-BLOCK	BLOCK	DE-BLOCK	
OPERATION LOCKOUT -1					
OPERATION LOCKOUT -2					
CLOSING LOCKOUT					
AUTO RECLOSING CIRCUIT					
LOW/HIGH PRESSURE					
ALARM CIRCUIT					
SETTING					
SAFETY VALVE					
OPERATIONS					

PRESSURE DROP DURING OPERATION : (IN KG/SQ.CM -BAR)

SR NO	DESCRIPTION	FACTORY SETTING VALUES	SITE SETTING VALUES
1.	TRIPPING THROUGH TC- I		
2.	TRIPPING THROUGH TC- II		
3.	CLOSING CIRCUIT		
4.	CLOSE-OPEN OPERATION		
5.	OPEN - CLOSE – OPEN		

LEAKAGE CHECK :

GAS PRESSURE DROP IN 24 HRS :
BREAKER ON: DROP IN PRESSURE: Kg/Cm^2 OR BAR
BREAKER OFF: DROP IN PRESSURE: Kg/Cm^2 OR BAR
INITIAL FILLING OF SF6 GAS AT ____ ^{o}C (AS PER TEMP. CORRECTION CHART): BAR
DROP IN SF6 GAS PRESSURE IN 24 HRS : BAR
FINAL SF_6 PRESSURE AT ________^{o} C AFTER ALL TESTING: BAR

SF6 DENSITY MONITOR DETAIS

		BLOCKING		DE-BLOCKING		SF6 GAS FILLED AT
		FACTORY	SITE	FACTORY	SITE	(BAR)
R - PHASE	LOW PRESSURE ALARM					
	OPERATION BLOCK					
Y - PHASE	ALARM					
	OPERATION BLOCK					
B - PHASE	ALARM					
	OPERATION BLOCK					

MEASUREMENT OF DEW POINT OF SF6 GAS :

MIN. VALUE OF DEW POINT REQUIRED AS PER DOC. NO. CE/PM/OS/INST-5B
MEASURED VALUE:
R-PHASE
Y-PHASE
B-PHASE
NOTE: DEW POINT MEASUREMENT OF SF_6 GAS NEEDS TO BE DONE POLE WISE IN CLOSE LOOP METHOD WITHOUT ANY WASTAGE OF SF_6 GAS

DOC NO: CP/CB/05/PCT/3
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

COIL RESISTANCE MEASUREMENT :

PHASE	COIL	MEASURED VALUE	SERIES RESISTOR	TOTAL (IN Ω)
R	COIL-1			
	COIL-2			
Y	COIL-1			
	COIL-2			
B	COIL-1			
	COIL-2			

CIRCUITARY / OPEARTIONAL CHECKS :

SN	CIRCUIT REFERENCE	CIRCUITRY CHECK	OPERATIONAL CHECK
		LOCAL/REMOTE	LOCAL/REMOTE
1.	TRIPPING THROUGH TC-I		
2.	TRIPPING THROUGH TC-II		
3.	CLOSING CIRCUIT		
4.	ANTI-HUNTING FEATURE		
5.	(CLOSE OPEN OPERATION)		
6.	POLE DISCREPANCY FEATURE		
7.	BREAKER POSITION INDICATION		
8.	HEATER IN SWITCH CUBICLE		
9.	HEATER IN CONTROL CUBICLE		
10.	ILLUM. IN SWITCH CUBICLE		
11.	ILLUM. IN CONTROL CUBICLE		

OPERATING TIME (IN MILLI-SECONDS):

PHASE	BREAK	CLOSE	TRIP-1	TRIP-II	CLOSE-TRIP-1	CLOSE-TRIP-II
R - PH MAIN CONTACT	BREAK 1					
R - PH PIR						
AUXILIARY CONTACT						
R - PH MAIN CONTACT	BREAK 2					
R - PH PIR						
AUXILIARY CONTACT						
Y - PH MAIN CONTACT	BREAK 1					
Y - PH PIR						
AUXILIARY CONTACT						
Y - PH MAIN CONTACT	BREAK 2					
Y - PH PIR						
AUXILIARY CONTACT						
B - PH MAIN CONTACT	BREAK 1					
B - PH PIR						
AUXILIARY CONTACT						
B - PH MAIN CONTACT	BREAK 2					
B - PH PIR						
AUXILIARY CONTACT						

CONTACT RESISTANCE MEASUREMENT

PHASE	ACROSS EACH POLE	ACROSS INTERRUPTER-1	ACROSS INTERRUPTER-2
	FACTORY/SITE	FACTORY/SITE	FACTORY/SITE
R			
Y			
B			

DOC NO: CP/CB/05/PCT/4
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

IR VALUE OF CONTROL CIRCUIT :

USING 500 VOLT MEGGER

MINIMUM VALUE 2 M OHM

CAUTION : ISOLATE DC FOR TRIP COIL I AND TRIP COIL II ,CLOSING COIL BEFORE MEGGARING.

COIL DETAILS	MEASUREMENT VALUE
R - PHASE TRIP COIL - I	M OHM
R - PHASE TRIP COIL - II	M OHM
R - PHASE CLOSE COIL	M OHM
Y - PHASE TRIP COIL - I	M OHM
Y - PHASE TRIP COIL - II	M OHM
Y - PHASE CLOSE COIL	M OHM
B - PHASE TRIP COIL - I	M OHM
B - PHASE TRIP COIL - II	M OHM
B - PHASE CLOSE COIL	M OHM

IR VALUE WITH BREAKER OPEN :

USING 5000 VOLT MEGGER

MINIMUM VALUE 1000 MOHM

ACROSS OPEN CONTACT	MEASUREMENT VALUE
R - PHASE BREAK 1	M OHM
R - PHASE BREAK-2	M OHM
Y - PHASE BREAK 1	M OHM
Y - PHASE BREAK-2	M OHM
B - PHASE BREAK 1	M OHM
B - PHASE BREAK-2	M OHM

IR VALUE WITH RESPECT TO EARTH WITH BREAKER CLOSED, EARTH SWITCH AND ISOLATOR OPEN :

USING 5000 VOLT MEGGER

MINIMUM VALUE 1000 M OHM

BETWEEN	MEASUREMENT VALUES
R - PHASE AND EARTH	M OHM
Y - PHASE AND EARTH	M OHM
B - PHASE AND EARTH	M OHM

MINIMUM PICKUP VOLTAGE OF COILS

COIL DETAILS	MEASUREMENT VALUES
R - PHASE TRIP COIL - I	V
R - PHASE TRIP COIL - II	V
R - PHASE CLOSE COIL	V
Y - PHASE TRIP COIL - I	V
Y - PHASE TRIP COIL - II	V
Y - PHASE CLOSE COIL	V
B - PHASE TRIP COIL - I	V
B - PHASE TRIP COIL - II	V
B - PHASE CLOSE COIL	V

GRADING CAPACITOR : CAPACITANCE AND TAN DELTA MEASUREMENT :

DESCRIPTION		INTERRUPTER-1	INTERRUPTER-II
CAPACITANCE-	SITE		
	FACTORY		
TAN DELTA-	SITE		
	FACTORY		

DOC NO: CP/CB/05/PCT/5
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

BREAKER OPERATION COUNTER READING :

COUNTER TYPE :

ELECTRICAL :

MECHANICAL :

PHASE-R	READING	DATE
PHASE-Y		
PHASE-B		

CHECK FOR ANNUNCIATIONS IN CONTROL ROOM AS PER THE FOLLOWING FORMATS & RECORD THE READINGS :

	DESCRIPTION	SOURCE OF INITIATION	WINDOW	RESULT	REMARKS
1.	SWITCH OFF THE DC SWITCH IN CONTROL CUBICLE OF CB	CONTROL CUBICLE DC SWITCH ON/OFF	SOURCE I/II DC FAIL	OK/NOTOK	
2.	SHORT THE ALARM CONTACTS OF SF_6 GAS DENSITY MONITOR (R-PHASE)	DENSITY MONITOR	SF_6 GAS LOW		
3.	SHORT THE ALARM CONTACTS OF SF_6 GAS DENSITY MONITOR (Y-PHASE)	DENSITY MONITOR	SF_6 GAS LOW		
4.	SHORT THE ALARM CONTACTS OF SF_6 GAS DENSITY MONITOR (B-PHASE)	DENSITY MONITOR	SF_6 GAS LOW		
5.	REMOVE THE CABLE CONNECTED TO DENSITY MONITOR (R-PHASE)	DENSITY MONITOR	OPERATION/CLOSE BLOCKING		
6.	REMOVE THE CABLE CONNECTED TO DENSITY MONITOR (Y-PHASE)	DENSITY MONITOR	OPERATION/CLOSE BLOCKING		
7.	REMOVE THE CABLE CONNECTED TO DENSITY MONITOR (B-PHASE)	DENSITY MONITOR	OPERATION/CLOSE BLOCKING		
8.	GIVE TRIPPING COMMAND TO R-PH ONLY AND CHECK THE OPERATION OF POLE DISCRIPANCY RELAY	POLE DISCREPANCY RELAY IN CB CUBICLE	POLE DISCREPANCY RELAY OF CB		
9.	GIVE TRIPPING COMMAND TO Y-PH ONLY AND CHECK THE OPERATION OF POLE DISCRIPANCY RELAY	POLE DISCREPANCY RELAY IN CB CUBICLE	POLE DISCREPANCY RELAY OF CB		
10.	GIVE TRIPPING COMMAND TO B-PH ONLY AND CHECK THE OPERATION OF POLE DISCRIPANCY RELAY	POLE DISCREPANCY RELAY IN CB CUBICLE	POLE DISCREPANCY RELAY OF CB		
11.	CHECK OTHER ALARMS AS PER CIRCUIT DIAGRAM				
12.	CLOSE THE BREAKER AND TRIP THROUGH OTHER PROTECTIONS/ PROTECTION CIRCUITS PROVIDED	AS PER SCHEME			

DYNAMIC CONTACT RESISTANCE & TRAVEL MEASUREMENT (400 KV & ABOVE CB'S)

MAKE OF TESTING KIT-

PHASE	FACTORY	SITE	REMARKS	APPROVAL FROM OS
R				
Y				
B				

A. OPERATION TIME MEASUREMENT OF POLE DISCREPANCY RELAY

B. MECHANICAL CLOSE INTERLOCK CHECKED (WHEREVER APPLICABLE)

FINAL DOCUMENTATION REVIEW

A. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED: YES/NO

B. DOCUMENTS REGARDING SPARES, EQUIPMENT, O&M MANNUALS ETC AVAILABLE AT SITE YES/NO

C. OS APPROVED DCRM SIGNATURES AVAILABLE YES/NO

REMARKS & OBSERVATIONS

SIGNATURE :	SIGNATURE :	SIGNATURE :
NAME :	NAME :	NAME :
DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION	ORGANISATION : P&M	ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)
(WHEREVER APPLICABLE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

DOC NO: CP/TF/ICT/06/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

GENERAL INFORMATION OF POWER TRANSFORMER/ ICT

P&M CIRCLE: P&M DIVISION: SUB-STATION:
DATE OF RECEIPT AT SITE:
DATE OF COMPLETION OF ERECTION & OIL FILLING:
DATE OF TESTING:
DATE OF ENERGISATION/TEST CHARGE:
DETAILS OF EQUIPMENT :
PO NO:
MAKE:
TYPE:
RATING
SR. NO-
VOLTAGE RATIO:
COOLING TYPE:
TYPE OF NEUTRAL GROUNDING
YEAR OF MANUFACTURE:
OIL QUANTITY Quantity In Main Tank:
Quantity in Radiators:

OIL TYPE
INHIBITED/UN-INHIBITED/STANDARD:

CHECK LIST OF ELECTRICAL TESTS CARRIED OUT FOR TRANSFORMER

SN	NAME OF TEST	RESULTS (OK/NOT OK)
1.	INSULATION RESISTANCE MEASUREMENT	
2.	VECTOR GROUP TEST & POLARITY CHECK	
3.	SHORT CIRCUIT IMPEDANCE TEST	
4.	MAGNETIC BALANCE TEST	
5.	FLOATING NEUTRAL VOLTAGE MEASUREMENT	
6.	MAGNETISATION CURRENT TEST	
7.	VOLTAGE RATIO TEST	
8.	INSULATION RESISTANCE MEASUREMENTS OFBUSHING CTs	
9.	MEASUREMENT OF WINDING RESISTANCE OF ICT/TRANSFORMER	
10.	CONTINUITY TEST OF BUSHING CTs	
11.	SECONDARY WINDING RESISTANCE OF BUSHING CTs	
12.	POLARITY TEST OF BUSHING CTs	
13.	CURRENT RATIO TEST	
14.	MAGNETISING CURVES PERFORMANCE	
15.	CONTACT RESISTANCE MEASUREMENT	
16.	TAN DELTA & CAPACITANCE MEASUREMENT OF BUSHING	
17.	TAN DELTA & CAPACITANCE MEASUREMENT OF WINDING	
18.	OTHER PROTECTION AND ALARM TESTS	
19.	STABILITY TEST OF DIFFERENTIAL AND REF PROTECTION	
20.	FREQUENCY RESPONSE ANALYSIS	
21.	INSULATION DIAGNOSTIC ANALYSIS	

SIGNATURE :	SIGNATURE :	SIGNATURE :
NAME :	NAME :	NAME :
DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION	ORGANISATION : P&M	ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

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DOC NO: CP/TF/ICT/06/PCT/2
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

CHECKS AFTER RECEIPT OF TRANSFORMER AT SITE:

N2 PRESSURE & DEW POINT RECORD	N_2 PRESSURE	DEW POINT	AMBIENT TEMP.	REMARKS*
1. DURING DISPATCH AT FACTORY				
2. AFTER RECEIPT AT SITE				
3. DURING STORAGE AT SITE BEFORE COMM.				

* Please write 'NIL' in case of No Remarks. NOTE: N2 PRESSURE AND DEW POINT SHOULD BE WITHIN PERMISSIBLE RANGE AS PER GRAPH PROVIDED BY MANUFACTURER AND ALSO GIVEN IN OS DOC- DURING STORAGE AT SITE, DEW POINT HAS TO BE MEASURED WHENEVER ANY DROP IN N_2 PRESSURE IS OBSERVED. DURING STORAGE AT SITE BEFORE COMMISSIONING, N2 PRESSURE HAS TO BE MEASURED DAILY AND RECORD TO BE MAINTAINED IN A SEPARATE SHEET.

IMPACT RECORER ANALYSIS:	**STATUS**	**BRIEF ANALYSIS**
RECEIVED IN HEALTHY CONDITION AT SITE	YES/NO	
ANALYSIS REPORT		
RECEIVED FROM MANUFACTURER BEFORE CHARGING	YES/NO	

Note: Impact Recorder should be detached from the Transformer/ Reactor preferably when the main unit has been placed on its foundation.

CORE INSULATION CHECK

APPLY 1.0 KV DC BETWEEN CL & CC+G

	INSULATION VALUE	RECOMMENDED VALUE.10 M OHMS
BETWEEN CC-G		
BETWEEN CL-G		
BETWEEN CC-CL		

Note: SHORTING LINK BETWEEN CC, CL & G TO BE REMOVED AND IR VALUE TO BE TAKEN BETWEEN CC-G, CL-G & CC-CL

CHECKS/ PRECAUTIONS DURING ERECTION

SN	NAME OF TEST	RESULTS (OK/NOT OK)	REMARKS
1.	ACTIVE PART OF TRANSFORMER SHOULD BE MINIMUM EXPOSED TO ATMOSPHERE		
2.	DURING EXPOSURE OF ACTIVE PART OF TRANSFORMER TO ATMOSPHERE DRY AIR GENERATOR/ DRY AIR CYLINDERS USED :		
3.	WHILE ENTERING IN TRANSFORMER TANK, CHECK AVAILABILITY OF PROPER OXYGEN		
4.	TRANSFORMER KEPT SEALED WITH N_2 IN BETWEEN DIFFERENT ERECTION ACTIVITIES		

REMARKS REGARDING ERECTION ACTIVITIES-

SIGNATURE :	SIGNATURE :	SIGNATURE :
NAME :	NAME :	NAME :
DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION	ORGANISATION : P&M	ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

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DOC NO: CP/TF/ICT/06/PCT/3
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

PRE-COMMISSIONING CHECKS

SL. NO	DESCRIPTION	STATUS		REMARK
		YES	NO	RECORD DEFICIENCIES, IF ANY
1.	ICT AND ITS AUXILIARIES ARE FREE FROM VISIBLE DEFECTS OPON PHYSICAL INSPECTION			
2.	ALL FITTINGS ARE AS PER GENERAL OUTLINE ARRANGEMENT & DRAWINGS			
3.	CHECK THAT MAIN TANK HAS BEEN PROVIDED WITH DOUBLE EARTHING			
4.	CHECK LEVELLING OF TRANSFORMER AND ITS ACCESSORIES			
5.	CHECK TIGHTNESS OF TERMINAL CONNECTORS			
6.	ALL NUTS AND BOLTS ARE TIGHTENED CORRECTLY			
7.	ERECTION ACTIVITIES ARE COMPLETE			
8.	CHECK NEUTRAL IS GROUNDED THROUGH SEPARATE			
9.	CONNECTIONS & EARTHING. ENSURE METALLIC REQUIREMENTS AS PER SPECIFICATION (e.g. Cu etc) IN EARTHING STRIPS USED			
10.	CHECK THAT MASHALLING BOX, T/C DRIVING GEAR, DIVERTER, RADIATOR BANK PUMPS & FAN MOTORS etc HAVE BEEN EARTHED			
11.	ANY PAINT REMOVED/SCRATCHED IN TRANSIT HAS BEEN TOUCHED UP			
12.	BUSHINGS ARE CLEAN AND FREE FROM PHYSICAL DAMAGES			
13.	OIL LEVEL IS SATISFACTORY IN ALL THE BUSHINGS			
14.	CHECK WHETHER HERMETICALLLY SEALING IS INTACT IN ALL BUSHINGS			
15.	CHECK OIL LEAKAGE THROUGH ANY JOINT/VALVE etc			
16.	CHECK THAT OIL DRAIN VALVES ARE PROPERLY CLOSED AND LOCKED.			
17.	CHECK THE OIL LEVEL IN MAIN/OLTC CONSERVATOR TANK			
18.	CHECK OIL LEVEL AT CONSERVATOR MATCHES WITH OIL TEMPERATURE OF TRANSFORMER			
19.	CHECK GEAR BOX OIL LEVEL IN OLTC			
20.	CHECK OTI AND WTI POCKETS AND REPLENISH THE OIL, IF REQUIRED			
21.	CKECK ALL VALVES FOR THEIR OPENING & CLOSING SEQUENCE			
22.	CHECK THE COLOUR OF BREATHER SILICA GEL (BLUE WHEN DRY)			
23.	CHECK THE LEVEL OF OIL IN THE BREATHER CUP			
24.	CHECK ALL ROLLERS ARE LOCKED AND TRACK WELDED WITH RAILS (WHEREEVER APPLICABLE)			
25.	CHECK THAT BUSHING TEST TAP IS GROUNDED			
26.	CHECK THERE IS NO DEBRIS, LOOSE T&P AND OIL STRAINS AROUND THE TRANSFORMER			
27.	CHECK DOOR SEALS OF MARSHALLING BOX IS INTACT AND ALL CABLE GLAND PLATES & UNUSED HOLES ARE SEALED			
28.	CHECK THAT PRESSURE RELIEF VALVE IS CORRECTLY MOUNTED			
29.	ENSURE UNUSED SECONDARY CORES OF BUSHING CT's, IF ANY, HAS BEEN SHORTED			

SL. NO	DESCRIPTION	STATUS		REMARK
		YES	NO	RECORD DEFICIENCIES, IF ANY
1.	CHECK- STAR POINT HAS BEEN FORMED PROPERLY AND GROUNDED AT ONE END ONLY AS PER SCHEME			
2.	CKECK THE AVAILABILITY OF ADEQUATE LIGHITING ARRANGEMENTS			
3.	CHECK THAT LABELLING AND IDENTIFICATION IS PERMANENT AND SATISFACTORY			
4.	CHECK THAT BUCHHOLZ RELAY IS CORRECLY MOUNTED WITH ARROW POINTING TOWARDS CONSERVATOR			
5.	CHECK CABLES ARE PROPERLY FIXED AND ENSURE CABLE ENTRY AT THE BOTTOM.			
6.	ENSURE ALL POWER AND CONTROL CABLE TERMINALS ARE TIGHTENED			
7.	CHECK ALL CABLES AND FERRULS ARE PROVIDED WITH NUMBER AS PER CABLE SCHEDULE (CROSS FERULING TO BE CHECKED)			
8.	CHECK -ALL CABLES ARE CORRECTLY GLANDED			
9.	CHECK EXTERNAL CABLING FROM JUNCTION BOX TO RELAY/CONTROL PANEL IS COMPLETED			
10.	CHECK -AIR HAS BEEN RELEASED FROM THE RADIATORS AND THEIR HEADERS/OLTC BUCHHOLZ RELAY/MAIN TANK/TANK/BUSHING TURRETS etc.			
11.	CHECK FIRE PROTECTION SYSTEM (NIFPS) & EMULSIFIRE SYSTEM SHOULD BE ADEQUATE & READY			
12.	CHECK THAT CC-CL&G ARE SHORTED			
13.	CHECK THAT ALL RADIATOR BANK VALVES ON TOP AND BOTTOM HEADERS ARE OPEN			
14.	CHANGE OVER OPERATION OF AC SUPPLY FROM SOURCE-I TO SOURCE-II CHECKED			
15.	CHECK THE FLANGES OF BUSHING & OLTC FOR ANY CRACK AFTER FIXING			
16.	CHECK VARIOUS INTERLOCKS PROVIDED WITH FIRE FIGHTING SYSTEM			

DETAILS OF VARIOUS INTER-LOCKS CHECKED

MEASUREMENT OF EARTH RESISTANCE OF ELECTRODE

LOCATION

VALUE (Before connection to grid)

VALUE (After connection to grid)

NOTE: VALUE OF EARTH RESISTANCE< 1.0 OHM

CALIBRATION OF OTI & WTI PERFORMED AS PER PROCEDURE

EVACUATING AND OIL FILLING

1. BEFORE FILLING OIL, EACH DRUM HAS BEEN PHYSICALLY CHECKED FOR MOISTURE AND APPEARANCE: YES/NO
2. EXPOSURE DURING ERECTION (Transformer to be kept sealed with N2 in between
3. N2 SEALING IN CASE OF DELAY IN OIL FILLING

TIGHTNESS TEST

4. STARTED EVACUATING ON COMPLETE UNIT AT ON
5. STOP EVACUATING AT 0.3 kPa (3 mbar) AT ON
6. PRESSURE P1 ..... kPa (1 HOUR AFTER STOP EVACUATING
7. PRESSURE P2 ..... kPa (0.5 HOUR AFTER READING PRESSURE P1)
8. LEAKAGE = (P2-P1)X V = (V=Oil quantity in Cu mtr)
   IF LEAKAGE <3.6, CONTINUE EVACUATING

VACCUM

9. PRESSURE BROUGHT EQUAL OR LESS THAN 0.13 kPa (1.3 mbar) REACHED
10. VACUUM IS KEPT FOR 12 HRS IN CASE OF 145 KV, 24 HRS FOR 145 KV TO 420 KV & 36 HRS FOR ABOVE 420 KV

OIL FILLING

11. OIL FILLING IS MADE
12. OIL CONSERVATOR WITH AIR CELL
13. DIVERTER SWITCH HOUSING FILED & HAS AN AIR CUSHION

STANDING TIME

14. Upto 145 KV , 12 HRS
15. 145 & upto 420 KV, 48 HRS
16. Above 420 KV, 120 HRS

RECORD OF DRYING OUT PROCESS (IF CARRIED OUT)

17. DRYING OUT STARTED ON ((HOURLY READING TO BE TAKEN)
18. AMBIENT TEMP :

REMARKS:

SIGNATURE :	SIGNATURE :	SIGNATURE :
NAME :	NAME :	NAME :
DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION	ORGANISATION : P&M	ORGANISATION : PROTECTION

SIGNATURE :
NAME :
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ORGANISATION : (SUPPLIER REPRESENTATIVE)

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DOC NO: CP/TF/ICT/06/PCT/4
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

INSULATION RESISTANCE MEASUREMENT : (USING 500 V MEGGER)

TESTING INSTRUMENT DETAILS:

SN	DESCRIPTION	STATUS (YES/NO)	REMARKS, IF ANY
1.	CONTROL WIRING		
2.	TAP CHANGER		
a.	MOTOR		
b.	CONTROL		
3.	COOLING SYSTEM		
a.	MOTOR FAN		
b.	MOTOR PUMP		
c.	CONTROL WIRING		

NOTE :- IR VALUES SHOULD BE > 50 M OHMS FOR CABLES

INSULATION RESISTANCE MEASUREMENT: (USING 5000 V MEGGER)

TESTING INSTRUMENT DETAILS:

AMBIENT TEMPERATURE AT THE TIME OF TEST:

TEMPERATURE OF OIL:

DAI MEANS: DIELECTRIC ABSORPTION INDEX

PI MEANS: POLARISATION INDEX

MAIN WINDING IR VALUES AFTER	15 SECS	60 SECS	600 SECS	DAI (R_{60}/R_{15})	PI (R_{600}/R_{60})
HV+IV to LV (For auto T/F)					
HV+IV Tto E (For auto T/F)					
LV to E (For auto T/F)					
HV+IV to LV (For 3 Wdg T/F)					
HV+IV Tto E (For 3 Wdg T/F)					
HV+IV + LV to E (For 3 Wdg T/F)					

IN CASE THERE IS ANY TEMPERATURE DIFFERENCE BETWEEN MANUFACTURERS TEST CERTIFICATE VALUE AND SITE VALUE, USE TEMPERATURE CORRECTION FACTOR PROVIDED IN PM MANUAL DOC.NO.CE/PM/OS/INST-4.

VECTOR GROUP TEST & POLARITY CKECKING

CONNECT NEUTRAL POINT WITH EARTH JOIN 1RI AND 3 RI TERMINALS

-APPLY 415V, 3-PHASE SUPPLY TO HV TERMINALS

TERMINALS	VOLTAGE MEASURED	REMARKS
1R1 -1Y1		
1Y1- 1B1		
1B1- 1R1		
3Y1- 1B1		
3Y1- 1Y1		
3R1- N		
3Y1- N		
1R1- N		
2R1- N		
2Y1- N		
2B1-N		

ENSURE 2R1 -N = 2Y1 -N = 2B1 - N = CONSTANT

SINCE IF 3R1 -N > 3Y1 - N > 3B1 - N, AND 3Y1 - 1B1 > 3Y1 - 1Y1

VECTOR GROUP Ynaod11 IS CONFIRMED AND POLARITY VERIFIED

MEASUREMENT OF WINDING RESISTANCE (IN OHM)

TESTING INSTRUMENT DETAILS:

TESTING EQUIPMENT CALIBRATION VALID OR NOT (FOR ODTL)

AMBIENT TEMPERATURE AT THE TIME OF TEST:

TEMPERATURE OF OIL:

WTI READING:

LOW VOLTAGE SIDE TEST RESULTS:-

BETWEEN WINDING	RESISTANCE	RESISTANCE AT 75 ºC		REMARKS
	SITE VALUE	FACTORY	SITE	
3R1 - 3B1				
3Y1 - 3R1				
3B1- 3Y1				

HIGH VOLTAGE SIDE TEST RESULTS:-

TAP POSITION	WINDING RESISTANCE (HV-N)			RESISTANCE AT 75^{o}			FACTORY VALUE			REMARKS
	1R1-2R1	1Y1-2Y1	1B1-2B1	R	Y	B	R	Y	B	
1										
2										
3										
4										
5										
6										
7										
8										
9B										
10										
11										
12										
13										
14										
15										
16										
17										
18										
REVERSE ORDER										
TAP NO……………….										
TAP NO……………….										
TAP NO……………….										
TAP NO……………….										

INTERMEDIATE VOLTAGE SIDE

BETWEEN WINDING	RESISTANCE	RESISTANCE AT 75 ºC		REMARKS
	SITE VALUE	FACTORY	SITE	
3R1 - N				
3Y1 - N				
3B1- N				

NOTE: LV WINDING RESISTANCE AT FACTORY MEASURED WITHOUT FORMATION OF DELTA. HOWEVER MEASUREMENTS CARRIED OUT AT SITE ARE AFTER FORMATION OF DELTA. HENCE A CORRECTION FACTOR OF 1.5 TIMES TO BE APPLIED IN SITE RESULTS

- PERMISSIBLE LIMIT OF ± 5% FROM FACTORY TEST RESULTS AFTER APPLYING TEMPERATURE CORRECTION FACTOR
- RESISTANCE AT 75^{o} C: $R_{75} = R_T\,(235 + 75)/(235 + T)$, WHERE R_T IS RESISTANCE MEASURED AT WINDING TEMPERATURE.

MAGNETIC BALANCE TEST

APPLY SINGLE PHASE 230 V ACROSS ONE PHASE OF HV WINDING TERMINAL AND NEUTRAL THEN MEASURE VOLTAGE IN OTHER TWO HV TERMINALS ACROSS NEUTRAL. REPEAT THE TEST FOR EACH OF THE THREE PHASES.

Apply 1-PH 230 V AC ACROSS	VOLTAGE MEASURED IN VOLTS		REMARKS
2R1-N	2Y1-N	2B1-N	
2Y1-N	2R1-N	2B1-N	
2B1-N	2R1-N	2Y1-N	

NOTE; APPROX. 1= 2 + 3

REPEAT THIS TET FOR IV AND LV WINDING AS THE CASE MAY BE

FLOATING NEUTRAL VOLTAGE MEASUREMENT

DISCONNENT THE TRANSFORMER NEUTRAL FROM THE GROUND. APPLY 3-PHASE, 415 VOLTS TO THE HIGH VOLTAGE WINDING AND MAKE THE MEASUREMENT IN THE IV WINDING WITH RESPECT TO NEUTRAL AND NEUTRAL POINT TO GROUND.

TAP POS	PRIMARY WINDING VOLTAGE APPLIED	IV WINDING VOLTAGE MEASURED	REMARKS
NORMAL ( )	1R-N	2R-N	
NORMAL( )	1Y-N	2Y-N	
NORMAL( )	1B-N	3B-N	
		N- EARTH	

NOW APPLY 3-PHASE, 415 VOLTS TO THE INTERMEDIATE VOLTAGE WINDING AND MAKE THE MEASUREMENT IN THE TERTIARY WINDING WITH RESPECT TO NEUTRALAND NEUTRAL POINT TO GROUND.

IV WINDING VOLTAGE APPLIED	TERTIARY WINDING VOLTAGE MEASURED	REMARKS
2R-N	3R-N	
2Y-N	3Y-N	
2B-N	3B-N	
	N- EARTH	

Check: After the test, neutral reconnected to Ground

VOLTAGE RATIO TEST:

TESTING INSTRUMENT DETAILS (Remarks: To be done by Automatic Turns ratio meter):

TESTING EQUIPMENT CALIBRATION VALID OR NOT:

AMBIENT TEMPERATURE AT THE TIME OF TEST:

TEMPERATURE OF OIL:

AS PER STANDARD PERFORMA GIVEN IN DOCUMENT DOC. N0. CE/PM/OS/INST-3 “MEASUREMENT OF VOLTAGE RATIO (D, E & F)”; FORMAT NO- SS/MAIN/TR. REACTOR/SOS

OIL CHARACTERISTICS

(SAMPLE TO BE TAKEN PRIOR TO CHARGING OF TRANSFORMER AND IT SHOULD FULFILLTHE RECOMMENDATIONS AS PER IS 1866 - 2000)

AS PER STANDARD PERFORMA GIVEN IN DOCUMENT DOC. N0. CE/PM/OS/INST-3 “TEST FORMAT FOR NEW OIL”; FORMAT NO- SS/MAIN/ODTL/YEARLY/HALF YEARLY

TAN DELTA MEASUREMENT OF BUSHINGS

MAKE OF TESTING KIT

TESTING EQUIPMENT CALIBRATION VALID OR NOT

AMBIENT TEMPERATURE AT THE TIME OF TEST

TEMPERATURE OF OIL

AS PER STANDARD PERFORMA GIVEN IN DOCUMENT DOC. N0. CE/PM/OS/INST-3 “TAN DELTA MEASUREMENT OF BUSHINGS BY TAN DELTA KIT”; FORMAT NO- SS/MAIN/TR. REAVTOR/2 YEARLY

TAN DELTA MEASUREMENT OF WINDING

AS PER STANDARD PERFORMA GIVEN IN DOCUMENT DOC. N0. CE/PM/OS/INST-3 “TAN DELTA MEASUREMENT OF WINDINGS BY TAN DELTA KIT”; FORMAT NO- SS/MAIN/TR. REAVTOR/4 YEARLY

MAGNETISATION CURRENT TEST :

TESTING INSTRUMENT DETAILS

TESTING EQUIPMENT CALIBRATION VALID OR NOT

AMBIENT TEMPERATURE AT THE TIME OF TEST

TEMPERATURE OF OIL

APPLY 1-PHASE AC SUPPLY ON HV TERMINALS AND KEEP IV & LV OPEN

TAP POSITION	VOLTAGE APPLIED	CURRENT MEASURED	REMARKS
LOWEST	R- N	R - PH	
	Y - N	Y - PH	
	B - N	B - PH	
NORMAL	R - N	R - PH	
	Y - N	Y - PH	
	B - N	B - PH	
HIGHEST	R - N	R - PH	
	Y - N	Y - PH	
	B - N	B - PH	

SIMILARLY APPLY 1-PHASE AC SUPPLY ON IV ERMINALS AND KEEP HV & LV OPEN. RECORD THE READINGS IN THE SAME FORMAT AS GIVEN ABOVE AT NORMAL TAP ONLY.

TESTS ON OLTC-

SN	DESCRIPTION	STATUS (YES/NO)
1.	VISUAL INSPECTION OF EQUIPMENT	
2.	MANUAL OPERATION ON ALL TAPS (LOCAL) WITH CONFIRMATION OF THE NO. OF REVOLUTIONS AND LOCKING AT EXTREME TAPS	
3.	OVER LOAD DEVICE OF DRIVING MOTOR	
4.	LOCAL OPERATION (ELECTRICAL)	
5.	REMOTE OPERATION (ELECTRICAL)	
6.	TAP POSITION INDICATOR	
7.	CHECK OPERATION WITH MASTER FOLLOWER SCHEME (PARALLEL OPERATION)	
8.	OUT OF STEP RELAY	
9.	STEP BY STEP CONTACTOR	
10.	LIMIT SWITCH	
11.	WINDING RESISTANCE AT ALL TAPS	
12.	CONTINUITY TEST OF WINDING DURING ONE COMPLETE CYCLE OF OPERATION	

ANY REMARKS

OPERATIONAL TEST OF OTHER EQUIPMENTS

CHECKING OF COOLING EQUIPMENTS :

1. ROTATION DIRECTION OF PUMPS
2. ROTATION DIRECTION OF FANS

PROTECTION CHECKS-

FAN NOS	SETTING VALUE	PICKUP VALUE	1-Φ PREVENTION CHECK
1………… TO			
16			
PUMPS			
1…….. TO			
4			

REMARKS

SIGNATURE :	SIGNATURE :	SIGNATURE :
NAME :	NAME :	NAME :
DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION	ORGANISATION : P&M	ORGANISATION : PROTECTION

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DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

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DOC NO: CP/TF/ICT/06/PCT/5
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

INSULATION RESISTANCE MEASUREMENT OF BUSHING CT's : (USING 500 V MEGGER)

NOTE : A) REMOVE THE CONNECTED EARTHING TO SYSTEM INVOLVING CT UNDER TEST
B) DISCONNECT THE CONNECTED TERMINALS OF CT M.BOX
C) PERMISSIBLE VALUES IS 2000 MOHMS

DETAILS OF TEST KIT:

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
EARTH-CORE I										
EARTH-CORE II										
EARTH-CORE III										
EARTH-CORE IV										
CORE I-CORE II										
CORE I- CORE III										
CORE I- CORE IV										
CORE II- CORE III										
CORE II- CORE IV										
CORE II- CORE IV										

CONTINUITY TEST OF BUSHING CT's :

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

SECONDARY WINDING RESISTANCE OF BUSHING CT's :

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

SECONDARY WINDING RESSTANCE OF BUSHING CT'S SHOULD BE COMPARABLE WITH THE FACTORY TEST CERTIFICATES AT SAME TEMPERATURES.

POLARITY TEST OF BUSHING CT's :

WITH 1.5 V DC SUPPLY & CONNECT +VE AT P1 AND - VE AT P2)

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

CURRENT RATIO TEST OF BUSHING CT's :

BY FEEDING UPTO MINIMUM OF 20% OF THE RATED CURRENT FROM PRIMARY SIDE, SECONDARY CURRENT IS MEASURED AT TERMINALS 1S1-1S2

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

MAGNETISING CURVES PERFORMANCE

IN CASE OF ICT TO BE DONE BY ODTL AS PER STANDARD FORMAT OF TEST KIT

(NOT TO BE DONE FOR METERING CORE)

THEORATRICAL KNEE POINT VOLTAGE (KVp) = ______________ VOLT (AS PER NAME PLATE)

NOTE :

1. CT SHOULD NOT SATURATE AT 110% OF KNEEPOINT VOLTAGE (KVp)
2. IF KNEE POINT VOLTAGE IS NOT MENTIONED THEN KNEE POINT CURRENT MAY BE TAKEN INTO CONSIDERATION

CONTACT RESISTANCE MEASUREMENT

NAME OF TESTING KIT:

VALUE TO BE TAKEN AT 100 A

THE VALUE OF CONTACT RESISTANCE SHOULD NOT BE MORE THAN 10 MICRO-OHMS PER JOINT / CONNECTOR

BETWEEN	R-PHASE	Y-PHASE	B-PHASE
ACROSS HV BUSHING TERMINAL JOINT			
ACROSS IV BUSHING TERMINAL JOINT			
ACROSS LV BUSHING TERMINAL JOINT			
ACROSS NEUTRAL CONNECTION POINT			
ACROSS SURGE ARRESTOR CONNECTION			

SHORT CIRCUIT IMPEDANCE TEST

TESTING INSTRUMENT DETAILS

TESTING EQUIPMENT CALIBRATION VALID OR NOT

AMBIENT TEMPERATURE AT THE TIME OF TEST

TEMPERATURE OF OIL

HV-IV

(IV WDG R Φ , Y Φ , B Φ AND N SHORTED, LV OPEN); APPLIED VOLTAGE=

SHORT CIRCUIT CURRENTS IN AMPERES ARE-

TAP NO	1U1(R)	1V1(Y)	1W1(B)
1			
9B OR 5 (NORMAL)			
17			

IV-LV

(LIV WDG R Φ , Y Φ , B Φ AND N SHORTED, HV OPEN); APPLIED VOLTAGE=

SHORT CIRCUIT CURRENTS IN AMPERES ARE-

TAP NO	1U1(R)	1V1(Y)	1W1(B)
9B OR 5 (NORMAL)			

HV-LV

(LV WDG R Φ , Y Φ , B Φ AND N SHORTED, IV OPEN); APPLIED VOLTAGE=

SHORT CIRCUIT CURRENTS IN AMPERES ARE-

TAP NO	1U1(R)	1V1(Y)	1W1(B)
1			
9B OR 5 (NORMAL)			
17			

REMARKS-

SIGNATURE :	SIGNATURE :	SIGNATURE :
NAME :	NAME :	NAME :
DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN	DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION	ORGANISATION : P&M	ORGANISATION : PROTECTION

SIGNATURE :

NAME :

DESIGNATION :

ORGANISATION : (SUPPLIER REPRESENTATIVE)

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DOC NO: CP/TF/ICT/06/PCT/5
SUB STATION :
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FINAL DATE OF TESTING

PROTECTION AND ALARMS

SN	DESCRIPTION	ALARM	TRIP
1.	HIGH WINDING TEMPERATURE.		
2.	HIGH OIL TEMPERATURE.		
3.	OIL FLOW FAILURE		
4.	PRESSURE RELIEF VALVE		
5.	MAIN TANK BUCHHOLZ RELAY		
6.	OLTC BUCHHOLZ RELAY		
7.	FAN FAILURE		
8.	LOW OIL LEVEL (MOG)		
9.	DIFERENTIAL RELAY		
10.	OVER LOAD RELAY		
11.	EARTH FAULT RELAY (REF)		
12.	OVER CURRENT RELAY		
13.	INTER TRIP , IF ANY		
14.	BACKUP OVER CURRENT		
15.	OVER FLUX		
16.	PROTECTION SETTINGS APPLIED AS PER ENGG. APPROVED SETTINGS		
17.	STABILITY TEST OF DIFFERENTIAL & REF PROTECTION:		

NOTE : PROVE THE TRIPPING OF ASSOCIATED BREAKERS BY ACTUALOPERATION OF THE VARIOUS DEVICES AND RELAYS AS PER THE SCHEMES.

SWEEP FREQUENCY RESPONSE ANALYSIS (SFRA)

1. CARRIED OUT AFTER COMPLETION OF ALL COMMISSIONING ACTIVITIES
2. INTERPRETATION OF TEST RESULTS CARRIED OUT
3. TEST RESULTS MATCHING WITH THE FACTORY RESULTS
4. FACTORY & SITE FRA TEST REPORT AVAILABLE AT SITE

INSULATION DIAGNOSTIC ANALYSIS (IDA)

1. CARRIED OUT AFTER COMPLETION OF ALL COMMISSIONING ACTIVITIES
2. INTERPRETATION OF TEST RESULTS CARRIED OUT
3. TEST RESULTS MATCHING WITH THE FACTORY RESULTS
4. FACTORY & SITE FRA TEST REPORT AVAILABLE AT SITE

Ø ALL ELECTRICAL TEST RESULTS COMPARED WITH FACTORY TEST RESULTS AND FOUND TO BE IN ORDER- YES/NO

RECORD THE FOLLOWING AFTER CHARGING:- (CHECKS AFTER CHARGING OF TRANSFORMER)

ANY ABNORMAL SOUND EMANATING FROM THE TRANSFORMER:

NO LOAD SECONDARY CURENT AT RELAY TERMINAL:

R PHASE Y PHASE B PHASE
(m A)

TEMPERATURE (AT THE TIME OF CHARGING IN ^{o}C): OTI: WTI: AMBIENT:

MAXIMUM TEMPERATURE AFTER 24 HOURS:

OLTC ELCTRICAL OPERATION CHECKED IN IDLE CHARGED CONDITION (FROM MIN POSITION TO MAX POSITION AND BACK TO NORMAL POSITION):-

THERMOVISION SCANNING DONE ATLEAST AFTER 24 HOURS OF LOADING:

THERMOVISION SCANNING AFTER ONE WEEK:

FINAL DOCUMENTATION REVIEW

A. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED: YES/NO

B. DOCUMENTS REGARDING SPARES, EQUIPMENT, O&M MANNUALS ETC AVAILABLE AT SITE YES/NO

REMARKS & OBSERVATIONS

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

DOC NO: CP/REACTOR/07/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

GENERAL INFORMATION OF REACTOR

P&M CIRCLE: P&M DIVISION: SUB-STATION:
DATE OF RECEIPT AT SITE:
DATE OF COMPLETION OF ERECTION & OIL FILLING:
DATE OF TESTING:
DATE OF ENERGISATION/TEST CHARGE:
DETAILS OF EQUIPMENT :
PO NO:
MAKE:
TYPE:
RATING
SR. NO-
VOLTAGE RATIO:
COOLING TYPE:
TYPE OF NEUTRAL GROUNDING
YEAR OF MANUFACTURE:
OIL QUANTITY Quantity In Main Tank:
Quantity in Radiators:

OIL TYPE
INHIBITED/UN-INHIBITED/STANDARD:

CHECK LIST OF ELECTRICAL TESTS CARRIED OUT FOR REACTOR

SN	NAME OF TEST	RESULTS (OK/NOT OK)
1.	INSULATION RESISTANCE MEASUREMENT	
2.	MAGNETISATION CURRENT TEST	
3.	INSULATION RESISTANCE MEASUREMENTS OFBUSHING CTs	
4.	MEASUREMENT OF WINDING RESISTANCE OF REACTOR	
5.	CONTINUITY TEST OF BUSHING CTs	
6.	SECONDARY WINDING RESISTANCE OF BUSHING CTs	
7.	POLARITY TEST OF BUSHING CTs	
8.	CURRENT RATIO TEST	
9.	MAGNETISING CURVES PERFORMANCE	
10.	CONTACT RESISTANCE MEASUREMENT	
11.	TAN DELTA & CAPACITANCE MEASUREMENT OF BUSHING	
12.	TAN DELTA & CAPACITANCE MEASUREMENT OF WINDING	
13.	OTHER PROTECTION AND ALARM TESTS	
14.	STABILITY TEST OF DIFFERENTIAL AND REF PROTECTION	
15.	FREQUENCY RESPONSE ANALYSIS	
16.	INSULATION DIAGNOSTIC ANALYSIS	
17.	VIBRATION TEST	

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

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NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

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DOC NO: CP/REACTOR/07/PCT/2
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

CHECKS AFTER RECEIPT OF TRANSFORMER AT SITE:

N2 PRESSURE & DEW POINT RECORD	N_2 PRESSURE	DEW POINT	AMBIENT TEMP.	REMARKS*
1. DURING DISPATCH AT FACTORY				
2. AFTER RECEIPT AT SITE				
3. DURING STORAGE AT SITE BEFORE COMM.				

* Please write 'NIL' in case of No Remarks. NOTE: N2 PRESSURE AND DEW POINT SHOULD BE WITHIN PERMISSIBLE RANGE AS PER GRAPH PROVIDED BY MANUFACTURER AND ALSO GIVEN IN OS DOC- DURING STORAGE AT SITE, DEW POINT HAS TO BE MEASURED WHENEVER ANY DROP IN N_2 PRESSURE IS OBSERVED. DURING STORAGE AT SITE BEFORE COMMISSIONING, N2 PRESSURE HAS TO BE MEASURED DAILY AND RECORD TO BE MAINTAINED IN A SEPARATE SHEET.

IMPACT RECORER ANALYSIS:	**STATUS**	**BRIEF ANALYSIS**
RECEIVED IN HEALTHY CONDITION AT SITE	YES/NO	

ANALYSIS REPORT

RECEIVED FROM MANUFACTURER BEFORE CHARGING YES/NO

Note: Impact Recorder should be detached from the Transformer/ Reactor preferably when the main unit has been placed on its foundation.

CORE INSULATION CHECK

APPLY 1.0 KV DC BETWEEN CL & CC+G

	INSULATION VALUE	RECOMMENDED VALUE.10 M OHMS
BETWEEN CC-G		
BETWEEN CL-G		
BETWEEN CC-CL		

Note: SHORTING LINK BETWEEN CC, CL & G TO BE REMOVED AND IR VALUE TO BE TAKEN BETWEEN CC-G, CL-G & CC-CL

CHECKS/ PRECAUTIONS DURING ERECTION

SN	NAME OF TEST	RESULTS (OK/NOT OK)	REMARKS
1.	ACTIVE PART OF REACTOR SHOULD BE MINIMUM EXPOSED TO ATMOSPHERE		
2.	DURING EXPOSURE OF ACTIVE PART OF TRANSFORMER TO ATMOSPHERE DRY AIR GENERATOR/ DRY AIR CYLINDERS USED :		
3.	WHILE ENTERING IN REACTOR TANK, CHECK AVAILABILITY OF PROPER OXYGEN		
4.	TRANSFORMER KEPT SEALED WITH N_2 IN BETWEEN DIFFERENT ERECTION ACTIVITIES		

REMARKS REGARDING ERECTION ACTIVITIES-

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NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

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ORGANISATION : (SUPPLIER REPRESENTATIVE)

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DOC NO: CP/REACTOR/07/PCT/3
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

PRE-COMMISSIONING CHECKS

SL. NO	DESCRIPTION	STATUS		REMARK
		YES	NO	RECORD DEFICIENCIES, IF ANY
1.	REACTOR AND ITS AUXILIARIES ARE FREE FROM VISIBLE DEFECTS OPON PHYSICAL INSPECTION			
2.	ALL FITTINGS ARE AS PER GENERAL OUTLINE ARRANGEMENT & DRAWINGS			
3.	CHECK THAT MAIN TANK HAS BEEN PROVIDED WITH DOUBLE EARTHING			
4.	CHECK LEVELLING OF REACTOR AND ITS ACCESSORIES			
5.	CHECK TIGHTNESS OF TERMINAL CONNECTORS			
6.	ALL NUTS AND BOLTS ARE TIGHTENED CORRECTLY			
7.	ERECTION ACTIVITIES ARE COMPLETE			
8.	CHECK NEUTRAL IS GROUNDED THROUGH SEPARATE			
9.	CONNECTIONS & EARTHING. ENSURE METALLIC REQUIREMENTS AS PER SPECIFICATION (e.g. Cu etc) IN EARTHING STRIPS USED			
10.	CHECK THAT MASHALLING BOX, RADIATOR BANK PUMPS & FAN MOTORS etc HAVE BEEN EARTHED			
11.	ANY PAINT REMOVED/SCRATCHED IN TRANSIT HAS BEEN TOUCHED UP			
12.	BUSHINGS ARE CLEAN AND FREE FROM PHYSICAL DAMAGES			
13.	OIL LEVEL IS SATISFACTORY IN ALL THE BUSHINGS			
14.	CHECK WHETHER HERMETICALLLY SEALING IS INTACT IN ALL BUSHINGS			
15.	CHECK OIL LEAKAGE THROUGH ANY JOINT/VALVE etc			
16.	CHECK THAT OIL DRAIN VALVES ARE PROPERLY CLOSED AND LOCKED.			
17.	CHECK THE OIL LEVEL IN MAIN/OLTC CONSERVATOR TANK			
18.	CHECK OIL LEVEL AT CONSERVATOR MATCHES WITH OIL TEMPERATURE OF TRANSFORMER			
19.	CHECK GEAR BOX OIL LEVEL IN OLTC			
20.	CHECK OTI AND WTI POCKETS AND REPLENISH THE OIL, IF REQUIRED			
21.	CKECK ALL VALVES FOR THEIR OPENING & CLOSING SEQUENCE			
22.	CHECK THE COLOUR OF BREATHER SILICA GEL (BLUE WHEN DRY)			
23.	CHECK THE LEVEL OF OIL IN THE BREATHER CUP			
24.	CHECK ALL ROLLERS ARE LOCKED AND TRACK WELDED WITH RAILS (WHEREEVER APPLICABLE)			
25.	CHECK THAT BUSHING TEST TAP IS GROUNDED			
26.	CHECK THERE IS NO DEBRIS, LOOSE T&P AND OIL STRAINS AROUND THE TRANSFORMER			
27.	CHECK DOOR SEALS OF MARSHALLING BOX IS INTACT AND ALL CABLE GLAND PLATES & UNUSED HOLES ARE SEALED			
28.	CHECK THAT PRESSURE RELIEF VALVE IS CORRECTLY MOUNTED			
29.	ENSURE UNUSED SECONDARY CORES OF BUSHING CT's, IF ANY, HAS BEEN SHORTED			

SL. NO	DESCRIPTION	STATUS YES	NO	REMARK RECORD DEFICIENCIES, IF ANY
30.	CHECK- STAR POINT HAS BEEN FORMED PROPERLY AND GROUNDED AT ONE END ONLY AS PER SCHEME			
31.	CKECK THE AVAILABILITY OF ADEQUATE LIGHITING ARRANGEMENTS			
32.	CHECK THAT LABELLING AND IDENTIFICATION IS PERMANENT AND SATISFACTORY			
33.	CHECK THAT BUCHHOLZ RELAY IS CORRECLY MOUNTED WITH ARROW POINTING TOWARDS CONSERVATOR			
34.	CHECK CABLES ARE PROPERLY FIXED AND ENSURE CABLE ENTRY AT THE BOTTOM.			
35.	ENSURE ALL POWER AND CONTROL CABLE TERMINALS ARE TIGHTENED			
36.	CHECK ALL CABLES AND FERRULS ARE PROVIDED WITH NUMBER AS PER CABLE SCHEDULE (CROSS FERULING TO BE CHECKED)			
37.	CHECK -ALL CABLES ARE CORRECTLY GLANDED			
38.	CHECK EXTERNAL CABLING FROM JUNCTION BOX TO RELAY/CONTROL PANEL IS COMPLETED			
39.	CHECK- AIR HAS BEEN RELEASED FROM THE RADIATORS AND THEIR HEADERS/ MAIN TANK/ TANK/ BUSHING TURRETS etc.			
40.	CHECK FIRE PROTECTION SYSTEM (NIFPS) & EMULSIFIRE SYSTEM SHOULD BE ADEQUATE & READY			
41.	CHECK THAT CC-CL&G ARE SHORTED			
42.	CHECK THAT ALL RADIATOR BANK VALVES ON TOP AND BOTTOM HEADERS ARE OPEN			
43.	CHANGE OVER OPERATION OF AC SUPPLY FROM SOURCE-I TO SOURCE-II CHECKED			
44.	CHECK THE FLANGES OF BUSHING & OLTC FOR ANY CRACK AFTER FIXING			
45.	CHECK VARIOUS INTERLOCKS PROVIDED WITH FIRE FIGHTING SYSTEM			

DETAILS OF VARIOUS INTER-LOCKS CHECKED

MEASUREMENT OF EARTH RESISTANCE OF ELECTRODE

LOCATION

VALUE (Before connection to grid)

VALUE (After connection to grid)

NOTE: VALUE OF EARTH RESISTANCE< 1.0 OHM

CALIBRATION OF OTI & WTI PERFORMED AS PER PROCEDURE

EVACUATING AND OIL FILLING

1. BEFORE FILLING OIL, EACH DRUM HAS BEEN PHYSICALLY CHECKED FOR MOISTURE AND APPEARANCE: YES/NO
2. EXPOSURE DURING ERECTION (Transformer to be kept sealed with N2 in between
3. N2 SEALING IN CASE OF DELAY IN OIL FILLING

TIGHTNESS TEST

4. STARTED EVACUATING ON COMPLETE UNIT AT ON
5. STOP EVACUATING AT 0.3 kPa (3 mbar) AT ON
6. PRESSURE P1 ..... kPa (1 HOUR AFTER STOP EVACUATING
7. PRESSURE P2 ..... kPa (0.5 HOUR AFTER READING PRESSURE P1)
8. LEAKAGE = (P2-P1)X V = (V=Oil quantity in Cu mtr)
   IF LEAKAGE <3.6, CONTINUE EVACUATING

VACCUM

9. PRESSURE BROUGHT EQUAL OR LESS THAN 0.13 kPa (1.3 mbar) REACHED
10. VACUUM IS KEPT FOR 12 HRS IN CASE OF 145 KV, 24 HRS FOR 145 KV TO 420 KV & 36 HRS FOR ABOVE 420 KV

OIL FILLING

11. OIL FILLING IS MADE
12. OIL CONSERVATOR WITH AIR CELL
13. DIVERTER SWITCH HOUSING FILED & HAS AN AIR CUSHION

STANDING TIME

14. Upto 145 KV , 12 HRS
15. 145 & upto 420 KV, 48 HRS
16. Above 420 KV, 120 HRS

RECORD OF DRYING OUT PROCESS (IF CARRIED OUT)

17. DRYING OUT STARTED ON ((HOURLY READING TO BE TAKEN)
18. AMBIENT TEMP :

REMARKS:

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

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ORGANISATION : P&M

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SUB STATION :
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FINAL DATE OF TESTING

INSULATION RESISTANCE MEASUREMENT: (USING 500 V MEGGER)

TESTING INSTRUMENT DETAILS:

SN	DESCRIPTION	STATUS (YES/NO)	REMARKS, IF ANY
1.	CONTROL WIRING		
2.	COOLING SYSTEM		
a.	MOTOR FAN		
b.	MOTOR PUMP		
c.	CONTROL WIRING		

NOTE :- IR VALUES SHOULD BE > 50 M OHMS FOR CABLES

INSULATION RESISTANCE MEASUREMENT: (USING 5000 V MEGGER)

TESTING INSTRUMENT DETAILS:
AMBIENT TEMPERATURE AT THE TIME OF TEST:
TEMPERATURE OF OIL:
DAI MEANS: DIELECTRIC ABSORPTION INDEX
PI MEANS: POLARISATION INDEX

MAIN WINDING IR VALUES AFTER	15 SECS	60 SECS	600 SECS	DAI (R_{60}/R_{15})	PI (R_{600}/R_{60})
HV to E					
NGR WINDING					

IN CASE THERE IS ANY TEMPERATURE DIFFERENCE BETWEEN MANUFACTURERS TEST CERTIFICATE VALUE AND SITE VALUE, USE TEMPERATURE CORRECTION FACTOR PROVIDED IN PM MANUAL DOC.NO.CE/PM/OS/INST-4.

MEASUREMENT OF WINDING RESISTANCE (IN OHM)

TESTING INSTRUMENT DETAILS:
TESTING EQUIPMENT CALIBRATION VALID OR NOT (FOR ODTL)
AMBIENT TEMPERATURE AT THE TIME OF TEST:
TEMPERATURE OF OIL:
WTI READING:

WINDING RESISTANCE (HV-N)	RESISTANCE AT 75^{o}			FACTORY VALUE			REMARKS
1R1-2R1 1Y1-2Y1 1B1-2B1	R	Y	B	R	Y	B	

WINDING RESISTANCE OF NGR WINDING	RESISTANCE AT 75^{o}	FACTORY VALUE

- PERMISSIBLE LIMIT OF ± 5% FROM FACTORY TEST RESULTS AFTER APPLYING TEMPERATURE CORRECTION FACTOR
- RESISTANCE AT 75^{o} C: $R_{75} = R_T (235+75)/(235+T)$, WHERE R_T IS RESISTANCE MEASURED AT WINDING TEMPERATURE.

MAGNETIC BALANCE TEST

APPLY SINGLE PHASE 230 V ACROSS ONE PHASE OF HV WINDING TERMINAL AND NEUTRAL THEN MEASURE VOLTAGE IN OTHER TWO HV TERMINALS ACROSS NEUTRAL. REPEAT THE TEST FOR EACH OF THE THREE PHASES.

Apply 1-PH 230 V AC ACROSS	VOLTAGE MEASURED IN VOLTS		REMARKS
2R1-N	2Y1-N	2B1-N	
2Y1-N	2R1-N	2B1-N	
2B1-N	2R1-N	2Y1-N	

NOTE; APPROX. 1= 2 + 3

OIL CHARACTERISTICS

(SAMPLE TO BE TAKEN PRIOR TO CHARGING OF TRANSFORMER AND IT SHOULD FULFILLTHE RECOMMENDATIONS AS PER IS 1866 - 2000)

AS PER STANDARD PERFORMA GIVEN IN DOCUMENT DOC. N0. CE/PM/OS/INST-3 "TEST FORMAT FOR NEW OIL"; FORMAT NO- SS/MAIN/ODTL/YEARLY/HALF YEARLY

TAN DELTA MEASUREMENT OF BUSHINGS

MAKE OF TESTING KIT
TESTING EQUIPMENT CALIBRATION VALID OR NOT
AMBIENT TEMPERATURE AT THE TIME OF TEST
TEMPERATURE OF OIL

AS PER STANDARD PERFORMA GIVEN IN DOCUMENT DOC. N0. CE/PM/OS/INST-3 "TAN DELTA MEASUREMENT OF BUSHINGS BY TAN DELTA KIT"; FORMAT NO- SS/MAIN/TR. REAVTOR/2 YEARLY

TAN DELTA MEASUREMENT OF WINDING

AS PER STANDARD PERFORMA GIVEN IN DOCUMENT DOC. N0. CE/PM/OS/INST-3 "TAN DELTA MEASUREMENT OF WINDINGS BY TAN DELTA KIT"; FORMAT NO- SS/MAIN/TR. REAVTOR/4 YEARLY

MAGNETISATION CURRENT TEST :

TESTING INSTRUMENT DETAILS

TESTING EQUIPMENT CALIBRATION VALID OR NOT

AMBIENT TEMPERATURE AT THE TIME OF TEST

TEMPERATURE OF OIL

APPLY 1-PHASE AC SUPPLY ON HV TERMINALS AND KEEP IV & LV OPEN

VOLTAGE APPLIED	CURRENT MEASURED	REMARKS
R- N	R-PH	
Y - N	Y-PH	
B - N	B-PH	

OPERATIONAL TEST OF OTHER EQUIPMENTS

CHECKING OF COOLING EQUIPMENTS :

3. ROTATION DIRECTION OF PUMPS
4. ROTATION DIRECTION OF FANS

PROTECTION CHECKS-

FAN NOS	SETTING VALUE	PICKUP VALUE	1-Φ PREVENTION CHECK
1………… TO			
16			
PUMPS			
1…….. TO			
4			

REMARKS

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

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NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

DOC NO: CP/REACTOR/07/PCT/5
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

INSULATION RESISTANCE MEASUREMENT OF BUSHING CT's : (USING 500 V MEGGER)

NOTE : A) REMOVE THE CONNECTED EARTHING TO SYSTEM INVOLVING CT UNDER TEST
B) DISCONNECT THE CONNECTED TERMINALS OF CT M.BOX
C) PERMISSIBLE VALUES IS 2000 MOHMS

DETAILS OF TEST KIT:

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
EARTH-CORE I										
EARTH-CORE II										
EARTH-CORE III										
EARTH-CORE IV										
CORE I-CORE II										
CORE I- CORE III										
CORE I- CORE IV										
CORE II- CORE III										
CORE II- CORE IV										
CORE II- CORE IV										

CONTINUITY TEST OF BUSHING CT's :

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

SECONDARY WINDING RESISTANCE OF BUSHING CT's :

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

SECONDARY WINDING RESSTANCE OF BUSHING CT'S SHOULD BE COMPARABLE WITH THE FACTORY TEST CERTIFICATES AT SAME TEMPERATURES.

POLARITY TEST OF BUSHING CT's :

WITH 1.5 V DC SUPPLY & CONNECT +VE AT P1 AND - VE AT P2)

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

CURRENT RATIO TEST OF BUSHING CT's :

BY FEEDING UPTO MINIMUM OF 20% OF THE RATED CURRENT FROM PRIMARY SIDE, SECONDARY CURRENT IS MEASURED AT TERMINALS 1S1-1S2

BETWEEN	HV SIDE (M Ω			IV SIDE (M Ω)			LV SIDE (M Ω)			NEUTRAL
	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	R-PHASE	Y-PHASE	B-PHASE	
CORE I/1S1-1S2										
CORE I/2S1-2S2										
CORE III/3S1-3S2										
CORE IV/4S1-4S2										

MAGNETISING CURVES PERFORMANCE

IN CASE OF ICT TO BE DONE BY ODTL AS PER STANDARD FORMAT OF TEST KIT

(NOT TO BE DONE FOR METERING CORE)

THEORATRICAL KNEE POINT VOLTAGE (KVp) = ______________ VOLT (AS PER NAME PLATE)

NOTE :

1. CT SHOULD NOT SATURATE AT 110% OF KNEEPOINT VOLTAGE (KVp)
2. IF KNEE POINT VOLTAGE IS NOT MENTIONED THEN KNEE POINT CURRENT MAY BE TAKEN INTO CONSIDERATION

CONTACT RESISTANCE MEASUREMENT

NAME OF TESTING KIT:

VALUE TO BE TAKEN AT 100 A

THE VALUE OF CONTACT RESISTANCE SHOULD NOT BE MORE THAN 10 MICRO-OHMS PER JOINT / CONNECTOR

BETWEEN	R-PHASE	Y-PHASE	B-PHASE
ACROSS HV BUSHING TERMINAL JOINT			
ACROSS IV BUSHING TERMINAL JOINT			
ACROSS LV BUSHING TERMINAL JOINT			
ACROSS NEUTRAL CONNECTION POINT			
ACROSS SURGE ARRESTOR CONNECTION			

VIBRATION MEASUREMENT TEST

VIBRATION MEASUREMENTS ARE TO BE CARRIED OUT AFTER ENERGIZATION OF THE REACTOR. THIS WILL BE A REFERENCE DATA FOR FUTURE MEASUREMENTS.

VARIOUS LOCATIONS ARE TO BE SHOWN IN THE DIAGRAM WITH X,Y CO-ORDINATES FOR EASY IDENTIFICATION.

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

DOC NO: CP/REACTOR/07/PCT/5
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

PROTECTION AND ALARMS

SN	DESCRIPTION	ALARM	TRIP
1.	HIGH WINDING TEMPERATURE.		
2.	HIGH OIL TEMPERATURE.		
3.	OIL FLOW FAILURE		
4.	PRESSURE RELIEF VALVE		
5.	MAIN TANK BUCHHOLZ RELAY		
6.	OLTC BUCHHOLZ RELAY		
7.	FAN FAILURE		
8.	LOW OIL LEVEL (MOG)		
9.	DIFERENTIAL RELAY		
10.	OVER LOAD RELAY		
11.	EARTH FAULT RELAY (REF)		
12.	OVER CURRENT RELAY		
13.	INTER TRIP , IF ANY		
14.	BACKUP OVER CURRENT		
15.	OVER FLUX		
16.	PROTECTION SETTINGS APPLIED AS PER ENGG. APPROVED SETTINGS		
17.	STABILITY TEST OF DIFFERENTIAL & REF PROTECTION:		

NOTE : PROVE THE TRIPPING OF ASSOCIATED BREAKERS BY ACTUAL OPERATION OF THE VARIOUS DEVICES AND RELAYS AS PER THE SCHEMES.

FREQUENCY RESPONSE ANALYSIS (SFRA)

1. CARRIED OUT AFTER COMPLETION OF ALL COMMISSIONING ACTIVITIES
2. INTERPRETATION OF TEST RESULTS CARRIED OUT
3. TEST RESULTS MATCHING WITH THE FACTORY RESULTS
4. FACTORY & SITE FRA TEST REPORT AVAILABLE AT SITE

INSULATION DIAGNOSTIC ANALYSIS (IDA)

1. CARRIED OUT AFTER COMPLETION OF ALL COMMISSIONING ACTIVITIES
2. INTERPRETATION OF TEST RESULTS CARRIED OUT
3. TEST RESULTS MATCHING WITH THE FACTORY RESULTS
4. FACTORY & SITE FRA TEST REPORT AVAILABLE AT SITE

➢ ALL ELECTRICAL TEST RESULTS COMPARED WITH FACTORY TEST RESULTS AND FOUND TO BE IN ORDER- YES/NO

RECORD THE FOLLOWING AFTER CHARGING:- (CHECKS AFTER CHARGING OF REACTOR)

ANY ABNORMAL SOUND EMANATING FROM THE TRANSFORMER:
NO LOAD SECONDARY CURENT AT RELAY TERMINAL:
R PHASE Y PHASE B PHASE
(m A)
TEMPERATURE (AT THE TIME OF CHARGING IN ^{o}C): OTI: WTI: AMBIENT:
MAXIMUM TEMPERATURE AFTER 24 HOURS:
THERMOVISION SCANNING DONE ATLEAST AFTER 24 HOURS OF LOADING:
THERMOVISION SCANNING AFTER ONE WEEK:

FINAL DOCUMENTATION REVIEW

A. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED: YES/NO
B. DOCUMENTS REGARDING SPARES, EQUIPMENT, O&M MANNUALS ETC AVAILABLE AT SITE YES/NO

REMARKS & OBSERVATIONS

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : P&M

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

DOC NO: CP/ISOL/08/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

GENERAL INFORMATION OF RISOLATORS

P&M CIRCLE: P&M DIVISION: SUB-STATION:
DATE OF COMPLETION OF ERECTIO:
DATE OF TESTING:
DATE OF ENERGISATION/TEST CHARGE:
OPERATING VOLTAGE: KV
DETAILS OF EQUIPMENT :
PO NO:
MAKE:
TYPE:
RATING
YEAR OF MANUFACTURE:
TYPE OF OPERATING MECHANISM:
CURRENT CARRYING CAPACITY:
BAY NAME:-
LOCATION OF ISOLATORS:
SR. NO- R-PHASE Y-PHASE B-PHASE

CONTROL VOLTAGE (DC): V

PRE-COMMISSIONING CHECKS

SL. NO	DESCRIPTION	STATUS		REMARK
		YES	NO	RECORD DEFICIENCIES, IF ANY
1.	EQUIPMENT IS FREE FROM DIRT/DUST FOREIGN MATERIALS ETC.			
2.	EQUIPMENT IS FREE FROM ALL VISIBLE DEFECTS ON PHYSICAL INSPECTION			
3.	SUPPORT STRUCTURES, MARSHALLING BOXES HAVE BEEN PROVIDED WITH DOUBLE EARTH PADS/ POINTS			
4.	ALL NUTS & BOLTS ARE TIGHTENED			
5.	EQUPIMENT ERECTION IS COMPLETE IN ALL RESPECTS			
6.	PERMANENT LABELLING AND IDENTIFICATION IS DONE			
7.	LEVELLING AND ALIGNMENT OF STRUCTURE AND BASE FRAME IS CHECKED			
8.	ALL INSULATORS ARE FREE FROM ANY PHYSICAL DEFECTS			
9.	TIGHTNESS OF NUTS BOLTS OF TERMINAL CONNECTORS ARE CHECKED			
10.	REVIEW OF OUTSTANDING ACTIVITIES			
11.	CONTROL BOX/MARSHALLING KIOSK IS FREE FROM ANY PHYSICAL DEFECTS			
12.	AUXILLARY CONTACTS AND RELAYS HAVE BEEN CLEANED AND ARE FREE FROM RUST/DAMAGE.			
13.	CORONA RINGS ARE PROVIDED/PROPERLY FIXED			
14.	CABLE TERMINATION AND TIGHTNESS CHECKED AND UNUSED HOLES SEALED			
15.	CABLE TERMINATION AND TIGHTNESS CHECKED AND UNUSED HOLES SEALED			
16.	ALL MOVING PARTS ARE LUBRICATED			
17.	FREENESS OF MANNUAL OPERATION IS OK			

SL. NO	DESCRIPTION	STATUS		REMARK
		YES	NO	RECORD DEFICIENCIES, IF ANY
1.	ALL THE CABLE IDENTIFICATION TAGS PROVIDED AND ALL CORES ARE PROVIDED WITH IDENTIFICATION FERRULES AT M.B.			
2.	ALIGNMENT OF ISOLATOR OK AND LOCKING BOLT PROVIDED, IF ANY			
3.	GREASING HAS BEEN MADE ON THE MAIN CONTACTS ACCORDING TO INSTRUCTIONS OF MANUFACTURER			
4.	FUCTIONAL CKECKING OF AUXILLARY CONTACTS FOR INDICATIONS AND INTERLOCKS			
5.	EARTH SWITCH CONNECTED TO EARTH THROUGH BRAIDED WIRES			
6.	INTERLOCKS CHECKED AS PER APPROVED SCHEME WITH ALL COMBINATIONS			
7.	CHECK THAT EARTH SWITCH BLADE ALIGNMENT CONDITION IS AT SUFFICIENT DISTANTCE FROM ISOLATOR			
8.	CHECK THAT OPERATION AND POSITIONING OF THE LIMIT SWITCH & THE AUXILIARY CONTACTS ASSEMBLY ARE OK			
9.	CHECK THAT ALL THREE PHASE ISOLATORS ARE CLOSING & OPENING AT A SAME TIME/ SIMULTANEOUSLY			
10.	CHECK ALL 3 EARTH SWITCHES CLOSE AT THE SAME TIME/ SIMULTANEOUSLY			
11.	PROVISION OF BIMETALLIC STRIPS ENSURED WHEREVER APPLICABLE			

INSULATION RESISTANCE VALUE OF MOTOR WINDING

USING A 500 VOLT MEGGER MEASURE RESISTANCE BETWEEN THE WINDING OF MOTOR AND EARTH

BETWEEN	PHASE		
WINDING – EARTH	R- PHASE	Y- PHASE	B- PHASE

OPERATIONAL CHECKS :

OPERATE THE ISOLATOR AND RECORD THE MOTOR CURRENT

ISOLATOR OPERATION	R-PHASE	Y-PHASE	B-PHASE (MOTOR CURRENT)
CLOSE			
OPEN			

OPERATION OF ISOLATOR FROM LOCAL/REMOTE

ISOLATOR OPERATION	R-PHASE	Y-PHASE	B-PHASE (MOTOR CURRENT)
CLOSE (LOCAL)			
OPEN (LOCAL)			
CLOSE (REMOTE)			
OPEN (REMOTE)			

INSULATION RESISTANCE TEST (USING 5000 VOLT MEGGER):-

ISOLATOR CONDITION	R-PHASE	Y-PHASE	B-PHASE
MALE SIFE TO GROUND			
FEMALE SIDE TO GROUND			
MALE TO FEMALE			

CONTACT RESISTANCE MEASUREMENT (ISOLATER)

ACROSS
CONNECTOR (MALE SIDE)
CONNECTOR (FEMALE SIDE)
MAIN CONTACT (MALE-FEMALE)
TO BE MEASURED AFTER AT LEAST 10 TO 15 OPERATIONS WITH ISOLATER IN CLOSED CONDITION (CONTACT RESISTANCE SHOULD BE LESS THAN 10 MICRO OHMS / CONNECTOR)
RESISTANCE OF OPERATING COIL
RESISTANCE OF INTERLOCKING COIL

FINAL DOCUMENTATION REVIEW

A. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED: YES/NO
B. DOCUMENTS REGARDING SPARES, EQUIPMENT, O&M MANNUALS ETC AVAILABLE AT SITE YES/NO

REMARKS & OBSERVATIONS

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

SIGNATURE :
NAME :
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ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

To be signed by all in case of turn key or out sourced projects only, otherwise only ASE/ Sr XEN of Protection team is required to sign the testing formats.

P&M CIRCLE: P&M DIVISION: SUB-STATION:

DOC NO: CP/WT/09/PCT/1
SUB STATION :
BAY NO :
EQUIPMENT IDENTIFICATION NO :
FINAL DATE OF TESTING

DATE OF COMPLETION OF ERECTIO:
DATE OF TESTING:
DATE OF ENERGISATION/TEST CHARGE:
VOLTAGE RATING: KV
m H RATING:
DETAILS OF EQUIPMENT :
PO NO:
MAKE:
TYPE:
RATING
YEAR OF MANUFACTURE:
CURRENT RATING:
BANDWIDTH:
BAY NAME:-
SR. NO- R-PHASE Y-PHASE B-PHASE

DETAILS: CHECKLIST/TESTING

SL. NO	DESCRIPTION	STATUS		REMARK
		YES	NO	RECORD DEFICIENCIES, IF ANY
1.	EQUIPMENT IS FREE FROM DIRT/DUST FOREIGN MATERIALS ETC.			
2.	EQUIPMENT IS FREE FROM ALL VISIBLE DEFECTS ON PHYSICAL INSPECTION			
3.	SUPPORT STRUCTURES, MARSHALLING BOXES HAVE BEEN PROVIDED WITH DOUBLE EARTH PADS/ POINTS			
4.	ALL NUTS & BOLTS ARE TIGHTENED			
5.	EQUIPMENT ERECTION IS COMPLETE IN ALL RESPECTS			
6.	PERMANENT LABELLING AND IDENTIFICATION IS DONE			
7.	LEVELLING AND ALIGNMENT OF STRUCTURE AND BASE FRAME IS CHECKED			
8.	TIGHTNESS OF NUTS BOLTS OF TERMINAL CONNECTORS ARE CHECKED			
9.	REVIEW OF OUTSTANDING ACTIVITIES			
10.	CONTROL BOX/MARSHALLING KIOSK IS FREE FROM ANY PHYSICAL DEFECTS			
11.	ALL INSULATORS & LINE MATCHING UNIT ARE FREE FROM ANY PHYSICAL DEFECTS			
12.	CHECK THAT THE TUNING UNIT AND ARRESTOR ARE PROPERLY TIGHTENED AND FREE FROM ANY DAMAGE			

INSULATION RESISTANCE MEASUREMENT:

SN	BETWEEN	MEGGER TEST VOLTAGE	R-PHASE	Y-PHASE	B-PHASE
1.	UPPER TERMINAL-E	5000 V			
2.	LA OF THE WAVE TRAP	500 V			

PERMISSIVE VALUE IS 1000 M OHM & 1 M OHM RESPECTIVELY

CONTACT RESISTANCE MEASUREMENT

THE VALUE SHOULD NOT MORE THAN 5 MICRO-OHMS PER CONNECTOR / JOINT

SN	ACROSS	R-PHASE	Y-PHASE	B-PHASE
1.	UPPER TERMINAL			
2.	BOTTOM TERMINAL			

FINAL DOCUMENTATION REVIEW

C. FINAL DOCUMENT OF PRE-COMMISSIONING CHECKS REVIEWED AND APPROVED: YES/NO

D. DOCUMENTS REGARDING SPARES, EQUIPMENT, O&M MANNUALS ETC AVAILABLE AT SITE YES/NO

REMARKS & OBSERVATIONS

SIGNATURE :
NAME :
DESIGNATION : ASE/ Sr XEN
ORGANISATION : CONSTRUCTION

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ORGANISATION : P&M

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NAME :
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ORGANISATION : PROTECTION

SIGNATURE :
NAME :
DESIGNATION :
ORGANISATION : (SUPPLIER REPRESENTATIVE)

ACCEPTABLE/PERMISSIBLE LIMITS OF TEST RESULTS DURING TESTING & MAINTENANCE OF SUB-STATION EQUIPMENT

Part-A & B

pstcl
PUNJAB STATE TRANSMISSION
CORPORATION LIMITED

PUNJAB STATE TRANSMISSION CORPORATION

Limited Head office: The Mall, Patiala

OPERATION SERVICES WING

VOLUME-V (for internal circulation only)

PERMISSIBLE/ACCEPTABLE LIMITS FOR OPERATION SWITCHYARD EQUIPMENTS

VOLUME-V PART-A (ICT'S, REACTORS, EHV CBS, CTS ETC.)

Edition	Date	Department	Signature
First edition-	01-04-16	OS	
1st Revision-			
2nd Revision-			

Prepared by Er Sukhjinder S. Virk

AEE 1-4-16 Operation Services

Reviewed by Er Rajbir S. Walia

Adll S.E 1-4-16 Protection & Operation Services

Recommended by Er Charanjit S. Aulakh

Chief Engineer 5-5-16 P&M

Approved by

23-6-16 BOD's of PSTCL in 37th meeting vide U.O No-1211/BOD/37.21/PSTCL, Dated 8-7-16

INDEX

PART- A

A. Permissible Limits of parameters during testing/maintenance of s/s equipment

SN	EQUIPMENT/TEST DATA	PERMISSIBLE LIMITS	REFERENCE
1.	Capacitance for Bushings Main capacitance (C1)	Within -5 % to +10 % of the variation from previous test result	PSTCL Doc. No: CE/ PM/OS/INST- 1
2.	Tan Delta for Bushing at 20ºC	Less than 0.007	IEC – 60137 ed.2003
3.	Contact Resistance of Bushing	10 Micro-Ohm /Connector	PSTCL Doc. No: CE/ PM /OS/INST- 1
4.	Tan Delta for Windings at 20 ºC	Less than 0.007	IEEE/C57.12.90.1999
5.	Magnetizing current Test	If excitation current is less than 50 mA, the difference between the two higher currents should be less than 10%. If the excitation current is more than 50 mA, the difference should be less than 5%. An agreement to within 25% of the measured exciting current with the previous test is considered satisfactory. In general, if there is an internal problem, these differences will be greater (more than 50 times).	PSTCL Doc. No: CE/PM /OS/INST- 1
6.	Magnetic Balance Test (Single Phase)	Supply voltage (230 V Ac) in one phase is equal to sum voltage induced in other two phases. When supply voltage is applied in middle limb, voltage induced in outer limbs should be roughly half of the applied supply voltage. If zero voltage or negligible voltage is induced in the other two windings, it should be investigated Normally, the voltage induced in the center phase shall be 50 to 90% of the applied voltage. But, when the center phase is excited then the voltage induced in the outer phases shall be 30 to 70% of the applied voltage	PSTCL Doc. No: CE/ PM/OS/INST- 1

Permissible Limits of parameters during testing/maintenance of s/s equipment

<table>
<tr><th>SN</th><th>EQUIPMENT/TEST DATA</th><th colspan="2">PERMISSIBLE LIMITS</th><th>REFERENCE</th></tr>
<tr><td>7.</td><td>DC Winding resistance</td><td colspan="2">± 5% variation between phases or from factory test results at a standard temperature of 75° C</td><td>PSTCL Doc No: CE/PM/OS/INST-1</td></tr>
<tr><td>8.</td><td>Voltage Ratio of Transformer (All Taps)</td><td colspan="2">Within ± 0.5% variation from specified values or FAT results. Trend of voltage ratio values with reference to the ratio values measured during the commissioning tests may also be considered</td><td>PSTCL Doc. No: CE/PM/OS/INST- 1</td></tr>
<tr><td>9.</td><td>INSULATION VALUE (Thumb rule/Empirical formula)</td><td colspan="2">Minimum insulation values for one minute insulation resistance measurements for transformers may be determined by using the following empirical formula:
$R=CE\sqrt{KVA}$

Where
R = Insulation resistance, in MΩ
C =1.5 for oil-filled transformers at 20 °C, assuming that the transformer's insulating oil is dry, acid free and sludge free
= 30.0 for un-tanked oil-impregnated transformers
E = Voltage rating, in V, of one of the single-phase windings(Ph-to-Ph for delta connected and ph-to-neutral for wye connected transformers)
KVA = Under root two of the rated capacity of the winding under test (If the winding under test is three-phase and the three individual windings are being tested as one, the rated capacity of three-phase winding is used . Selection of rated voltage should be done accordingly.</td><td>PSTCL Doc No: CE/PM/OS/INST-1</td></tr>
<tr><td rowspan="4">10.</td><td rowspan="4">IR Value of winding</td><td>Rated voltage winding</td><td>Minimum desired IR value after 1 minute at 30°C (Mega ohm)</td><td rowspan="4">PSTCL Doc No: CE/PM/OS/INST-1</td></tr>
<tr><td>11kV</td><td>300</td></tr>
<tr><td>33kV</td><td>400</td></tr>
<tr><td>66 kV& above</td><td>500</td></tr>
</table>

Permissible Limits of parameters during testing/maintenance of s/s equipment

<table>
<tr><th>S N</th><th>EQUIPMENT/TEST DATA</th><th colspan="2">PERMISSIBLE LIMITS</th><th>REFERENCE</th></tr>
<tr><td rowspan="7">11.</td><td rowspan="7">Polarization Index (Ratio of IR values at 10 minute to 1 minute)</td><td>Polarization Index</td><td>Insulation Condition</td><td rowspan="7">PSTCL Doc. No:CE/ PM/OS/INST- 1</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>12.</td><td>CORE INSULATION Test (Min Between CL and CC + G with tank grounded)</td><td colspan="2">1000 K Ohms at 2.0 kV D.C (Transformer) / 3.5 kV DC (Reactors) for 1 min</td><td>PSTCL Doc. No:CE/ PM/OS/INST- 1</td></tr>
<tr><td>13.</td><td>Transformer / Reactor Neutral Resistance Value</td><td colspan="2">Less than 1 Ohm</td><td>PSTCL Doc. No:CE/ PM/OS/INST- 1</td></tr>
<tr><td>14.</td><td>Turret/neutral CT ratio errors</td><td colspan="2">± 3%</td><td>IS– 2705 Part 2- 2^{nd} Ed- 1992</td></tr>
<tr><td>15.</td><td>Vibration Level for reactors</td><td colspan="2">200 Microns (Peak to Peak)
60 Microns (Average)</td><td>PSTCL Doc. No:CE/ PM/OS/INST- 1</td></tr>
</table>

B. Permissible limits for tests carried out at Oil & Diagnostic Testing Laboratory Ludhiana-
Specifications of uninhibited mineral insulating new/unused oil before filling in transformer

SN	EQUIPMENT/TEST DATA	PERMISSIBLE LIMITS	REFERENCE
a.	Appearance	Clear & transparent; free from suspended matter/sediments	IS 335 – 1993
b.	Density at 29.5 °C	0.89 g / cm^3 (Max.)	IS 335 – 1993
c.	Kinematic Viscosity at 27 °C at 40 °C, Max	27 cSt (Max.) As per ODTL test report	IS 335 – 1993
d.	Interfacial Tension (IFT) at 27 °C	0.04 N/m (Min.)	IS 335 – 1993
e.	Flash point, Pensky Marten closed	140 °C (Min.)	IS 335 – 1993
f.	Pour point	- 6 °C (Max.)	IS 335 – 1993
g.	Acidity (Neutralisation Value) I.Total Acidity II.Inorganic acidity/ Alkalinity	0.03 mg KOH / g (Max.) Nil	IS 335 – 1993 IS 335 – 1993
h.	Corrosive Sulphur	Non – Corrosive	IS 335 – 1993
i.	Di-Electric Strength (BDV) I.New unfiltered oil II.After filtration	30 KV , rms (Min.) 60 KV , rms (Min.)	IS 335 – 1993 IS 335 – 1993
j.	Dielectric Dissipation Factor (Tan**δ**)	0.002 (Max.) at 90 °C	IS 335 – 1993
k.	Specific Resistance (Resistivity) I.at 90 °C II.at 27 °C	$35X10^{12}$ Ω-cm (Min.) $1500X10^{12}$ Ω-cm (Min.)	IS 335 – 1993 IS 335 – 1993
l.	2–Furfural (Furan Analysis (Test Method– IEC 61198:1993)	0.1 mg/ kg (Max.)	IEC- 60296, 2003
m.	Furfural (Aging criteria for oil-immersed Power Transformer) as per CIGRE DOC No 227	Warning Trouble 1.5 ppm 15 ppm Life Management Technique for Power Transformers	CIGRE DOC No 227
n.	Total furan content	250 parts per billion (ppb)	Transformer Diagnostic USBR, June 2003, Page-15
o.	Dissolved Gas Analysis (DGA)	Not applicable	IS 335 – 1993
p.	PCB Content (Polychlorinated Biphenyls)	Not detectable 0.1 mg/ kg (Max.)	IEC- 60296, 2003
q.	PCA content (Polycyclic Aromatics)	3 % by mass (Max.)	IEC- 60296, 2003
r.	Water content of New unfiltered oil	50 ppm (Max.)	IS 335 – 1993

Permissible limits for tests carried out at Oil & Diagnostic Testing Laboratory Ludhiana-
Specifications of uninhibited mineral insulating new/unused oil before filling in transformer

SN	EQUIPMENT/TEST DATA	PERMISSIBLE LIMITS	REFERENCE
s .	Oxidation Stability a)Neutralization value after oxidation b)Total sludge after oxidation	0.40 mg KOH / g (Max.) 0.1 % by weight (Max.)	IS 335 – 1993 IS 335 – 1993
t .	Ageing characteristics after accelerated ageing (Open beaker method with copper catalyst) a)Specific Resistance (Resistivity) at 27 °C at 90 °C b)Dielectric Dissipation Factor (Tan δ) at 90 °C c)Total Acidity d)Total Sludge	$2.5X10^{12}$ Ω-cm (Min.) $0.2X10^{12}$ Ω-cm (Min.) 0.2 (Max.) 0.05 mg KOH/ g (Max.) 0.05 % by weight (Max.)	IS 335 – 1993 IS 335 – 1993 IS 335 – 1993 IS 335 – 1993 IS 335 – 1993
u .	Presence of Oxidation Inhibitor	Oil shall not contain anti-oxidant additives. Value of 0.05 % by mass (Max.) shall be treated as absence of DBPC- Phenolic type inhibitor	IS 335 – 1993
v .	<u>Additional requirement for inhibited oil</u> Inhibitor content (Anti-oxidant additive content) DBPC (Ditertiary Butyl Paracresol) DBP (Ditertiary Butyl Phenol)	Minimum 0.08% by mass and Maximum 0.4% by mass Minimum 0.15% by mass and Maximum 0.3% by mass	IEC-60296, 2003

C Permissible limits for tests carried out at Oil & Diagnostic Testing Laboratory Ludhiana- Specifications of IN-SERVICE mineral insulating oil

SN	EQUIPMENT / TEST DATA	PERMISSIBLE LIMITS		REFERENCE
a.	Oil Parameters	At time of first charging	During O&M	IS-1866 -2000
b.	Appearance	Clear, sediment free from any suspended matter	Clear without visible contamination	IS-1866 -2000
c.	Break Down Voltage (BDV) (G1AP – 2.5 mm) – Minimum	40 kV for <72.5kV 50 kV for (72.5 to 170 kV) 60 kV for > 170kV	30 kV for <72.5kV 40 kV for 72.5 to 170 kV 50 kV for > 170kV	IS-1866 -2000
d.	Acidity (Neutralization) value	0.03 mg KOH/g (Max)	0.3 mg KOH/g (Max)	IS-1866 -2000
e.	Sediment & Sludge (Max)	0.01 % by mass	0.02 % by mass	IS-1866 -2000
f.	Resistivity Resistivity at 20 ºC (Min) Resistivity at 90 ºC (Min)	6X 10^{12} Ohm–cm	1X10^{12} Ohm–cm 0.1X10^{12} Ohm-cm	IS-1866 -2000 IS-1866 -2000
g.	Dielectric Dissipation Factor at 90ºC and 40-60 Hz (Tan Delta/Power Factor) (Max)	0.015 for < 170 kV 0.10for ≥ 170 kV	1.0 for < 170 kV 0.2 for ≥ 170 kV	IS-1866 -2000
h.	Inter Facial Tension (IFT) at 27ºC(Min)	35 mN/ m	15 mN/ m	IS-1866 -2000
i.	Flash Point (Min)	140 ºC	Max decrease of 15ºC from initial value	IS-1866 -2000
j.	Density at 29.5 °C (Max.)	0.89 g / cm^3	Not Applicable	IS-1866 -2000
k.	Kinematic Viscosity at 27 °C (Max.)	27 cSt	Not Applicable	
l.	Pour point (Max.)	- 6 °C	Not Applicable	IS-1866 -2000
m.	Oxidation Stability of uninhibited oil Neutralization Value (Max.) Sludge (Max.)	0.4 mg KOH / g 0.1 % by mass	Not Applicable Not Applicable	IS-1866 -2000 IS-1866 -2000
n.	Oxidation Stability of inhibited oil {Antioxidant additive content}	Minimum 0.08 % by mass and Maximum 0.4% by mass		IEC- 60296, 2003

Permissible limits for tests carried out at Oil & Diagnostic Testing Laboratory Ludhiana-

<table>
<tr><th>SNo.</th><th>EQUIPMENT / TEST DATA</th><th colspan="2">PERMISSIBLE LIMITS</th><th>REFERENCE</th></tr>
<tr><td>o.</td><td>Dissolved Gas Analysis (DGA)
Typical rates of increase of gas formation in power transformers
Hydrogen (H_2)
Methane (CH_4)
Ethane(C_2H_6)
Ethylene (C_2H_4)
Acetylene (C_2H_2)
Carbon Monoxide (CO)
Carbon Dioxide (CO_2</td><td colspan="2">Values in milliliters per day
<5
<2
<2
<2
<0.1
<50
<200</td><td rowspan="2">IEC: 60599-1999
Given only as a guideline for information and Interpretation of DGA results. Need to be reviewed by OS or DGA Committee</td></tr>
<tr><td>p.</td><td colspan="3">Equation to calculate the rate of gas increase as per IEC: 60599-1999
Rate = (Y2 - Y1)m / {(d2-d1)} ml/day where
Y1 = is the reference analysis
Y2 = is the last analysis
(Y2 - Y1) = is the increase in micro-litre per litre
m = is the mass of oil , in kilograms
= the mass density, in kilograms per cubic metre
d2 = is the date for Y1
d1 = is the date for Y2</td></tr>
<tr><td rowspan="2">q.</td><td>Moisture measurement of Winding (RVM or IDA Measurement)
Insulation condition</td><td colspan="2">IEEE Std. 62-1995
% Moisture by dry weight in paper (Wp | % Water saturation of oil (RS)</td><td rowspan="2">CIGRE DOC.No. 227 Life Management Technique for Power Transformer</td></tr>
<tr><td>Dry (at commissioning)
Normal in operation
Wet
Extremely wet</td><td>0.5-1.0 %
< 2 %
2-4 %
> 4.5 %</td><td>< 5 %

6-20 %
> 30 %</td></tr>
<tr><td rowspan="2">r.</td><td>Sweep Frequency Response Analysis Test (20 Hz to 2 Mhz)</td><td colspan="2">In general, changes of ±3 dB (or more) in frequency ranges described below may indicate following faults:</td><td>Euro-Doble Client Committee/ Transformer Diagnostic-
USBR, June 2003</td></tr>
<tr><td>Frequency Range</td><td colspan="3">Probable Fault</td></tr>
<tr><td></td><td>5 Hz to 2 Khz</td><td colspan="3">Shorted turns, open circuit, residual magnetism or core movement</td></tr>
<tr><td></td><td>50Hz to 20KHz</td><td colspan="3">Bulk movement of windings relative to each other</td></tr>
<tr><td></td><td>500 Hz to 2 Mhz</td><td colspan="3">Deformation within a winding</td></tr>
<tr><td></td><td>25 Hz to 10 MHz</td><td colspan="3">Problems with winding leads and/or test lead placement or OLTC</td></tr>
<tr><td rowspan="2">s</td><td rowspan="2">Degree of polymerization (DP)
New insulation
60% to 66% life remains
30% life remaining
0% life remaining</td><td colspan="3">EPRI- guidelines for life extension of sub-stations 2002</td></tr>
<tr><td colspan="2">1,000 DP to 1,400
DP 500 DP
300 DP
200 DP</td><td>Given only for guide-lines and information Interpretation of test results need to be reviewed by OS or Committee meant for them</td></tr>
</table>

PERMISSIBLE/ACCEPTABLE LIMITS FOR OPERATION SWITCHYARD EQUIPMENTS

Volume-V
(EHV CBs, CTs etc.)

VOLUME-V
Doc.No.CE/PM/OS/INST-5B

PART-B

OPERATION SERVICES WING
PUNJAB STATE TRANSMISSION CORPORATION

Head Office The Mall, Patiala

(for internal circulation only)

ACCEPTABLE / PERMISSIBLE LIMITS FOR CIRCUIT BREAKERS

SN	EQUIPMENT / TEST DATA	PERMISSIBLE LIMITS				REFERENCE
1.	DEW POINT OF SF_6 GAS	AS PER Doc.No.CE/PM/OS/INST-2				
	DEW POINT OF OPERATING AIR	(-) 45 °C At Atmospheric Pressure				
2.	CB OPERATING TIME	400kV	220kV	132kV	66kV	
	CB CLOSING TIME (MAX)	150ms	150ms	150ms	150ms	
	CB TRIPPING TIME (MAX)	25ms	35ms	40ms	40ms	
	CLOSE/TRIP TIME POLE DISCREPANCY AT RATED OPERATING PRESSURE					
3.	PHASE TO PHASE (MAX)- CLOSE OPERATION	5 ms				IEC-62271-100 (2001)
	PHASE TO PHASE (MAX)- OPEN OPERATION	3.33 ms				IEC-62271-100 (2001)
	BREAK TO BREAK (MAX)- OF SAME POLE	2.5 ms				IEC-62271-100 (2001)
4.	CO TIME (With simultaneous close & trip command)	35 ms				
5.	SAMPLING FREQUENCY FOR OPERATING TIME MEASUREMENT	5 kHz (MIN)				400 kV CB's
6.	TRIP DELAY TIME FOR DCRM TEST (CO OPERATION)- t_{co}	300 ms				
7.	SAMPLING FREQUENCY FOR DCRM & CONTACT TRAVEL MEASUREMENT	10 kHz (MIN)				
8.	DEVIATION FROM STANDARD TIMINGS AS PER GTP OF MANUFACTURER'S	CLOSE		OPEN		IEC-62271-100 (2001)
		±5		±3		

ACCEPTABLE PERMISSIBLE LIMITS FOR CIRCUIT BREAKERS

<table>
<tr><th>SN</th><th>EQUIPMENT / TEST DATA</th><th colspan="4">PERMISSIBLE LIMITS</th><th>REFERENCE</th></tr>
<tr><td>9.</td><td>RECOMMENDED PIR TIMES (400 kV)</td><td colspan="4">AS PER MANUFACTURER</td><td></td></tr>
<tr><td rowspan="2">10.</td><td>PIR OPERATING TIME PRIOR TO OPENING OF MAIN CONTACTS</td><td colspan="4">5ms (MIN) AT RATED PRESSURE OR AS PER MANUFACTURER</td><td></td></tr>
<tr><td>PIR AND MAIN CONTACTS OVERLAP TIME</td><td colspan="4">5ms (MIN) AT RATED PRESSURE OR AS PER MANUFACTURER</td><td></td></tr>
<tr><td rowspan="2">11.</td><td rowspan="2">TRAVEL OF OPERATING ROD OF 400 kV CB (mm)</td><td>CGL</td><td colspan="2">SIEMEN</td><td>ABB</td><td rowspan="2"></td></tr>
<tr><td>140</td><td colspan="2">150</td><td>200</td></tr>
<tr><td rowspan="3">12.</td><td>TAN DELTA OF GRADING CAPACITORS (400 Kv)</td><td colspan="4">0.007 (MAX)</td><td rowspan="3"></td></tr>
<tr><td>RATE OF RISE OF TAN DELTA</td><td colspan="4">0.001 PER YEAR (MAX)</td></tr>
<tr><td>CAPACITANCE OF GRADING CAPACITORS</td><td colspan="4">WITHIN ±5% OF RATED VALUE</td></tr>
<tr><td></td><td colspan="6">Since temperature correction factor for tan delta depends on make, type, ageing conditions, so correction factors are not same. In case of violation of tan delta values refer to CA/OS</td></tr>
<tr><td rowspan="3">13.</td><td rowspan="2">CONTACT RESISTANCE (μΩ-MICRO OHMS)</td><td>400 kV</td><td>220 kV</td><td>132 kV</td><td>66 kV</td><td rowspan="3">*75 μΩ PER BREAK
NGC UK</td></tr>
<tr><td>150*</td><td>100</td><td>120</td><td>150</td></tr>
<tr><td>CRM OF CB TERMINAL CONNECTOR</td><td colspan="4">10μΩ per connector but not ≥20μΩ</td></tr>
<tr><td>14.</td><td>Evacuation Level Before SF_6 Filling</td><td colspan="4">5 mbar (MIN)</td><td></td></tr>
<tr><td>15.</td><td>N_2 leakage rate through N_2 accumulator</td><td colspan="4">3 bar per year</td><td>400 kV</td></tr>
<tr><td>16.</td><td>IR VALUES WITH IR TESTER
a) PHASE-E
b) ACROSS OPEN CONTACTS
c) CONTROL CABLES</td><td colspan="4">MINIMUM
1000 MΩ
1000 MΩ
50 MΩ</td><td>Megger
5 kV/10 kV
5 kV/10 kV
500 V</td></tr>
<tr><td>17.</td><td>PRESSURE SWITCH SETTINGS
a) SF_6 GAS PRESSURE SWITCHES
b) Operating AIR Pressure Switches
c) Operating OIL Pressure Switches</td><td colspan="4">WITHIN ± 0.1 BAR OF SET VALUE</td><td></td></tr>
</table>

ACCEPTABLE / PERMISSIBLE LIMITS FOR CURRENT TRANSFORMERS

S N	EQUIPMENT / TEST DATA	PERMISSIBLE LIMITS	REFERENCE
18.	IR VALUES WITH IR TESTER d)PRIMARY-E e)SECONDARY-E f)SECONDARY-SECONDARY g)CONTROL CABLES	MINIMUM 1000 MΩ 50 MΩ 50 MΩ 50 MΩ	Megger 5 kV/10 kV 500 V 500 V 500 V
19.	TAN DELTA OF CT's	0.007 (MAX)	
	RATE OF RISE OF TAN DELTA	0.001 PER YEAR (MAX)	
	Since temperature correction factor for tan delta depends on make, type, ageing conditions, so correction factors are not same. In case of violation of tan delta values refer to CA/OS		
20.	MONITORING OF TAN DELTA (20^0C) a) UPTO 0.007 (RISE @ 0.001/YEAR) b) 0.007 TO 0.010 c) MORE THAN 0.010	 AS PER SCHEDULE HY MONITORING REPLACEMENT	Doc.No.CE/PM/ OS/INST-1
21.	CONTACT RESISTANCE OF CT TERMINAL CONNECTOR	10μΩ per connector but not ≥20μΩ	NGC UK
22.	CT RATIO ERRORS a) PROTECTION CORE b) METERING CORE	 ±3% ±1%	 CT ANALYSER IS-2705
23.	N_2 GAS FILLING PRESSURE	PRESSURE0	
	AT 10^0C AMBIENT TEMPERATURE	.10 kg/cm^2	
	AT 20^0C AMBIENT TEMPERATURE	0.20 kg/cm^2	
	AT 30^0C AMBIENT TEMPERATURE	0.30 kg/cm^2	
	AT 40^0C AMBIENT TEMPERATURE	0.40 kg/cm^2	
	AT 50^0C AMBIENT TEMPERATURE	0.50 kg/cm^2	

ACCEPTABLE/PERMISSIBLE LIMITS FOR CAPACATIVE VOLTAGE/POTTRANSFORMERS

SN	EQUIPMENT / TEST DATA	MINIMUM (CVT/PT)		REFERENCE
24.	IR VALUES WITH IR TESTER a) PRIMARY-E b) SECONDARY-E c) SECONDARY-SECONDARY d) CONTROL CABLES	1000 MΩ 50 MΩ 50 MΩ 50 MΩ		Megger 5 kV/10 kV 500 V 500 V 500 V
25.	TAN DELTA OF CT's (CVT'S)	0.007 (MAX)		
	CHANGE IN TAN DELTA FROM PCT VALUES	MEAS. VALUE	MEAS. FREQ.	
		UPTO +0.002	3Y	
		+0.002 to +0.003	Y	REPLACEMENT
		ABOVE +0.003	ALARMING	
	Since temperature correction factor for tan delta depends on make, type, ageing conditions, so correction factors are not same. In case of violation of tan delta values refer to Competent Authority /OS			
26.	CHANGE IN CAPACITANCE FROM PCT VALUES (CVT'S)	MEAS. VALUE	MEAS. FREQ.	
		UPTO ±2%	3Y	
		±2% TO ±3%	Y	
		ABOVE ±6%	ALARMING	REPLACEMENT
27.	CONTACT RESISTANCE OF CVT/ PT TERMINAL CONNECTOR	10μΩ per connector but not ≥20μΩ		NGC UK
28.	CVT/PT RATIO ERRORS a) PROTECTION CORE b) METERING CORE	 ±5% ±0.5%		 CVT ANALYSER IS-2705
29.	DRIFT in SECONDARY VOLTAGE	CONDITION	FREQUENCY	
	TO BE MEASURED WITH 0.2 OR 0.5 CLASS MULTIMETERS (CVT/PT)			
	UPTO ±0.5 V	HEALTHY	6M	
	+0.5V TO +0.8V	MONITORING	3M	
	±0.8V TO ±2.0V	ALARM	1M	
	< -4.0V & > +2.0V	REPLACE		

ACCEPTABLE/PERMISSIBLE LIMITS FOR ISOLATORS/BATTERIES/SURGE ARRESTORS

SN	EQUIPMENT / TEST DATA	PERMISSIBLE LIMITS		REFERENCE
30.	IR VALUES WITH IR TESTER a) PHASE-E b) ACROSS OPEN CONTACTS c) CONTROL CABLES	MINIMUM 1000 MΩ 1000 MΩ 50 MΩ		Megger 5 kV/10 kV 5 kV/10 kV 500 V
31.	CONTACT RESISTANCE	300 μΩ (MAX)		NGC UK
32.	CONTACT RESISTANCE OF TERMINAL CONNECTOR	10μΩ per connector but not ≥20μΩ		NGC UK
33.	**SURGE ARRESTORS-** THIRD HARMONIC RESISTIVE CURRENT (THRC) FOR ALL MAKES	ELPRO/ ALSTOM/ OBLUM/ CGL		
34.	FOR NEW LA'S	30 μA		
35.	FOR LA'S IN SERVICE-	UPTO 150 μA	NORMAL	
		>150 μA	ALARM	
	GAPLESS TYPE	150- 350 μA BEYOND 350 μA	If IR VALUE<1000 MΩ, REMOVE FROM SERVICE	
	GAPPED TYPE	BEYOND 500 μA	REMOVE FROM SERVICE	
36.	IR VALUES WITH IR TESTER	1000 MΩ (MINIMUM)	Megger 5 kV/10 kV	
37.	**BATTERIES-**			
38.	TERMINAL CONNECTOR RESISTANCE	10μΩ ± 20%		ANSI/IEEE-450- 1987
39.	SPECIFIC GRAVITY	1200 ± 5GM/L AT 27^{0}C		
40.	CELL VOLTAGE- FULLY CHARGED CELL VOLTAGE FULLY DISCHARGED CELL VOLTAGE	 2.1 V 1.75 V		

ACCEPTABLE/PERMISSIBLE LIMITS FOR DG SETS, YARDS ETC

SN	EQUIPMENT / TEST DATA	PERMISSIBLE LIMITS		REFERENCE
41.	**DG SETS-** IR VALUES WITH IR TESTER ➢ WINDING	MINIMUM 50 MΩ ±10% OF THE STANDARD		500 V Megger
	STATOR WINDING RESISTANCE	VALUE		
42.	CONTACT RESISTANCE OF TERMINAL CONNECTOR	10μΩ per connector but not ≥20μΩ		NGC UK
43.	**STATION EARTH RESISTANCE**	1.0 Ω (MAX)		IEEE
44.	**THERMOVISION SCANNING OF YARD**	TEMP. ABOVE AMBIENT	CONDITION TO ATTEND	STANDARD IEEE/C 37.010-1979
		ABOVE 15^0C	NORMAL	
		15^0C TO 50^0C	ALERT	
		ABOVE 50^0C	IMMEDIATE	
45.	**CONTACT RESISTANCE OF ALL TERMINAL CONNECTORS**	10μΩ per connector but not ≥20μΩ		NGC UK
46.	**IR VALUES WITH 500 V MEGGER-**			
47.	ALL ELECTRICAL MOTORS	50 MΩ		IS 900
48.	CONTROL CABLES	50 MΩ		
49.	LT TRANSFORMER	100 MΩ		
50	SLT SWITCHGEAR	100 MΩ		

ACCEPTABLE/PERMISSIBLE LIMITS – GENERAL PROCEDURES/COMMITEES

SN	EQUIPMENT/ TEST DATA PERMISSIBLE LIMITS REFERENCE
51.	IF THE RESULTS OR VALUES ARE WITHIN DEFINED PERMISSIBLE LIMITS OR UPTO 10% OF SPECIFIED LIMITS (subject to the safety of equipment), OFFICER COMPETENT TO CHARGE THE EQUIPMENT WILL BE THE SR XEN/ASE INCHARGE OR AEE/AE OF THE TESTING TEAM (i.e PROTECTION, P&M, HOTLINE, ODTL, SAS ETC). THIS IS APPLICABLE ON NEW OR IN-SERVICE EQUIPMENT.
52.	IF THE VALUES ARE 10% TO 25% BEYOND THE SPECIFIED LIMITS AND NOT DANGEROUS (CAN RESULT IN DAMAGE OF THE EQUIPMENT), DECISION CAN BE TAKEN & CONVEYED IN WRITING TO SUB-STATION INCHARGE BY COMMITTEE HEADED BY CONCERNED SE/DY CE, SR XEN/ASE (PROTECTION) & ASE/SR XEN (P&M). IF THAT EQUIPMENT IS TESTED BY ODTL, ASE/SR XEN/POS WILL ALSO BE A PART OF THE COMMITTEE. IN CASE OF EQUIPMENT ERECTED BY CONSTRUCTION WING, SR XEN/ASE/GRID CONSTRUCTION WILL ALSO BEA A PART OF COMMITTEE.
53.	IF THE VALUES ARE BEYOND THE COMPETENCY OF COMMITTEE AT SR NO-52, AND NOT DANGEROUS (WHICH CAN RESULT IN DAMAGE OF THE EQUIPMENT), DECISION CAN BE TAKEN & COMMUNICATED IN WRITING TO SUB-STATION BY COMMITTEE HEADED BY CONCERNED SE/DY CE, SR XEN/ASE (PROTECTION) & ASE/SR XEN (P&M) WITH THE APPROVAL OF C.E/P&M. IF THAT EQUIPMENT IS TESTED BY ODTL, ASE/SR XEN/POS WILL ALSO BE A PART OF THE COMMITTEE. IN CASE OF EQUIPMENT ERECTED BY CONSTRUCTION WING, SR XEN/ASE/GRID CONSTRUCTION WILL ALSO BE A A PART OF COMMITTEE. IF THE VALUES ARE IN ALARMING STAGE THAT MAY RESULT IN DAMAGING, EQUIPMENT SHOULD NOT BE CHARGED.

INSTRUCTIONS ON OPERATION OF SUB-STATIONS

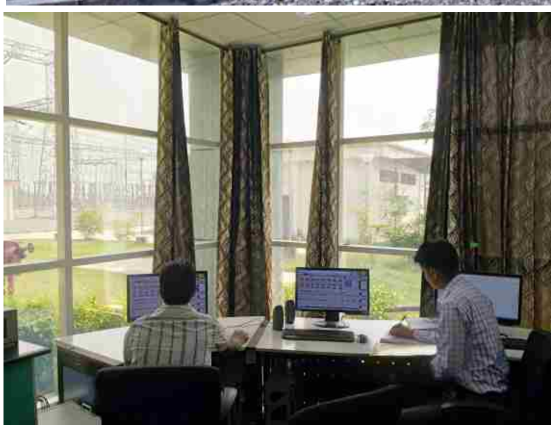
VOLUME VI

Doc.No.CE/PM/OS/INST-6

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

Head office- The Mall, Patiala



OPERATION SERVICES WING
PUNJAB STATE TRANSMISSION CORPORATION LIMITED
LUDHIANA

Edition	Date	Department	Signature
First edition-	01-04-16	OS	
1st Revision-			
2nd Revision-			

Prepared by	Er Sukhjinder S. Virk	
AEE	1-4-16 Operation Services	
Reviewed by	Rajbir S. Walia	
Adll S.E	1-4-16 Protection & Operation Services	
Recommended by	Er Charanjit S. Aulakh	
Chief Engineer	5-5-16 P&M	
Approved by		

23-6-16 BOD's of PSTCL in 37th meeting vide U.O No-1211/BOD/37.21/PSTCL, Dated 8-7-16

1.0 GENERAL GUIDE LINES FOR SHIFT ENGINEER/OPERATOR

AT THE TIME OF TAKE-OVER OF SHIFT

a) Ensure all data in the log sheet is duly filled in from & signed by Shift Personnel on duty.
b) Ensure all records in monthly registers are duly entered and signed by Shift Personnel.
c) Ensure availability of all keys in the keyboard.
d) Ensure availability of all operating handles and safety gears in the Control Room.
e) Check defect register for any defective equipment and remind sub-station In-charge or Maintenance Engineer for its rectification and reminder with date and time may be entered in the defects register.
f) Check instruction book for any instruction and ensure compliance of instruction.
g) Check Message Book for incoming and outgoing messages.
h) Test annunciation facias for healthiness and make attempt to RESET the facias if appearing since previous shift.
i) Check DC Earth fault relay to identify any Earth fault in the D.C. system.
j) Record any abnormality in the system/equipment in the Log Book and Defect Register.
k) Ensure availability of DG Set, Fire Fighting System, DC System & AC system.
l) Inspect all the equipment in the switchyard and record deficiencies, if any, in the logbook & defect register and bring to the notice sub-station In-charge or Maintenance Engineer.
m) Check for any Relay Indication in the C&R Panel and RESET, if any and record observations in logbook and inform Sub-Station In-charge.
n) Ensure locking of all entry points to the Sub-station & availability of keys in the keyboard.

2.0 DURING SHIFT OPERATION

a) Observe the system parameters and record them in logsheet at stipulated intervals.
b) Conduct trial run of the equipment as per the trial run schedule.
c) Follow operating instructions from Power Controller /sub-station In-charge for operation of system and equipment. In case of multiple instructions, instructions of PC is final.
d) Exchange of codes/messages from NRLDC/SLDC strictly in confidential manner.
e) Issue & maintain records for *permit to work, no backfeed certificate& restricted area pass* etc. as per instructions laid down in PSTCL safety rule hand book.
f) Pay visit to battery rooms, DG set, Float Charger, C&R panels and ensure healthiness.
g) Inspect the equipment in the sub-station premises at regular intervals and in case of any abnormality, record it in the logbook and defect register and inform sub-station In-charge
h) Inspect the work spots in the sub-station premises & ensure adherence to PSTCL safety regulations.
i) Control any unauthorized entry in the switchyard & issue keys with proper record register.
j) Shift Engineer/operator should be available in the sub-station control room expect during the inspection of outdoor yard.
k) Interchanging of shift roasters without written authorization from sub-station In-charge is not permitted.

3.0 AT THE TIME OF HANDING OVER OF THE SHIFT

a) Record any abnormality in the system/equipment in the logbook at time of handing over of the shift. Also pass on necessary operational messages, if any.

b) Ensure all parameters and observations during the shift have been duly recorded in the log sheets, logbook & registers and have been duly signed by the concerned officials engaged during the shift duty.

c) Ensure availability of all keys in the keyboard and in case of non-availability of any key in the keyboard, same should be duly checked from the key control register & recorded specifically in the logbook.

d) Don't hand over shift to any unauthorized employee.

4.0 DO'S AND DON'TS DURING THE SHIFT

a) DO remain alert during the shift to meet any emergency.

b) DO close Isolators on both sides of circuit Breaker before communicating clearance to charge the line from REMOTE end.

c) DO open Circuit Breakers after the system voltage has collapsed and in case of Air Blast Circuit Breaker associated Isolators should also be opened.

d) DO tag the DO NOT OPERATE/UNDER PERMIT boards on the control switches of the equipment or C&R panel to which the work permit is issued.

e) DO ensure proper system conditions before synchronizing.

f) DO open the isolators on both sides of CB if is to be kept in open condition for long time.

g) DO confirm isolation of power supply i.e. racking out of LT breakers and removal of fuses in the distribution board physically before issuing of work permit on LT system..

h) DO distribute outgoing and incoming feeders uniformly on both the Main Buses of Double Main and Transfer Bus arrangement.

i) CLOSE Main & Tie Circuit Breakers of a diameter in one and a half breaker scheme. Check the Isolators physically after operating from remote, even if semaphores show open position.

j) Check working of GPS synchronizing equipment.

k) DO NOT depend only on interlocks. Ensure safety personally before doing any operation.

l) DO NOT close any Circuit Breaker until Gas pressure, Air pressure, Hydraulic oil pressure are within operating/permissible limits.

m) DO NOT attempt to charge a line after it has tripped after unsuccessful Auto Re-closure.

n) DO NOT issue ***permit to work/sanction for test*** on verbal requests.

o) DO NOT operate any control switch under ***permit to work/sanction for test*** unless, ***permit to work/sanction for test*** is returned and canceled.

p) DO NOT issue ***sanction for test*** on any equipment which is already under permit to work.

q) DO NOT synchronize Circuit Breaker in BYPASS mode

r) DO NOT keep any Circuit Breaker in closed position when the system has collapsed.

s) DO NOT close any Circuit Breaker without personally ensuring that the associated Isolators are in fully closed condition.

t) DO NOT close any Circuit Breaker from local while charging.

u) DO NOT operate Isolator/Earth switch by pressing the power contactors.

v) DO NOT operate any Isolator to isolate the system if the circuit breaker has failed to open.

w) DO NOT operate control switch of Circuit Breaker controlling line feeder even under shutdown without clearance from the shift In-charge at remote end Sub-Station.

x) DO NOT attempt to charge Transformer or Reactor subsequent to its tripping on Differential / REF/ Buchholz /PRV without carrying out complete electrical tests on the equipment. Recharging of the equipment may be attempted with due permission of Protection team.

y) DO NOT leave the sub-station during the shift.

5.0 GENERAL SAFETY GUIDE LINES

During shift operation, shift in-charge needs to ensure compliance of all safety rules by all concerned in the sub-station premises to avoid any mishap during the shift for the sake of safety to equipment and human life. The shift in charge is required to ensure at least the following:

a) All personnel engaged in O&M must wear proper safety gear.

b) No work on live equipment to be done expect the Hot Line work.

c) All earthing connections of the equipment under maintenance should be proper & tight.

d) Proper isolation and earthing of equipment prior to issue of ***permit to work*** and putting of ***do not operate/PTW*** boards on the handles of the C&R panels or the equipment under shutdown.

e) No work to be started without *PERMIT TO WORK/SANCTION FOR TEST.*

f) Use proper T&P for work & don't use any bare wire for any connection.

g) No jointing for temporary connections in control cable/wire to be done.

h) Use proper rating of control cables/wires, switches, fuses, terminals etc for any connection & Cordon off the “area of work”.

i) No cable to be buried directly into the earth without proper protection.

j) Use of abnormally long metallic objects like ladders, sticks etc. in the switchyard is prohibited.

k) Don't meddle with the switches where ***do not operate*** or ***PTW*** Board is tagged.

l) Induced voltage in the equipment to be taken for maintenance should within safety limits (100V), otherwise shutdown of adjacent bay should be arranged.

OPERATING GUIDE LINES DURING ROUTINE OPERATIONS

6.0 GENERAL OPERATING GUIDELINES FOR CHARGING OR SYNCHRONISING OF TRANSMISSION ELEMENTS

a) Ensure that all PTW/SANCTION FOR TEST issued against the equipment to be charged and its controlling devices are returned and canceled.

b) Ensure removal of all men and material from the equipment/bay to be charged.

c) Ensure removal of all temporary earths from the equipment/bay to be charged.

d) Ensure the charging/synchronizing code from SLDC/RLDC, wherever applicable.

e) Ensure fire-fighting system is in working condition and kept in AUTO Mode.

f) Ensure all bay equipment of the bay is healthy & is in service with flags RESET.

g) Ensure all bay equipment to be charged is normal as per physical inspection.

h) Ensure SF_6 pressure/air pressure/hydraulic oil pressure etc of the Circuit Breakers are in normal operating range.

i) Ensure healthiness of system at annunciation windows.

j) Ensure that all the Earth Switches in the bay are OPEN condition.

k) Ensure LOCAL/REMOTE selector switches of the Circuit Breaker and Isolators are in REMOTE position.

l) Ensure recording of LA & Circuit Breaker counter readings.

m) Ensure that all monitoring equipment like Fault Locator, Disturbance Recorders, Event Logger etc. are working and in service.

n) Every operation should be verified in EL printout with respect to time.

o) Ensure PLCC channels are working and in service. Record PLCC counter readings.

p) Ensure remote end line Earth switch is OPEN.

q) Ensure availability of clearance from remote end prior to dead line charging.

r) Ensure Auto-reclose switch is kept in non-auto mode while first charging.

s) Ensure recording of system parameters before and after charging of element.

t) Ensure that there is no abnormality viz noise, sparking, flashover in the outdoor yard after charging/Synchronization during physical inspection.

u) In case of tripping during first charging second attempt should be taken after clearance by sub-station Incharge or Protection team. Element should be declared faulty after tripping on fault on second attempt & further attempt to be made only after ascertaining the reason for tripping.

v) In case of charging of line after long outage or after major maintenance of line, the line needs to be meggered with 5 kV Insulation Tester prior to charging. However, in the event of adverse weather condition or any other exigency, waival of insulation testing may be given by Sub-station or Protection Incharge depending on the site conditions.

7.0 DEAD LINE CHARGING OF LINE FROM REMOTE END STATION

a) Ensure all PERMIT TO WORK/SANCTION FOR TEST issued for the line/equipment are returned and canceled.

b) Ensure removal of all men and material from the respective equipment/by.

c) Ensure removal of all temporary earths from the equipment.

d) Ensure availability of charging code from SLDC/RLDC.

e) Ensure fire-fighting system is in working condition and kept in AUTO Mode.

f) Ensure that all the protective relays of the feeder/equipment are working and are in service with flags in RESET condition.

g) Ensure that all the bay equipment of the feeder to be charged should be physically inspected & in normal operating condition.

h) Ensure SF_6 pressure/air pressure/hydraulic oil pressure of the Circuit Breaker's are in normal operating range or safe zone & no annunciation indication is persisting.

I) Ensure all the earth switches in the bay are OPEN & LOCAL/REMOTE selector switches of the Circuit Breaker and Isolators are in REMOTE position.

j) Ensure recording of LA counter readings, Circuit Breaker operation counter readings,

k) All monitoring equipment like Fault Locator, Disturbance Recorder, Event Logger, etc. should be working and in service.

l) PLCC channels should be working and IN SERVICE. Record PLCC counter readings.

m) Ensure line earth switch is OPEN & Inspect switchyard for any abnormality.

n) Ensure Line Isolator is CLOSED. Isolator on either side of the Main & Tie Circuit Breakers should also be CLOSED & respective Shunt Reactor isolator is also Closed..

o) Communicate clearance for charging of the line from remote end & record line voltage after charging of the line from remote end and bus voltage & frequency.

8.0 SYNCHRONISING

While connecting an incoming system with the running system, proper synchronism of both the systems should be checked. The ideal conditions for synchronism between the two isolated electrical systems are given below:

a) Phase sequence, frequency & voltage magnitude of both the systems should be same.

b) Phasor position of both the systems should be same but for comparison of the above parameters, check synchronizing relay is provided. Since conditions are never ideal, there is some permissible limit in case of mismatching of above parameters to synchronize the two systems & these mismatching limits are set in the check synchronizing relay. While synchronizing, when all the parameters fall within the set limits, indication lamp marked “SYNCHRONISING IN LIMIT” glows which enables operator to send close command to the Circuit Breaker through the C.B control switch. In no case, C.B should be closed with synchronizing selector switch in “*by pass*” mode as wrong synchronization of two system can lead to severe power swing in the system resulting in grid collapse and failure of the Circuit Breaker. In the event of difficulty in synchronizing any feeder, RLDC should be approached through SLDC.

9.0 GENERAL OPERATING INSTRUCTIONS FOR SHUTDOWN OF LINE/REACTOR TRANSFORMER/ICT OR BAY EQUIPMENT

a. Permission of SLDC or RLDC for allowing shutdown should be taken.

b. Ensure receipt of opening code from SLDC/RLDC before opening of feeder CB.

c. Ensure recording of system parameters before and after opening of the transmission element.

d. Ensure remote end sub-station has been intimated about opening code of the line prior to its opening.

e. Open the Circuit Breakers and then open associated Isolators of that element.

f. Ensure DO NOT OPERATE/UNDER PERMIT boards are attached on the control panel of the respective line or transmission element.

g. All associated earth switches are closed from LOCAL. Receipt of clearance from remote end sub-station for closing of line earth switch should be obtained.

h. Earth Switches at both ends of line/Transformer/ICT/Reactor should be closed.

i. Ensure Pad locking of line earth switch & physically check opening of all the Isolators.

j. Opening and closing of isolator & earth switch should be recorded by Event Logger.

k. Issue Permit to Work (PTW) in prescribed format.

10.0 OPERATING GUIDELINES DURING EMERGENCY CONDITION

A system is considered to have attained emergency when it operates beyond the specified operating parameters which normally happens due to failure of equipment, tripping of line/ICT/Power Transformer etc. Further, operation of system on overload, over/under voltage, high/low frequency can lead to emergency in the system. Fire hazards, though rare in nature, may cause criticality to the entire system.

11.0 TRIPPING OF LINE/ICT/POWER TRANSFORMER

In the event of tripping of line/ICT/ Power Transformer, the operating personnel need to do at least the following:

a) Record all the indications on the C&R panel and annunciation windows of the tripped transmission element. Record all relay flag indications & inform sub-station Incharge.

b) Record indications appeared during incident of tripping in the C&R panels of other feeders also.

c) RESET of relays or facia windows should be done only after the approval of sub-station incharge

d) Record system parameters like voltage, frequency, load (Current, MW & MVAR) flow in other unaffected lines/ICTs/Power Transformer also.

e) Obtain print out from D.R's and EL's and send to Operation Services for analyis

f) Record reading of line Fault Locator and give input to AEE/TL

g) Record Oil & Winding temperature of Power Transformer/ICT/Reactor .

h) Record PLCC Transmit and Receive counter readings and exchange PLCC counter advancement details with remote end station.

i. Inform SLDC about the tripping of line/ICT/Power Transformer with all indications.
j. Inform adjoining Sub-Station about the tripping & inspect outdoor equipment
k. Also record the C&R panel indications & happenings at from remote station
l. For interpretation of C&R panel indications, inform Sub-Station Incharge.
m. In the event of load imbalance due to tripping of any one of the lines/ICT's/Power Transformers, SLDC should be informed to regulate load at sub-station.
n. For re-energising, forward request to SLDC for charging code & after receiving the charging code from SLDC, share it with remote end station.
o. But before re-energising line, obtain clearance from remote end station.
p. Don't synchronies line/ICT keeping check synchronizing relay bypassed.
q. Record system parameters viz voltage, frequency before and after charging.
r. In the event of simultaneous trippings of more than one feeder, obtain charging code from SLDC for each feeder and restore them one after the other in coordination with remote end station and SLDC. Keep close watch on system parameters viz. voltage frequency and load (Current, MW & MVAR) flow.
s. After tripping of any feeder for reason not attributable to the sub-Station, don't issue any PERMIT TO WORK / SANCTION FOR TEST to maintenance staff.
t. If during the process of re-energising any feeder trips on fault, the same is to be declared faulty and inform sub-station/divisional head & line maintenance In-charge.
u. In case of unsuccessful auto reclosing, make attempt to charge the line only once subject to receipt of charging code from SLDC and if the line fails to hold, the line is to be declared faulty. Sub-station/divisional head & line maintenance In-charge should be informed for necessary corrective action.
v. For every unsuccessful auto reclosure for single phase to earth fault, the reason for failure may be explained in tripping report. If it is due to mal-operation, same should be entered in defects register also.
w. Main-I & II relays should exchange carrier if they have operated for any line fault in Zone-I. If not same shall be entered in defects register.
x. If any unwarranted flags of relays have operated. It should also be entered in defects register.

12.0 AUTORECLOSING OF LINE

In the case of successful auto-reclosure of line, the operating personnel should-

a. Record all indications on C&R panel and annunciation windows of auto- reclosed line or any other panel in control room, which have appeared simultaneously during re-closing.
b. Record system parameters like voltage, frequency, load (current, MW & MVAR) flow.
c. Download DR's/EL's for analysis by OS wing along with fault location/distance.
d. Record C&R panel indications from remote end station and record PLCC transmit and receive counter readings from PLCC counter.
e. Inform SLDC, sub-station/Line Incharge/remote station about the tripping of line with all C&R panel indications for patrolling of line.

13.0 OVER LOADING OF LINE / ICT / POWER TRANSFORMER

Over loading of line/ICT/Power Transformer may be due to un-planned addition of load or due to tripping of adjacent Line/ ICT/Power Transformer in the system. Under such conditions, operation personnel need to do the following:

a. Record voltage. Frequency, load (Current, MVAR).
b. Monitor winding and oil temperature of ICTs/Power transformer and Reactors continuously and record readings.
c. Ensure functioning of all cooling devices of ICTs/Power transformers and Reactors.
d. Contact SLDC and inform all system parameters requesting for regulation of load.
e. Inform sub-Stations at the down end & also contact remote end station for any abnormality & seek assistance, if possible for load regulation.
f. Inspect Outdoor Equipments for any visible hot spot, flashover or noise.
g. No maintenance work is to be permitted on any sub-station equipment during period of over loading, even if work does not require shutdown of the equipment.
h. Get back the PTW/SANCTION FOR TEST issued for maintenance work in sub-station for cancellation and keep the equipment ready to bring back in the service.
i. For transformer, loading should not exceed values printed on the name plate. Overloading, if any, should be for very short duration only. It should be controlled with help of SLDC at 400 kV stations and by load control at 220 kv or 132 kV S/S's.

14.0 OVER VOLTAGE

If the voltage on 220 KV side exceeds beyond +10% of the nominal rated voltage, the system may considered to be approaching towards criticality. Under such conditions shift incharge should follow these instructions:

a. Bus reactor must be taken into service when 400 kV system voltage reaches 415 kV after obtaining charging code from the SLDC/NRLDC.
b. Record parameters like voltage, frequency, Load (Current, MW & MVAR) of all the feeders and intimate SLDC for necessary regulatory action.
c. Record remote end readings of reactive power flow towards the– station and intimate SLDC for necessary regulatory measure.
d. Enquire with adjacent Sub-Station/generating station for any tripping or load throw off
e. Contact adjoining generating stations/sub-stations, requesting necessary regulatory action by way of absorbing MVAR and changing of transformer tap positions through the office of SLDC.
f. If the over voltage is coupled with high or low frequency SLDC should be requested for immediate action in coordination with Generating station.
g. If situation warrants, approach SLDC for manual opening of lightly loaded long lines.
h. If feeder trips on over voltage stage–I & II, measure rms value of voltage from DR printout (before CB open) and record in trip report. If it is different from set value 110% or 150% of line voltage, record it in defects register & inform protection.

15.0 UNDER VOLTAGE

If the voltage on 220 kV sides falls by 5% of the nominal rated voltage, the system may be considered to be approaching towards criticality. Under such conditions, the shift personnel need to do at least the following:

a. Bus Reactor must be taken out of service if 400 kV system voltage falls below 390 kV after obtaining the discharging code from the SLDC/RLDC..

b. Record parameters like voltage, frequency, load (Current, MW & MVAR) of all the feeders and intimate PC for necessary regulatory action.

c. Contact remote end stations to confirm that bus reactors have been taken of service.

d. Contact adjoining generating stations requesting injection of MVAR into the system as per capacity of the machines and capacitor banks at downstream stations must be energized..

e. Request feeding sub-stations through SLDC to reduce MVAR drawl from the system.

16.0 OPERATION DURING HIGH / LOW SYSTEM FREQUENCY

If the system frequency exceeds 50.5 Hz and falls below 48.5 Hz, the system may be considered to be approaching towards criticality. Under such conditions, the shift Incharge should:

a. Intimate SLDC for requisite regulatory measure by way of load shedding or control of generation, as the case may be.

b. Keep a close watch on the system parameters.

17.0 OVER FLUXING

Decrease in power frequency & over voltage causes an increase in stress on the insulation and proportionate increase in the working flux. The later effect causes an increase in iron loss and a disproportionate increase in magnetizing current. In addition, flux is diverted from the laminated core structure into steel structural parts. Under condition of over-excitation of the core, the core bolts may rapidly heat to a temperature which destroys their own insulation and can damage the coil insulation, if the condition continues. Reduction of frequency has an effect with regard to flux density, which is similar to that of over voltage. Transformer can operate with some degree of over voltage but with a corresponding increase in frequency but this operation must not be continued with high voltage input at low frequency. The condition does not call for high speed tripping but normal condition must be restored or the transformer must be isolated within two/three minutes at most. At stage–I, it provides ALARM and subsequently at stage-II, it isolates the transformer from the system. As soon as the alarm is received, the operating personnel needs to do the following:

a. Note voltage and frequency from indicating meters in the control panel
b. Bus Reactor must be taken into service when 400 kv system voltage is 415 kV.
c. Enquire from adjacent Sub-Station/generating station for any line tripping or load throw-off and request necessary regulatory action by way of absorbing MVAR and changing of transformer tap position.
d. Any tripping due to over fluxing should be verified by measuring voltage and frequency from DR/SCADA/Voltage and frequency recorder. Any deviation from operating value of relay shall be recorded in defect register.
e. Over flux settings and over voltage settings (110%) of parallel elements should be graded as per instructions from NRPC/NRLDC or OS wing of PSTCL with respect to time delay and plug settings.
f. Intimate SLDC for necessary regulatory measures & manual opening of lightly loaded lines.
g. If the Transformer trips on over flux relay, it may not be charged till normalization.

18.0 FAILURE OF 400/220 KV SUPPLY

In the event of total failure of 400 KV or 220 kV supply:

a. Ensure total collapse of the system from the voltmeters mounted on panels for 400/220 KV buses and all line/ICT/feeders, voltage and frequency recorders & from the adjoining sub-stations.
b. Inform SLDC, Sub-station Incharge, Divisional Incharge about total system collapse.
c. Trip all the Circuit Breakers manually after obtaining opening code from SLDC.
d. Open Isolators at both sides of the Circuit Breakers, particularly in case of Air Blast Circuit Breakers.
e. Record all indications in the annunciation windows, relays and line fault locators etc
f. Record any increment in PLCC transmits & receives counters for all line feeders.
g. Obtain Disturbance Recorder & Event Logger print outs, Bus voltage and frequency recorders, C&R panel indications, relay indications, increment in PLCC transmit and receive counters, fault locator readings from local & remote end stations for analysis by protection, OS Wing, NRPC, NRLDC etc.
h. Record observations from DR's & EL's & inspect outdoor yard for any abnormality.
i. Communicate control and protection panel indications to SLDC with correct interpretation in consultation with Sub-Station Incharge.
j. Charge/ Synchronized line/ICTs one by one to restore the total system only after obtaining charging codes for each and every feeder from SLDC/RLDC.
k. Obtain clearance from Sub-Station In charge/Testing Engineer prior to according permission for dead line charging from remote end station.
l. RESET all control and relay panel indications prior to charging of any circuit.
m. Obtain clearance and “NO BACK FEED” Certificate from remote end station prior to dead line charging.

19.0 FAILURE OF AC AUXILIARY POWER SUPPLY

In the event of failure of AC auxiliary power supply, the operating personnel in the Sub-Station need to take the following actions:

a. Start DG set if power supply is not restored within 10 minutes after ensuring proper lube oil/cooling water level in the DG set and after disconnection of grid supply from LT the board.
b. Ascertain the reason for failure of supply and ensure availability of diesel if the DG set is required to be run for longer time.
c. If the DG set is required to be run for longer time, cut off unimportant loads.
d. In case long outage of the auxiliary power supply is anticipated, approach PSPCL through SLDC or station in charge.
e. Follow up with respective grid station of PSPCL/PSTCL through Maintenance Engineer of PSTCL for early restoration of supply.
f. Continuously monitor the operating parameters of DG set and ensure that they are within permissible operating limits.
g. In case of low voltage in auxiliary power supply, the LT Transformer should be taken out and DG set is to be taken into service,
h. In case, DG set fails to take start, then cut off redundant lighting load and other load in consultation with Sub-station incharge.
i. Monitor D.C Voltage and Current Continuously & rRecord all the observation and subsequent operations in the long book.

20.0 EQUIPMENT FAILURE

In case of abnormality in any equipment of Sub–station the operating staff need to take action:

a. Record time and nature of abnormality in log book & immediately inspect the equipment. Record observation in detail.
b. Inform sub-station Incharge/Group Incharge/ Maintenance Engineer, SLDC & adjacent sub–station of the effected circuit. Failed equipment should be isolated at the earliest.
c. Record all system parameters like voltage frequency load (Current , MW etc) and oil & winding temperature in case of transformer/reactor.
d. If the failure of the equipment is so serious that it may affect the adjacent equipment or human life, the said circuit may be manually tripped immediately & SLDC may be informed accordingly.
e. In case of fire, fire extinguishing equipment should be used immediately & if it is not controllable, services of fire brigade should be called.

21. FAILURE OF PROTECTION

In the event of failure of any element in the protection scheme the operating personal should:

a. Record all indication as appearing in the control & relay panel in the logbook.

b. Record system parameters at the instant of failure & record defects in the defect register. Inform Sub-station Incharge.

c. In the event of protection (relay) mal-operation, the protection is to be taken out of service by Shift Engineer in consultation with sub- Station in charge & Protection Incharge should be informed immediately.

d. In case of failure of one of the two Distance Protection schemes, the line can be kept into service only after concurrence of sub-station/protection in charge .

e. In case of operation of bucholz relay or pressure release devices or differential or restricted earth fault relays, ICT/power transformer/reactor should not be charged till it has been cleared for charging by protection Incharge.

22. FAILURE OF PLCC

In the event of failure of PLCC system, following should be done:

a. Record all the observation appearing in the PLCC cabinet and annunciation window in the log book and RESET the windows. Inform sub–station in charge.

b. In case of failure of speech terminal stations, make effort to establish speech with remote and station directly from the PLCC cabinet.

c. Continuation of operation when both the PLCC channels have failed is risky and requires permission from POS Incharge and CO&C wing should be immediately informed.

23. FAILURE OF 220 VOLTS DC SYSTEM

In the event of failure of 220 V D.C system following should be done:

a. Immediately inform Sub-station Incharge.

b. Cut off redundant D.C Lighting loads and other DC loads in consultation with Sub-station Incharge.

c. In case of very low DC system voltage boost the battery till normal DC Voltage is restored.

d. Continuation of operation when both the 220V DC sources have failed requires permission from sub-station Incharge.

e. With consultation of SLDC & sub-station Incharge, isolate the element whose DC has failed. If whole of the sub-station is affected, immediately trip outgoing 11 KV VCB's & then 66 kV lines feeding PSPCL stations.

f. Then try to restore DC step by step. It must be ensured that from one point of DCDB, not more than three 66 kV or 132 kV bays be fed. For 220 kv bays, each bay should be fed from a dedicated point of DCDB.

24. FAILURE OF 50 VOLTS DC SYSTEM

In the event of failure of 50V DC system the operating personnel should:

a. Inform Sub–station in charge/Maintenance Engineer/CO&C Incharge (Sr XEN).

b. In case of very low DC system voltage, boost charge the battery till normal DC voltage is restored.

c. Continuation of operation when both the 50V DC sources have failed is very critical for the system and CO&C/sub-station Incharge should take immediate action.

25. DC EARTH FAULT

Inspection of DC earth fault in system should be closely monitored. The operating personnel are required to be very sensitive regarding this.

a. Inform sub-station/maintenance Incharge. Identify the faulty source.

b. Record observation in the log book or defect register & record event when the earth fault has been noticed.

c. Isolate the faulty section in consultation with sub-station Incharge.

26. FIRE

In case of fire in any equipment in a sub-station the operating personal should take the following action:

a. In case of fire, immediately operate the fire alarm so that staff can be gathered for quenching of the fire with appropriate extinguishers.

b. In the event of likelihood or spread of fire, the effected equipment may be electrically isolated by manual tripping immediately.

c. In case of fire in the transformer, HV, IV and LV sides are to be electrically isolated by manual tripping of the circuit breakers, if they have not tripped due to protection failure.

d. In case of fire in the cable, identify and isolate the section of cable where fire has occurred to avoid spreading of fire. Inform the nearest fire station immediately.

e. Inform sub-station Incharge, maintenances engineer and safety staff along with SLDC and adjacent sub–station.

f. Isolate AC and DC auxiliary supply to the effected equipment.

g. In case of fire in transformer/reactor, if emulsifier system does not come into operation automatically, than operate deluge valve manually.

h. Use hydrant system and foam type fire Extinguishers to avoid spread of fire.

i. NIFPES system if has not operated automatically should be operated manually.

j. Ensure safety of working personnel also.

27. STRUCK BREAKER CONDITION

Circuit breaker is provided to isolate the element when it is intended to isolate, but during the process of isolation it has been observed that some times, all the poles of the circuit breaker have failed to open due to inherent problem in the circuit breaker mechanism. This kind of situation may pose serious operational problems for operation personnel. In the event of such problem in the circuit breaker isolation, on protection, appropriate measure by way of provision of LOCAL BREAKER BACKUP Protection has been in operation at all the 220 kV & above voltage level sub–stations to safe guard the system from total collapse. However, the failure of circuit breaker during manual opening cannot be ruled out. Under such kind of failure the operating personnel need to:

a. Intimate remote and sub-station where the affected circuit is connected to.
b. Request SLDC for opening code of circuit breaker at remote end sub–station.
c. Intimate Sub–station in charge and Maintenance Engineer.
d. Ensure load of the circuit has reduced to Zero & feeder is isolated from remote end.
e. Request SLDC to give code from transferring all other feeder connected to the bus which is feeding the effected circuit to other bus.
f. Ensure total load on bus feeding the effected circuit is Zero.
g. Isolate both buses through bus Coupler or tie circuit breaker.
h. Ensure that the effected circuit is totally de energized.
i. Open the circuit breaker manually with the assistance of the maintenance Engineer.
j. OPEN Isolators on both sides of the faulty circuit breaker to isolate it.
k. Close earth switches on both sides of the circuit breaker.
l. Restore back the buses and the feeder to the original operating configuration in close coordination with PC

28. ARCING ACROSS ISOLATOR CONTACTS

While closing or opening of isolators electrically from REMOTE it may become in operative midway leading to arcing across the male and female contacts of the isolator. Prolonged arcing is likely to cause damage to the contacts and arcing horns. Under such condition the operating personnel need to do at least the following:

a. Intimate SLDC for arcing and obtain code for isolation of the affected isolator.
b. Intimate Remote end station of the affected feeder.
c. Intimate Sub-station In charge and maintenance Engineer.
d. Isolate the isolator totally from voltage source by hand tripping the connected CB.
e. Open the affected isolator and restore back the disconnected circuit.

29.0 DETECTION OF HOT SPOT

The shift In-charge is required to inspect the outdoor yard at regular intervals to detect any abnormality in the outdoor yard. In the event of detection of any HOT SPOT in the outdoor yard the operating personal need to:

a. Inform sub-station in charge and maintenance engineer.
b. Record system parameters like voltage, load (Current, MW& MVAR) of the affected circuit.
c. Inform SLDC for necessary regulatory measure, if required.
d. Request SLDC for opening code for opening the affected circuit/section if the hot spot requires immediate attention.
e. Ensure thermo-vision scanning of the spot after rectification is over.

30.0 ABNORMAL SOUND /EXCESSIVE VIBRATION

After charging the ICT/Reactor/Power Transformer, always inspect the equipment for any abnormal humming sound or excessive vibrations. In case the humming sound is high the same needs to be measured and compared with the factory test reports.

a. The maximum vibrations of the reactors shall not exceed 200 Macrons (peak to peak)and average vibrations shall not exceed 60 macrons (peak to peak) and in case it is noticed that the vibrations are high, the same needs measurement at rated voltage at different locations on the tank body and matter needs to be taken up with the manufacturer.
b. In case of 400/220KV CVTs or CT's or PT's, if abnormal sound is noticed immediately arrange for shut down of the equipment. This may be due to lose core clamp bolt of the EMU of CVT or looseness of secondary terminals of the CT's. The EMU should be inspected and the core clamps or secondary connections, if loose should be tightened.

31.0 CHARGING OF AUTO-TRANFORMER

PRE-CORDINATION FOR CHARGING

Auto-transformer shall be charged preferably from 220 kV side and synchronization shall be done at 400 kV side in a normal condition.

a. In case, charging of auto-transformer is to be done from 400 kV side, 400 kV bus voltage shall be maintained around 400 kV.
b. In case auto transformer remained out of service for a long period , the oil need to be tested for of BDV, Tan Delta, resistivity and moisture content prior to charging of the same.

c. Before putting the ICTs into service, ensure that the taps of the ICTs are at the same position and mode selection switch off OLTC of one of the ICTs shall be in "MASTER" and other one in "follower" mode.
d. Ensure earth switch of corresponding 400 kV side of transformer is OPEN.
e. Check humming sound from transformer for any abnormality.
f. If the transformer trips on fault, second attempt shall not be taken until transformer is properly tested and reasons for tripping are ascertained..
g. Inspect outdoor yard for any abnormality viz. sparking, Hot Spot etc.

32.0 ISSUE OF PTW ON OUT DOOR EQUIPMETS:

A. ISSUE OF PTW ON 400KV BUS ISOLATOR

PTW on any one of the 400 kV main bus isolators can be issued subject to-

a. Obtain permission from SLDC
b. De–energise the concerned bus ,depending on the actual conditions, open the de-energised isolator on which PTW is to be issued

B. ISSUE OF PTW ON 400KV MAIN CIRCUIT BREAKER

PTW on 400kV main circuit breaker can be issued subject to:

a. Obtain permission from SLDC
b. Ensure that the concerned feeder is connected to the other 400 kV main bus through tie circuit breaker and other bus associated main circuit breaker in the diameter.
c. OPEN Circuit breaker intended to be taken under shut down.
d. OPEN isolator at both side of the circuit breaker.
e. CLOSE earth switch at both sides of the circuit breaker.
f. Ensure auto–reclose selector switch is in "NON AUTO" mode.
g. Put tag boards with control switches of isolator at both side of the circuit breaker.

C. ISSUE OF PTW ON 400KV TIE CIRCUIT BREAKER

PTW on 400kV TIE circuit breaker can be issued subject to:

a. Obtain permission from SLDC
b. Ensure that the 400 kV feeders in the diameter are connected to respective 400 kV main buses through their associated main circuit breakers.
c. OPEN TIE Circuit breaker intended to be taken under shut down.
d. OPEN isolator at both side of the circuit breaker.
e. CLOSE earth switch at both sides of the circuit breaker.
f. Ensure auto–reclose selector switche is in "NON AUTO" mode.
g. Put tag boards with control switches of isolator at both side of the circuit breaker

D. <u>ISSUE OF PTW ON 400KV FEEDER</u>

PTW on 400 kV can be issued subject to following:

a. Obtain permission from SLDC
b. Intimate remote end station in case of line feeder.
c. Record system parameter viz voltage, frequency, load(Current, MW &MVAR) prior to opening of the line.
d. OPEN both main and tie circuit breaker of respective feeder.
e. OPEN respective feeder isolator and reactor isolator (in case of line feeder).
f. CLOSE respective feeder earth switch.
g. CLOSE both the main and Tie circuit breaker for continuity of the diameter when PTW is intended to be issued on the line/transformer /reactor only.
h. Ensure auto re-close selector switch of the main circuit breaker is in “NON AUTO” Mode.
i. Put tag board with the control switches of feeder isolator and 220kv side isolator in case of transformer feeder.
j. Ensure remote and line earth switch is CLOSED.

E. <u>ISSUE OF PTW FOR HOT LINE MAINTAIANCE</u>

PTW for hot line maintenance on 400/220 kV Transmission lines can be issued subject to following:

a. Obtain permission from SLDC
b. Intimate remote end station about the hot line maintenance being carried out on the particular line.
c. Ensure auto–re close selector switch off concerned feeder is kept in “NON AUTO” mode at both the local 400/220 kV S/C lines and in case of D/C lines auto-reclose selector switches of both the circuits at both the ends are kept in “NON AUTO” Mode.
d. In case of 400/220 KV S/C line trips on operation of protection functions during hotline maintenance, line shall not be charged without specific approval of hot line maintenance Incharge.
e. In case of D/C Line, if any one of the circuit trips on protection functions during hotline maintenance, the same shall not be charged without specific approval of hot line maintenance in charge.

INSTRUCTIONS & GUIDELINES ON TRANSFORMER OIL TESTING

VOLUME VII

Doc.No.CE/PM/OS/INST-7

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

Head office- The Mall, Patiala

Oil & Diagnostic Testing Laboratory

OPERATION SERVICES WING
PUNJAB STATE TRANSMISSION CORPORATION LIMITED
LUDHIANA

INSTRUCTIONS & GUIDELINES ON SAMPLING OF OIL FROM OIL FILLED ELECTRICAL EQUIPMENT

DOC.NO.CE/PM/OS/INST-7-A

VOLUME - VII

PART - A

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

HEAD OFFICE THE MALL, PATIALA

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Prepared by Er Sukhjinder S. Virk

AEE 1-4-16 Operation Services

Reviewed by Rajbir S. Walia

Adll S.E 1-4-16 Protection & Operation Services

Recommended by Er Charanjit S. Aulakh

Chief Engineer 5-5-16 P&M

Approved by

23-6-16 BOD's of PSTCL in 37th meeting vide U.O No-1211/BOD/37.21/PSTCL, Dated 8-7-16

CONTENTS

OIL SAMPLING PROCEDURES (REACTORS/TF's

Title : **Sampling of oil from oil filled electrical equipment.**

Scope:

This procedure describes the techniques for sampling oil from oil filled equipment such as power transformer and reactors using stainless steel sampling bottles fitted with valves on both sides.

Purpose:

Gases may be formed in oil filled electrical equipment due to ageing and or due to some internal faults. Operation of the equipment with fault can cause irreparable damage to the equipment. It is extremely important to detect the fault at the earliest or at a very early stage of development. During the early stages of fault, the gases formed will normally dissolve in the oil. By extracting dissolved gases from an oil sample and analyzing the quantity of composition of gases formed, severity of fault can be inferred.

Responsibility-: Maintenance engineer (SSE)

Reference: I.E.C 567- 1992
I.S 9434- 1992

Apparatus:

1. Stainless steel sampling bottle of volume one litre as per IS 9434-1992
2. Oil proof transparent plastic or transparent PVC tubing.
3. A drilled flange in case sampling valve is not suitable for fixing a tube.

Sampling Procedure: (Refer fig. 1)

1. Remove the blank flange or cover (2) of the sampling valve and clean the outlet with a lint free cloth to remove all the visible dirt.
2. If the sampling valve is not suitable for fitting a tube, it may be necessary to use separate flange with a nozzle in the centre, suitable to connect the transparent plastic/PVC tube. (refer fig. 2)
3. Connect a short oil proof plastic tube (around one meter long) at both the ends of the stainless steel sampling bottle (5) as shown in (fig.1)
4. Open the valves (4) & (6) on the SSB (5), allow about 250 ml of oil to flow into the SSB by opening valve (1). Close (4), (6) and (1). Disconnect the tube from the flange and rinse by gently tilting the bottle upside down such that no air bubble is formed inside, during rinsing. Expel this oil into the waste bucket (7) by opening valves (4) & (6).
5. Connect the tube (3) to the flange (2). Hold the bottle in vertical position as shown in fig.(1). Slowly open the equipment sampling valve so that oil flows through the sampling bottle (SSB).
6. After SSB (5) has been completely filled with oil, allow about one to two litres of oil to flow to waste bucket (7), till no air bubbles are seen from the top outlet.
7. Stop the oil flow by closing the first valve (6) and then valve (4) and finally the sampling valve (1).
8. Disconnect the SSB (5) and then disconnect the tube from the equipment & SSB.
9. Label the sample as per annexure I and send the informations as per Annexure-II & III with the normal & critical samples respectively.

Precautions:

1. While sampling, precaution should be taken to deal with any sudden release of oil.
2. Sample should normally be drawn from the bottom sampling valve.
3. Proper closing of both the valves (4) & (6) of the bottle should be ensured immediately after the sample is collected.
4. Due care should be taken to avoid exposure of oil to air while sampling
5. Sampling should be done preferably in a dry weather condition.
6. Sample should be taken when the equipment is in its normal operating condition.
7. Care should be taken to hold the bottle in place inside the container while transporting.
8. Testing should be carried out as early as possible.

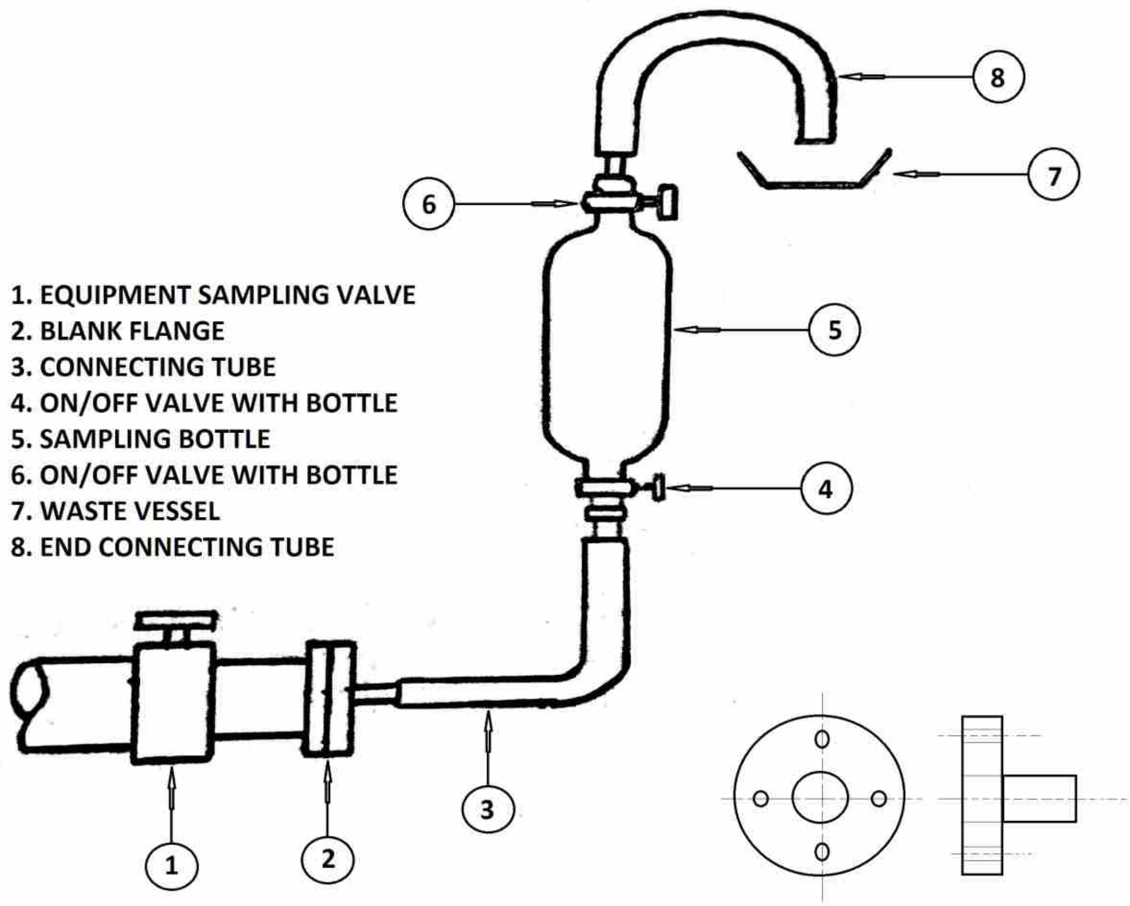


FIGURE - 1

FIGURE -2

Annexure I

LABLING OF THE OIL SAMPLE BOTTLE

i. Bottle Number
ii. Company Name
iii. Name
iv. Equipment Name or ID No.
v. Sampling date

Annexure - II

DETAILS TO BE FURNISHED ALONG WITH THE SAMPLES:

1. Bottle Number
2. Name of Substation
3. Equipment Name / Identification No.
4. Date of sampling
5. Oil temperature
6. Winding Temperature
7. Load (in case of transformer)
   or, Voltage (in case of reactor
8. Date of last filtration
9. Oil top up (if any)
10. Manufacturer's Serial Number
11. Weather condition

In case of New Transformer/Reactor following additional information to be furnished

12. Date of commissioning :
13. MVA/MVAR rating :
14. KV rating :
15. Oil type (*Parafinic / Napthanic*) :
16. Cooling (*ONAN/ONAF/OFAF*) :
17. Type of oil preservation :
    (Air Cell/Diaphragm type/Direct breathing)
18. Make

Annexure-III

1. Voltage Profile for the last six months indicating the maximum and minimum values and % of time voltage more than rated voltage.
2. Loading Pattern (Monthwise) of the transformer for last six months

   oil was changed any time:

MAX. LOAD	CURRENT(A)	MW	MVAR ....
MIN. LOAD	CURRENT(A)	MW	MVAR ....
NORMAL LOAD	CURRENT(A)	MW	MVAR ....

3. Date of last filtration carried out
4. Type of oil preservation system:

   AIR CELL IN CONSERVATOR/DIAPHRAGM IN CONSERVATOR OR DIRECT BREATHING
5. Any Buchholz Alarm/ trip Operation in past : YES/NO
6. Any oil topping up done in the past : YES/NO
7. Whether complete oil was changed any time: YES/NO
8. Present BDV / MOISTURE Content value :
9. Color of Silicagel
10. Date of Commissioning:
11. Manufacturer's Serial Number:

DGA INTERPRETATION PROCEDURES
DOC.NO.CE/PM/OS/INST-7-B

VOLUME - VII
PART - B

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

HEAD OFFICE THE MALL, PATIALA

1.0 INTRODUCTION

1.1 The transformer undergoes electrical or thermal stresses and chemical deterioration when it is in service & this may result in slow evolving of incipient faults in the transformer. The gases formed under abnormal electrical or thermal stresses are hydrogen (H_2), methane(CH_4), ethane(C_2H_6), ethylene(C_2H_4), acetylene(C_2H_2), carbon monoxide(CO), carbon dioxide(CO_2), nitrogen(N_2) and oxygen(O_2) which get dissolved in oil. Collectively these gases are known as FAULT GASES, which are routinely detected and quantified at extremely low level, typically in parts per million (ppm) while conducting Dissolved Gas Analysis (DGA). Commonly used method to determine the content of these gases in oil is using a VACUUM GAS EXTRACTION APPARATUS AND GAS CHROMATOGRAPH

DGA through Head Space Sampler- AGILENT Headspace Sampler & AGILENT Gas Chromatograph

Separate Gas Extraction Apparatus is not required in this chromatograph

1.2 DGA is a powerful diagnostic technique for detection of slow evolving faults inside the transformer by analyzing the gases formed during the fault which get dissolved in the oil. For Dissolved Gas Analysis to be useful and reliable, it is essential that sample taken for DGA should be representative of lot and no dissolved gas should be lost during transportation and laboratory analysis for precise and accurate results. Oil sampling procedure based on IEC 60567 has been standardized in PSTCL and is currently being used by all sub-stations for oil sampling (Doc.No.CE/PM/OS/INST-7A).

Effective fault gas interpretation should clearly tell us whether there is any incipient fault present in the transformer? If there is any problem, what is the nature of fault? Whether the fault is serious and the equipment needs to be taken out of service for further investigation? DGA can identify deteriorating insulation i.e paper & oil, hot spots, partial discharges or arcing. The health of oil is reflective of the health of the transformer itself. DGA analysis helps the user to identify the reason for gas formation & materials involved. It also indicates the urgency required to take corrective action.

1.3 PSTCL proposes to constitute a DGA Committee having representatives from Protection, O&M, & oil lab (i.e ODTL,Ludhiana) to analyse the DGA data of Power Transformers and reactors periodically and to shortlist the critical transformers or reactors requiring urgent attention as per the DGA record notes. The criteria for interpretation of DGA data depends on experience from failed transformers, engineering judgment, transformers with incipient faults, laboratory simulations, inputs by Lab, protection results and statistical studies. The interpretation of DGA results is enhanced by including specific information of a particular transformer and its past DGA history. Since there is no simple “litmus paper “ type of approach with black and white answers for resolving the DGA problems and sometimes it needs to be supplemented by additional specialized tests like FRA, RVM, IDA, winding resistance etc. The DGA committee will consist of-

1. Dy C.E/S.E (P&M) of concerned will be the Chairman
2. A.S.E (P&M) of concerned Division
3. A.S.E (Protection) of concerned Division
4. A.S.E (Incharge of ODTL)
5. SSE of concerned S/S will be the convener & will collect and present all the study results

After exhausting all the remedial channels, committee Chairman will refer the matter to C.E/P&M for approval of Director/T:-

1. If internal inspection of transformer is not possible at site and shifting to crane bay is required or if remedy is not possible without the help of Grid Construction organization.
2. For newly commissioned transformers in warranty period, to involve Design organization.
3. Wherever help of manufacturer is required to analyse the fault.
4. Wherever transformer has outlived its life and it is dangerous to keep it in-service.

2.0 INTERPRETATION METHODS

Many techniques for the detection and measurement of gases have been established but it must be recognized that analysis of these gases and interpretation of their significance is not a science, but an art. Their presence and quantity are dependent on equipment variables such as type, location and temperature of the fault; solubility and degree of saturation of various gases in oil; the type of oil preservation system; the type and rate of oil circulation; the kinds of material in contact with the fault; and finally, the variables associated with sampling and measuring procedures. Because of the variability of acceptable gas limits and the significance of various gases and their formation rates, a consensus is difficult to arrive. The principal obstacle in the development of fault interpretation by exact methods or formulas is the lack of positive correlation of the fault-identifying gases with actual faults in transformers. Hence, exact causes or conditions within transformers may not be inferred from the various procedures. The continued application of the rules and limits in this guide, accompanied by actual confirmation of the causes of gas formation, will result in continued refinement and improvement in the correlation of the rules and limits for interpretation.

Following interpretation methods will be general guidelines to be used by DGA committee for the purpose of identifying critical units in P&M organization of PSTCL:

Individual Fault Gases Acceptable Limits

To ensure that a transformer (with no previous dissolved gas history) is behaving normal, the DGA results are compared with the gassing characteristics exhibited by the majority of similar transformers. As the transformer ages and gases are generated, the normal levels for 90% of a typical transformer population can be determined. From these values and based on experience, acceptable limits or threshold levels have been determined as given in table 1 below:

Table 1: Range of 90% typical concentration values (all type of transformers) As per IEC 60599/1999

Transformer Sub Type	FAULT GASES (in µ l/l)						
	H2	Ch4	C2H6	C2H4	C2H2	CO	Co2
No OLTC	60-150	40-110	50-90	60-280	3-50	540-900	5100-13000
Communicating OLTC	75-150	35-130	50-70	110-250	80-270	400-850	5300-12000
NOTE 1- The values listed in this table were obtained from individual networks. Values on other networks may differ.							
NOTE 2- "Communicating OLTC" means that some oil and/or gas communication is possible between the OLTC compartment and the main tank or between the respective conservators. These gases may contaminate the oil in the main tank and affect the normal values in these types of equipment. "NO OLTC" refers to transformers not equipped with an OLTC, or equipped with an OLTC not communicating with or leaking to the main tank.							
NOTE 3- In some countries, typical values as low as 0.5µ l/l for C_2H_2 and 10 µl/l for C_2H_4 are also considered.							

2.2 Total Dissolved Combustible Gas (TDCG) limits

The severity of an incipient fault can also be evaluated by the total dissolved combustible gases present. Limits for TDCG are given in table-2 below. An increasing gas generation rate indicates a problem of more severity and therefore we should opt for shorter sampling frequency for close monitoring of fault gases.

Table 2: Action based on TDCG limits (IEEE standard C: 57.104-1991)

TDCG LIMITS, ppmACTION	ACTION
< or = 720	Satisfactory operation, unless individual gas acceptance values are exceeded
721-1920	Normal ageing/slight decomposition, trend to be established to see if any evolving incipient fault is present.
1921-4630	Significant decomposition, immediate action to establish trend to see if fault is progressively becoming worse.
>4630	Substantial decomposition, gassing rate & cause of gassing should be identified and appropriate corrective action such as removal from service may be taken.

NOTE: TDCG value includes all hydrocarbons, CO & H_2 but does'nt include CO_2 which is not a combustible gas.

2.2.1 The relationship of evolved gas with temperature and type of fault is shown in table 3 & 4:

Table 3: Relationship of evolved gases with temperature

Relationship with temperature	
Methane (Ch4)	> 120° C
Ethane (C2H6)	> 120° C
Ethylene (C2H4)	> 150° C
Acetylene (C2H2)	> 700° C

Table 4: Associated faults with different fault gases

Associated faults with different gases
Oil Overheating : C_2H_4, C_2H_6, CH_4
Traces of acetylene with smaller quantity of Hydrogen may be evolved
Overheated Cellulose : CO & CO_2
Large quantity of Carbon-Di-Oxide (CO_2) and Carbon Monoxide (CO) are evolved from overheated cellulose. Hydrocarbon gases such as Methane and Ethylene will be formed if the fault involves an oil impregnated structure.
Partial discharge in Oil (Corona): H_2, Ch_4
Ionization of high stressed area where gas/vapour filled voids are present or 'wet spot' produces hydrogen and methane and small quantity of other hydrocarbons like ethane and ethylene. Comparable amounts of carbon mono-oxide and di-oxide may result due to discharges in cellulose.
Arcing in Oil : C_2H_2, H_2
Large amount of hydrogen and acetylene are produced with minor quantities of methane and ethylene in case of arcing between the leads, lead to coil and high stressed area. Small amounts of carbon mono-oxide and di-oxide may also be formed, if fault involves cellulose.

It is well known that there is no definite DGA interpretation method in the world, which can indicate the exact location and type of the fault. The different interpretation methods only provide guidelines to take an engineering judgment about the equipment. Apart from the DGA results various other factors are taken into consideration such as past history of the transformer, grid condition, loading patterns etc.

2.3 INTERPRETATION TECHNIQUES AS PER STANDARDS

Several well- known methods/criteria (like Rogers ratio, IEC 60599, Dornenberg, Key gas etc are being used by utilities to interpret the DGA results, based mostly on the relative concentrations (i.e. ratios) of the constituent gases. These ratios generally give an indication of the existence and nature of a problem.

Typical faults in power transformers

Sr No	Fault	Examples
1	Partial discharges	Discharges in gas-filled cavities resulting from incomplete impregnation, high-humidity in paper, oil super saturation or cavitations and leading to X-wax formation.
2	Low energy discharges	Sparking or arcing between bad connections of different or floating potentials, 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, oil break downl, selector breaking current.
3	High energy Discharges	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.
4	Thermal fault t<300 °C	Overloading of the transformer in emergency situations, Blocked/restricting oil flow in windings, stray flux in damping beams of yokes.
5	Thermal fault 300°C < t < 700 °C	Defective contacts between boiled connections (particularly between aluminium, busbar), gliding contacts, contacts within selector switch (pyrolitic carbon formation), connections from cable and draw-rod of bushings. Circulating currents between yoke clamps & bolts, clamps & laminations. In ground wiring, defective welds or clamps in magnetic shields, abraded insulation between adjacent parallel conductors in windings.
6	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 etc

Typical faults detectable through DGA in transformers as given above.
Please note: 1. X wax formation comes from Paraffinic oils (paraffin based).
2. The overheating problem in the table says "over 700°C." Recent studies have found that acetylene traces can be produced at 500°C also, which is not reflected in this table. There are transformers that show small traces of acetylene which is probably not active arcing but is the result of high temperature thermal faults. It may also be the result of one arc, due to a nearby lightning strike or voltage surge.

3. A bad connection at the bottom of a bushing can be confirmed by comparing infrared scans of the bushing tops with a sister bushings. When loaded, heat from a poor connection at the bottom will migrate to the top of the bushing, which will display a markedly higher temperature. If the top connection is checked and found tight, the problem is probably a bad connection at the bottom of the bushing.
Trend Analysis
Transformers from same manufacturers and of same type some time exhibit almost same specific

patterns of gas evolution which subsequently slow down (or plateau's) & they are called **Fingerprints or Normal characteristics**, which are characteristic to the transformer and do not represent an incipient fault condition.

When a possible incipient fault condition is identified for first time, it is advised to determine gas formation trend with subsequent analysis giving information, such as, which gas/gases are are being generated andwhat is the rate of generation of these gases. The level of gases generated in subsequent analysis provides a baseline from which future judgment can be made. In the trend examination of key gases, TDCG, rate of gas generation and fingerprints (of normal trends) of particular transformer should also be considered.

The rate of gas generation is a function of load supplied by the transformers and this information is vital in determining the severity of fault condition and decision of removal of the equipment from service for further investigation. Two methods have been suggested in literatures for assessing the gassing rate:

- Change of concentration of gas in ppm
- Determination of actual amount of gas generated

General guidelines for rate of gas generation to remove a transformer from service are 100ppm/day.

Action Recommended Based on Review of DGA for Critical Transformers

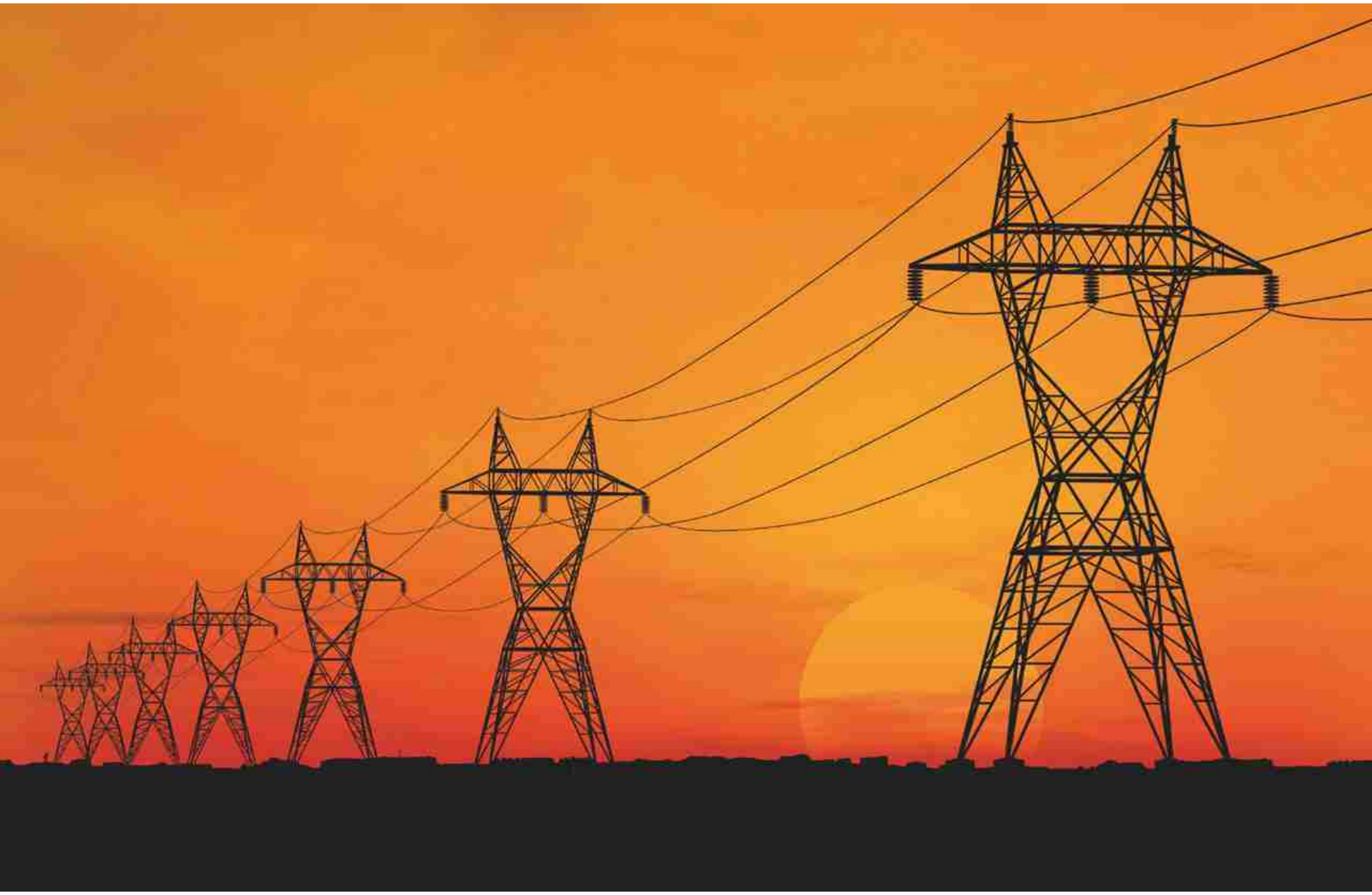
All the in-service transformers and reactors above (50 MVA capacity) in PSTCL are to be sampled for DGA on 6-monthly basis and other capacities are to be sampled on yearly basis. DGA data obtained after carrying out DGA test is first to be reviewed at the laboratory. Based on the results obtained, the oil laboratory shall decide on the subsequent frequency of sampling. Frequency can also be further revised during the review by DGA Committee. The frequency of sampling can be changed (increased or decreased) depending upon the trend of fault gases, rate of gas increase etc. based on various standards being followed. The various actions that can be proposed are as follows:

1. If there is sudden rise in fault gases which is not in conformity with earlier trend, a confirmatory oil sample is required to be sent to laboratory on urgent basis to confirm the trend.
2. In case of violation of any gas, the frequency may be increased suitably for close monitoring.
3. In case of detection of arcing (normally associated with C_2H_2), severe overheating or partial discharges etc, a decision regarding internal inspection can be taken.
4. In case of certain old transformers/reactors which are running under full load, a decision to increase the frequency of oil sampling can be taken on case to case basis.

INSTRUCTIONS ON MAINTENANCE OF EHV TRANSMISSION LINES

VOLUME VIII

Doc.No.CE/PM/OS/INST-8



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GENERAL GUIDE LINES FOR MAINTENANCE OF TRANSMISSION ILNES:-

(AS PER SCHEDULE ALREADY INVOGUE/ FOLLOWED IN ERSTWHILE PSEB)

SN	DESCRIPTION	SD/ WSD	PERIODICITY				
			LINE STAFF	JE/ TL	AEE/ TL	Sr XEN	S.E
1.	TO CHECK THE NUMBER PLATES/ DANGER PLATES/ LADDER BOLTS/ ANTI-CLIMBING DEVICES/ PHASE PLATES/ CIRCUIT NUMBER PLATES ETC	WSD	Q	HY	Y	60 TOWERS/ MONTH	30 TOWERS/ MONTH
2.	TO CHECK VERTICLE AND HORIZONTAL CLEARANCES OF EXISTING AND UP-COMING TELEPHONE LINES, BUILDINGS, OTHER LT/ HV/ EHV POWER LINES, RAILWAY CROSSINGS, ROAD CROSSINGS, BRIDGES ETC FROM THE EHV TRANSMISSION LINES	WSD	Q	HY	Y	DO	DO
3.	TO CHECK BEIRD NESTS, IF ANY	WSD	Q	HY	Y	DO	DO
4.	TO CHECK BRICK KLIN OR POLLUTING INDUSTRIES NEAR THE LINE	WSD	Q	HY	Y	DO	DO
5.	TO CHECK GROUND CONDITIONS OF TOWERS	WSD	Q	HY	Y	DO	DO
6.	TO CHECK ANY DAMAGE OF MAIN AND OFF SHOOT STUBS AND RETAINING WALLS	WSD	Q	HY	Y	DO	DO
7.	TO CHECK MAIN STUBS/ OFF SHOOTS AND MEMBERS OF TOWER AGAINST CORROSION	WSD	Q	HY	Y	DO	DO
8.	TO CHECK MISSING MEMBERS, NUTS & BOLTS OF TOWERS	WSD	Q	HY	Y	DO	DO
9.	TO CHECK DISC INSULATORS AND SUSPENSION CLAMPS	WSD	Q	HY	Y	DO	DO
10.	TO CHECK PROPER POSITIONING OF DAMPERS/ CLEAT & TO SEE IF ANY DAMPER/CLEAT IS MISSING	WSD	Q	HY	Y	DO	DO
11.	TO CHECK BIRD GUARDS	WSD	Q	HY	Y	DO	DO
12.	TO CHECK CONDITION OF JUMPERS AND DEAD END CLAMPS WITH BINOCULARS	WSD	Q	HY	Y	HY	Y
13.	TO CHECK WILD GROWTH/TREES/ SHRUBS NEAR OR UNDER THE LINE	WSD	Q	HY	Y	30 TOWERS/ MONTH	30 TOWERS/ MONTH
14.	TO CHECK EARTH BONDS AND EARTH DAMPERS	WSD	Q	HY	Y	DO	DO
15.	TO CHECK THE CONDITION OF CONDUCTOR JOINTS WITH BINOCULARS	WSD	Q	HY	Y	HY	Y
16.	TO CHECK THE CONDITION OF EARTH WIRE & EARTH JOINTS WITH BINOCULARS	WSD	Q	HY	Y	30 TOWERS/ MONTH	30 TOWERS/ MONTH
17.	NIGHT PATROLLING IN MAY & OCTOBER	WSD	HY	HY	HY	NA	NA

SN	DESCRIPTION	SD/ WSD	PERIODICITY				
			LINE STAFF	JE/ TL	AEE/ TL	Sr XEN	S.E
18.	TO CHECK DEAD END CLAMPS & CONDUCTOR JOINTS WITH THERMOVISION CAMERA	WSD	NA	NA	NA	Y (HOTLINE)	10% - 20% RANDOM CHECK
19.	TO CHECK DEAD END CLAMPS & CONDUCTOR JOINTS WITH THERMOVISION CAMERA AT ALL RAILWAY CROSSINGS	WSD	NA	NA	NA	Q (HOTLINE)	10% - 20% RANDOM CHECK
20.	TO CHECK DEAD END CLAMPS & CONDUCTOR JOINTS WITH THERMOVISION CAMERA AT ALL NATIONAL HIGHWAY CROSSINGS	WSD	NA	NA	NA	H (HOTLINE)	10% - 20% RANDOM CHECK
21.	TO SCAN WITH FAULT LOCATER	SD	Y	Y	SOS	SOS	SOS
22.	TO PATROL THE LINE THE LINE DURING THE MONTH OF MAY/JUNE TO CHECK THE SAG OF CONDUCTOR	WSD	NA	HY	Y	NA	NA
23.	EARTH RESISTANCE OF TOWERS	WSD	NA	2Y	2Y	NA	NA
24.	TO CHECK VULNERABLE TOWERS (ESPICIALLY BEFORE MONSOON)	WSD	Q	HY	HY	Y	SOS
25.	BREAKDOWN OF CONDUCTOR	SD	SOS	SOS	SOS	SOS	SOS
26.	DAMAGING OF INSULATOR DISCS	SD	SOS	SOS	SOS	SOS	SOS
27.	TO ATTEND HOT POINTS INTIMATED BY Sr XEN/HOTLINE	SD	SOS	SOS	SOS	SOS	SOS
28.	TO MAKE PATHS TO REACH TOWERS LOCATED IN JUNGLES OR HILLY AREAS (BEFORE MONSOON)	WSD	Y	NA	NA	NA	NA
29.	TO ATTEND HOT POINTS OF WAVE TRAPS (PLC)	SD	SOS	SOS	SOS	SOS	SOS
30.	TO CHECK DISPLACEMENT OF DAMPERS & TO SET RIGHT IT	SD	Y	Y	NA	NA	NA
31.	TO REMOVE MUD FROM THE MUFFS & SHOOTS OF TOWERS	WSD	Y	Y	NA	NA	NA
32.	TO CHECK CLEARANCE OF CONDUCTOR AT CROSSINGS IN HOT SUMMER SEASON	WSD	Y	Y	Y	SOS	SOS
33.	TO CLEAN DRAINS OF TOWERS	WSD	Y	Y	NA	NA	NA
34.	TO REPAIR CONDUCTOR DAMAGED DUE TO KITE STRINGS	SD	SOS	SOS	SOS	SOS	NA

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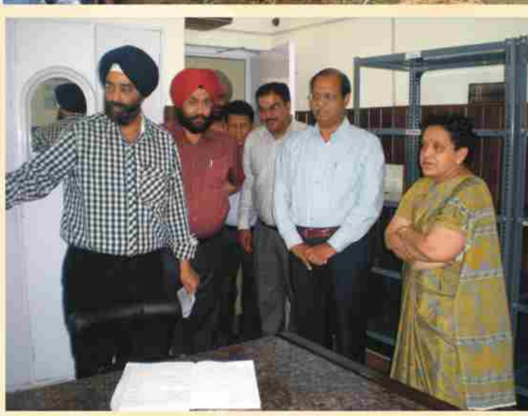



400/220 KV GRID SUB-STATION, CHAKVENDAL(NAKODAR)


CONTROL ROOM

Award Winning Sub-Stations of PSTCL

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

OPERATION SERVICES WING

PUNJAB STATE TRANSMISSION CORPORATION LIMITED

Head Office- The Mall, Patiala