

**Karnataka Power Transmission
Corporation Limited**



MAINTENANCE SCHEDULE
for
Sub-Stations

Maintenance Schedule For Sub-Stations	Page No.	03
	Revisions	RO

P R E F A C E

The Sub-stations in a power System are important links between generation and distribution of power. Any breakdown in a substation not only causes interruption but also results in additional expenditure towards the repair/replacement of the failed equipment. Apart from this, it also results in loss of revenue due to interruption.

Generally causes of failure of equipment is inadequate/improper maintenance due to lack of guide lines for maintenance of equipment. With this in view it was proposed to bring out a manual giving guidelines for maintenance of Sub-stations indicating details of maintenance works to be carried out on the various equipments and the frequency.

A Working group consisting of the following members was constituted for the preparation of this manual:

- | | |
|--------------------------------|---|
| 1. Er. Ganapathy Madyastha | Exe. Engineer, (Ele), Hoody Division. |
| 2. Er. Sudeendra Kumar M. | Exe. Engineer, (Ele), Projects, Bangalore. |
| 3. Er. Vasantha Kumar B. | Exe. Engineer, (Ele), D.G. Plant, Yelahanka. |
| 4. Er. Keshava Murthy. R. | Exe. Engineer, Ele., MRT, (South), Bangalore. |
| 5. Er. Ramesh B.M. | Exe. Engineer, (Ele), R&D, Bangalore. |
| 6. Er. Katagihallimath K.S | Exe. Engineer, Ele., R&D, Bangalore. |
| 7. Er. Satyanarayan K.R. | Asst. Exe. Engineer, Ele., PFC, ADB, Bangalore. |
| 8. Er. Girish | Asst. Engineer, Ele., Hoody Station, Bangalore. |
| 9. Er. Shiva Kumar | Asst. Engineer, Hebbal Station, Bangalore. |
| 10. Er. Ghanti P.M. (Convener) | Asst. Exe. Engineer, R&D Center. |

Karnataka Power Transmission Corporation Limited

Table of Contents

Sl. No.	Description	Page No.
1.	Foreword	2
2.	Preface	3
3.	Mission Statement	5
4.	Index	6
5.	Revision Record	7
6.	Daily Maintenance Schedule	8
7.	Quarterly Maintenance Schedule	8
8.	Yearly Maintenance	11
9.	Details of Transformer Maintenance	15
10.	Details of Maintenance for CTs, PTs, and CVTs	24
10.	Details of Maintenance for Battery Set and Battery Charger	27
11.	Maintenance of D. G. Sets, Oil Filter Sets, Compressors, and Over Head Cranes	35
12.	List of DO's	37
13.	List of DON'Ts	38
14.	List of T and P Articles	39
15.	List of Consumables	41
16.	Bibliography	49

33	Sira	Tumkur	Tumkur	66KV	Madhugiri-1	LILO	serviced	10-06-2004	Seimens
34	Sira	Tumkur	Tumkur	66KV	HiriYur	LILO	serviced	10-08-2004	Seimens
35	Sira	Tumkur	Tumkur	66 KV	Kallambella	LILO	Serviced	NA	EE
36	Sira	Tumkur	Tumkur	66KV	Buckkapatna	LILO	serviced	10-08-2004	Seimens
37	Kallambella	Tumkur	Tumkur	66KV	Sira	Tail End	Not serviced	NA	ER
38	Bukkapatna	Tumkur	Tumkur	66KV	Sira	Tail End	Serviced	23.1.2008	ER
39	Chikkatottala Kere	Tumkur	Tumkur	66kv	AN Halli	Tail End	Not serviced	NA	ER
40	Guligenahalli	Tumkur	Tumkur	66KV	Sira	LILO	Serviced	23-07-2004	ABB
41	Guligenahalli	Tumkur	Tumkur	66KV	Madhugiri	LILO	Serviced	23-07-2004	ABB
42	Urdigere	Tumkur	Tumkur	66KV	Kolala	LILO	Serviced	19.6.2007	ER
43	Urdigere	Tumkur	Tumkur	66KV	Dabaspet	LILO	Serviced	19.6.2007	ER
44	Ungra	Tumkur	Tumkur	110KV	KG Temple	LILO	Serviced	11.3.2008	Sifang
45	Banddihalli	Tumkur	Tumkur	66KV	Incoming Line	LILO	Serviced	25/6/08	Sifang
46	Banddihalli	Tumkur	Tumkur	66KV	Outgoing Line	LILO	Serviced	25/6/08	Sifang
12	Hosakere	Tumkur	Tumkur	66KV	Madhugiri	LILO	Serviced	NA	ER
13	Hosakere	Tumkur	Tumkur	66KV	Payagada	LILO	Serviced	NA	ER
63	Mallasandra	Anch	Tumkur	66KV	Anchepalya	Tail End	Not Serviced	NA	ABB
64	Hebbur	Anch	Tumkur	66KV	Anchepalya	Tail End	Serviced	29.3.2004	Seimens
65	Kumigal	Anch	Tumkur	66KV	Anchepalya	Tail End	Not Serviced	NA	ABB
66	Anchepalya	Anch	Tumkur	66KV	Anchepalya - 1	LILO	Serviced	NA	EE
67	Anchepalya	Anch	Tumkur	66KV	Huliyurdurga	LILO	Serviced	NA	ER
68	Anchepalya	Anch	Tumkur	66KV	Hebbur	LILO	Serviced	NA	ER
69	Anchepalya	Anch	Tumkur	66KV	Kadur	LILO	Serviced	NA	ER
70	Anchepalya	Anch	Tumkur	66KV	Anchepalya - 2	LILO	Serviced	NA	ER

Maintenance Schedule For Sub-Stations

Page No. 08

Revisions RO

MAINTENANCE SCHEDULE FOR SUB - STATIONS

DAILY

- 1) General cleaning of control & Relay panels, LT, AC, DC panels, Battery Charger & Equipments in Control Room.
- 2) Inspection of Battery Charger for Healthy Charging of Batteries, Electrolyte level in Batteries, etc. Check readings of Pilot Cells.
- 3) Visual Inspection of Oil Level in HV-Bushing, Main and OLTC Conservators, OLTC Counter Readings, Silicagel Breathers. Silicagel Breathers shall be reconditioned if found necessary.
- 4) Cleaning of Out-Door Yard, Earth Electrode Pits etc.
- 5) Operation of D.G. Set if provided & to run for 10 minutes for its Battery Charging.
- 6) Inspection of Level & Condition of Oil in Air Compressors (Once in a Week).
- 7) Inspection of Level of Electrolyte & Top up with Distilled Water if necessary (Once a Week).
- 8) Cleaning & Applying Petroleum Jelly for battery terminals (Monthly).
- 9) Recording the No. of OLTC Operations in the Day and recording cumulative No. of operations.
- 10) Review of Log Books/Reports of Shift Engineers.
- 11) Inspection of ODY for any Arcing/Oil Leakages.

QUARTERLY

A) TRANSFORMERS :-

- 1) Cleaning of all HV/LV Bushing, Checking Bushing Oil Level.
- 2) Checking of Cooling Fans, Pumps, Oil Coolers wherever provided, Auto Start, Local/Remote Start/Stop.
- 3) Checking of Oil Leaks if any and rectification.
- 4) Checking of OLTC and its drive mechanism for Local/Remote Operation and lubrication. (Once in 6 months).
- 5) Air Release in Main Tanks, Bucholtz Relays, Bushing, etc.
- 6) a) Testing of Oil for BDV (Once in 6 Months) Main Tank.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No.	09
Revisions	RO

5)b) BDV of OLTC Oil Yearly or 5000 Operations whichever is earlier. Oil to be replaced if BDV < 24 KV (2.5 mm gap 12.7 mm sphere.)

7) Measurement of IR Value's with Polarisation Index for records.

8) Checking of Transformer Alarm Circuits.

9) Transformer Neutral Earth Connections at both ends & Tightning of Connectors.

B) BREAKERS :-

1. Check Compressed Air and Gas Pressures if any Leaks Rectify (In each pole for 220-KV Breakers)

2. Checking of Oil Leaks & Rectification. In case of BOCB, MOCB's Hydraulic Operated Breaker Mechanism Topping up if necessary.

3. Checking of Auto Start/ Stop of Compressors/Pumps.

4. Checking of Alarm & Lock Out for Air/Gas.

5. Recording No. of Operation of Counters.

6. Lubrication of Operating & Linkage mechanisms as well as Trip & Close mechanism.

7. Changing of Compressor Oil every Six Months.

8. Tightning of Control Circuit terminals every Six months.

9. Checking of Breaker status indicator (Mechanical).

10. Tightning of clamps, jumps connections, Breaker assembly frame, foundation and structural bolts (Quarterly).

11. Tightning of Auxiliary Switches (Half Yearly).

12. Check Closing and tripping of Breaker through relays (Quarterly)

13. Meggering of Breakers (Across & Phase to ground) Half Yearly

C) CT's PT's CVT's :-

1) Checking for Oil Leaks & Oil Level.

2) Visual Inspection of HF Point Bushing for any damage & Earthing if not used for PLCC.

3) Measurement of Voltages at Marshalling Box & Control Room in case of PT & CVT.

4) Cleaning.

Maintenance Schedule For Sub-Stations	Page No.	11
	Revisions	RO
<p><u>YEARLY</u></p> <p>A) <u>TRANSFORMERS</u> :-</p> <ol style="list-style-type: none"> 1) Testing of Main Tank Oil for BDV, PPM etc. as per IS - 1866 (At Research Centre, Bangalore). BDV of OLTC Oil Yearly or 5000 Operations whichever is earlier. Oil to be replaced if BDV < 24 KV (2.5 mm gap, 12.7 mm sphere) 2) Check for Transformer Alarms, Trip Circuit for Buchholtz Relays, PRV, OLTC Diverter etc. 3) Check Oil Level in OTI, WTI Sensor Pockets 4) Tan - Delta and Capacitance Measurement (In association with R & D Centre) of bushings and winding. 5) Check Operation of Buchholtz Relay by external Air Injection for Alarm & Trip. 6) Check the Contactors for OLTC, Fan, Pump Control & Tightning of Wiring & Vermin Proof of Marshalling Box. 7) Oil Temperature reading comparison with external Thermometer in OTI Pocket and Calibration of Oil Temperature Indicator (OTI) & Winding Temperature Indicator (WTI). 8) Checking Arcing Horn Gaps of Bushings. <p>B) <u>H.V. BREAKERS</u> :-</p> <ol style="list-style-type: none"> 1) C.B. Timing Checks (In association with MRT/Research) 2) Contact Resistance (In association with MRT/Research) 3) Pole Discrepancy Relay Check including Checking of Alarm. 4) Operation of Lock Out Checks. 5) Measurement of Tan - Delta & Capacitance (Research & Development Centre) 6) Earth Connections Check. 7) Detailed CheckUp of Breaker Operating Mechanism & Compressors. 		
Karnataka Power Transmission Corporation Limited		

Maintenance Schedule For Sub-Stations

Page No. 12

Revisions RO

C) CTs, PTs, CVTs :-

- 1) Check Earth Connections.
- 2) Paint Rusted Metal Portion.
- 3) Measure IR Values for Record & Comparison with Previous Values.
- 4) Checking of Primary Jumper Clamps & Primary Connections in C.T's.
- 5) Vermin Proof of Marshalling Box.

D) LIGHTNING ARRESTORS :-

- 1) Cleaning of L.A. Stacks.
- 2) Observe any Cracks.
- 3) Check earth connections at L.A. & Electrode, Line Jump connections.
- 4) Determine IR Values for comparison with earlier values.
- 5) Check for Leakage Current and Surge Counter.

E) OUT DOOR YARD :-

- 1) Check tightness of PG / T-Clamps.
- 2) Cleaning of Bus Bar String Insulators.
- 3) Check for Hot Spots using Thermovision Camera (Available with Hot Line Sub. Division).
- 4) Check Damage to ACSR Conductor in Jumps (Aluminum Strands not cut).
- 5) Apply Petroleum Jelly and tightening of Spacers in case of double conductor bus.
- 6) In case of Rigid bus, tightening of clamps and expansion joints.

F) GENERAL :-

- 1) Cleaning of Auxillary Transformer, Checking of HV/LV Connections, Neutral & Earth Electrode.
- 2) Checking of IR Values, Silicagel, BDV of Oil, Top-up Oil if necessary. (Auxillary transformers).
- 3) Checking of DC Emergency Lamps in Control Room.
- 4) Tightning of Cable Connections, Breakers, Checking LT-AC Breaker Operation, Vermin Proof for Cable Entry.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No. 13

Revisions RO

- 5) Tightning of Cable Connections, Cleaning of Bus Bar, Panels, Vermin Proof of Cable Entry in DC Panels.
- 6) Painting of Transformers, Breakers, Structures etc. Once in 5 years
- 7) Inspection/Overhauling of OLTC in Transformers 25,000 Operations or 2 years, whichever is earlier, with oil replaced or as recommended by the Transformer Supplier.
- 8) Replenishing of Fire Extinguishers after every usage or if not operated, Once in a Year.
- 9) Painting of Name Plates and Phase Indications and Bay Indications and Earth Electrodes.
- 10) Earth Resistance testing of all equipments specially of Transformer Neutral and L.A.'s.
- 11) Calibration of relays and meters (by MRT) Yearly
- 12) Wherever cranes are provided in the repair bays, check the operation of the crane (Mechanical and Electrical System) as per the recommendation of the manufacturer).

MAINTENANCE SCHEDULE OF 11 KV SWITCH GEAR

- 1) Vermin Proof of all Cable Entry — Half Yearly
- 2) Earthing of Switch Gear & Pot Heads-CT, PT — Yearly
- 3) Bus Bar Cleaning, IR Values & tightening of Bus Bar Connections — Yearly
- 4) Oil, Main & Auxillary Contacts checking & Replacement if necessary whenever required in MOCB, BOCB — or at least once in 6 month
- 5) Cleaning of Mechanism & Lubricating, Tightening of all Bolts & Nuts—Half Yearly
- 6) Check Healthiness of VCB — Monthly (Booklet to be referred for VCB)
- 7) Relay Tripping of Breakers & Spring Charging & annunciation Checks—Quarterly
- 8) Tightness of Cable Connection and IR Values of Cables — Half Yearly
- 9) Check for Earthing of Cable Sheath at D.P. Structure and connected Electrodes (in case of only 3 core cables)

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations	Page No.	14
	Revisions	RO

- 10) Check for Earth connections of single core cable sheath either at Transformer end or Switchgear end (to be earthed at only one end).
- 11) Calibration of Relays and Meters (To be done in association with MRT).
- 12) Testing of SF₆ Gas Pressure Switches.
- 13) Applying Petroleum Jelly for Auxiliary Switches.

Maintenance Schedule for Sub-Stations

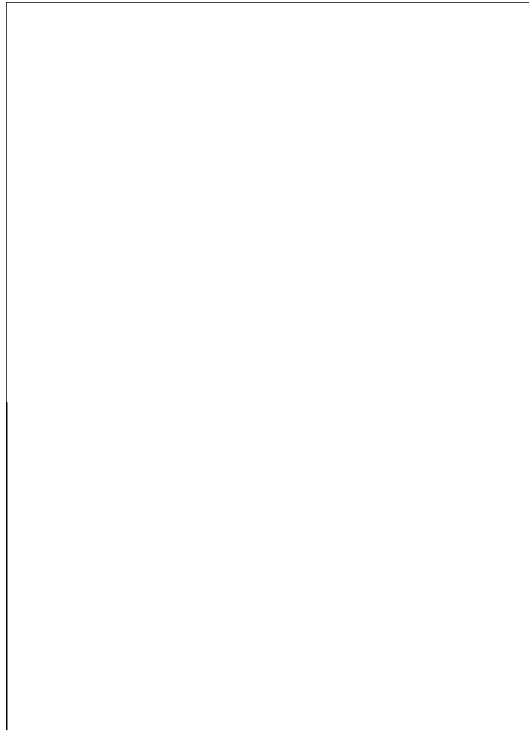
Page No. 15

Revisions RO

DETAILS OF TRANSFORMER MAINTENANCE:

S.No.	Items to be Inspected	Inspection	Action Required
A	B	C	D
1	Oil level.	<ul style="list-style-type: none"> a) Check Oil Level in Conservator as shown by Magnetic Oil Gauge with reference to Oil Temperature. b) Check Oil Level in OLTC Conservator also. c) Check Oil Level in Sight glass of the Bushing. 	<p>Top-up with Good New Tested Oil if Oil level is Low.</p> <p>If Low, Investigate and take Remedial Action. Top up Oil if Bushing is not Hermetically sealed.</p>
2	Testing of Oil	<ul style="list-style-type: none"> a) Check for BDV, min. Values as per IS: 1866 (2.5 mm gap) <ul style="list-style-type: none"> i) 145 KV and above - 50 KV ii) 72.5 - 145 KV - 40 KV iii) Below 72.5 KV - 30 KV b) Check for BDV of OLTC Oil Min. Value of BDV: 24 KV c) Oil Samples to be sent to R & D Centre Once a year for test as per IS 1866 	<p>Take action to restore quality of Oil, procedure for testing BDV as per Appendix - A</p> <p>Take action to restore BDV of Oil of OLTC to 50 KV. Sampling Method as per Appendix - B</p>
3	Reliefvent.	Check for damage to Diaphragm	Replace if damaged.
4	Breather	<ul style="list-style-type: none"> a) Check Oil Level in Cup b) Check Colour of Silicagel c) Ensure that the Air Passage is free in the Breather. 	<ul style="list-style-type: none"> a) Fill Oil upto Mark. b) Reactivate or Replace if the Colour is White or Pink. c) Clean Air Passage if blocked and use only Large Size Crystals(3 to 5mm) d) Colour of good Silicagel is Blue.

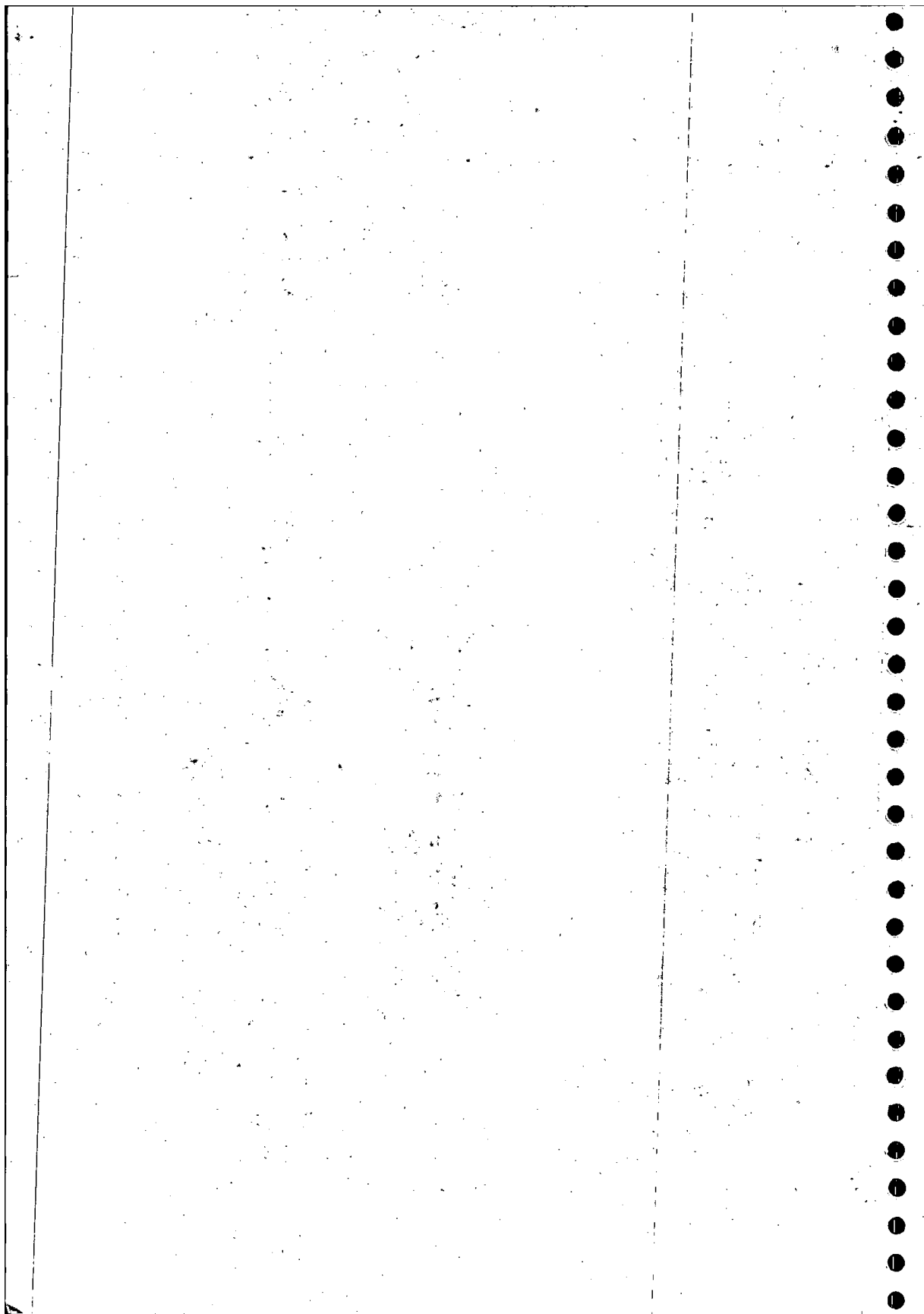
Karnataka Power Transmission Corporation Limited



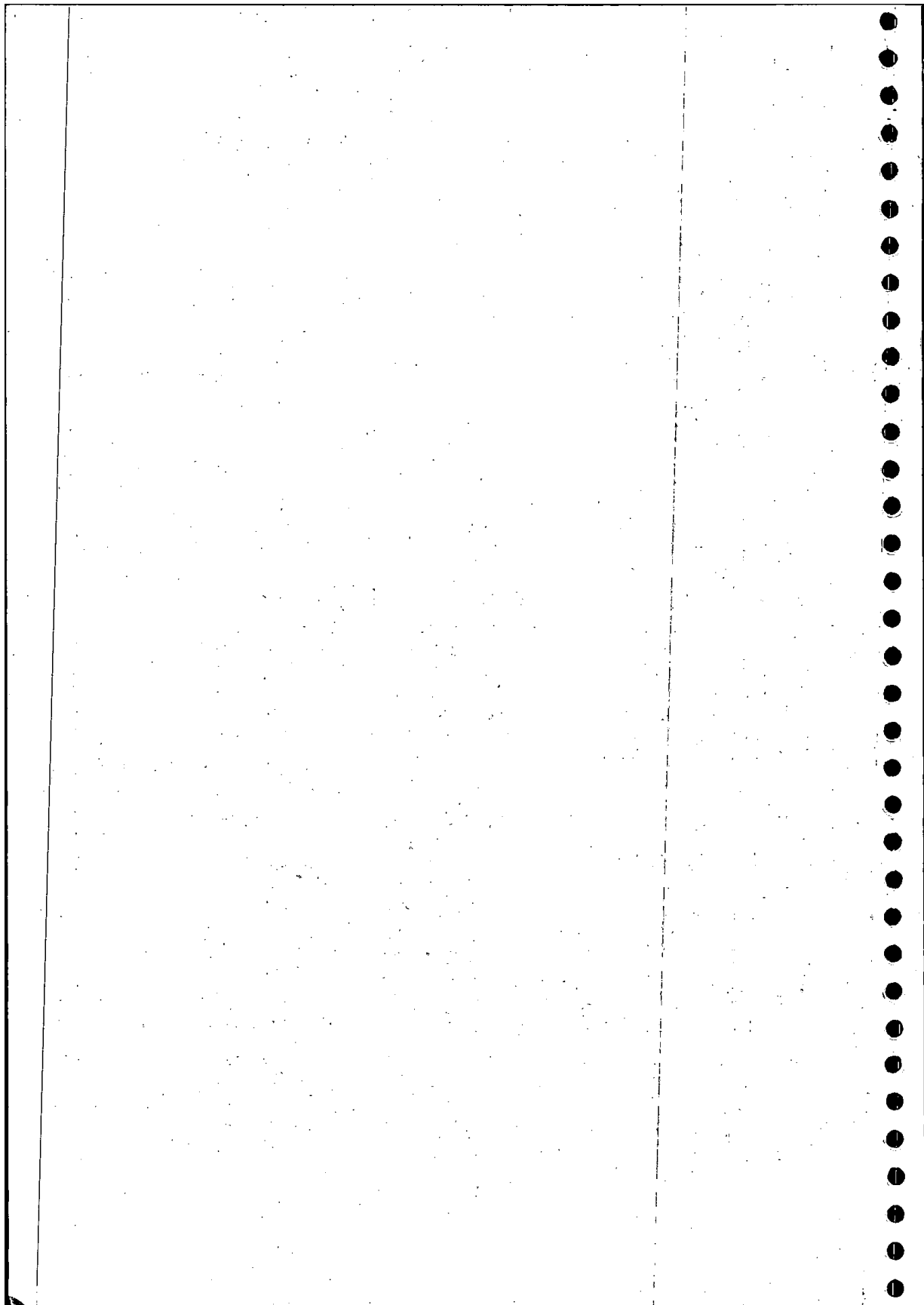
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

Maintenance Schedule for Sub-Stations				Page No. 16
A	B	C	D	Revisions RO
5	OLTC Counter	a) Check Reading of Counter and Verify its Working.	Rectify/Replace if Faulty. Keep daily record of No. of Tap Changer Operation with cumulative total.	
6	Jumper Connection and Earthing	a) Check for Tightness of Clamps and Damage to Conductor & Earthing Leads	Take Remedial Measures	
7	Bushings	a) Examine for Cracks/Damages and Dust.	a) Clean/Replace if necessary	
8	OLTC Motor Drive and Control Panel	a) Lubricate Bearings, Cleaning, Check Gear Box Oil Level. b) Check Operation of Limit Switches Sequence Switches with Transformer in off condition	a) Top up Oil in Gear Box. Clean Contactors etc. b) Rectify defect in Electrical Operation. Loose Wiring to be tightened.	
9	Cooler Fan and Pump	Lubricate Bearings examine Contactor Contacts	Replace Contactor if Contacts are burnt.	
10	IR & PI Values	Compare with previous Values	See Note No - 2 on Page -23	
11	Trip Relays and Alarm Relays	a) Check Operation of Auxiliary Relay, Breaker Tripping of Buchholz Relay, (Main & OLTC), PRV, Oil and Winding Temperature (Trip) by Injecting Air and Artificially actuating the Temperature Indicator respectively. b) Check Operation of Annunciation for Oil/Winding Temperature by actuating the Temperature Indicators and MOG by shorting. c) Check Auto Start of Fans and Pumps through temperature indicator and also observe whether operates at the set temperature	Attend to defect if any. Refer Note-3 on Page - 23	

Karnataka Power Transmission Corporation Limited



Maintenance Schedule for Sub-Stations		Page No.	17
		Revisions	RO
A	B	C	D
12	Gasket Joints	Check for Leakages	Tighten the Bolts evenly to avoid uneven pressure and take measure to stop leak
13	Temperature Indicator	Pocket (Holding Thermometer Sensor) to be checked	Oil to be replaced after cleaning Pocket and Probe
14	Dial Type Oil Gauge (Magnetic Oil Gauge)	Check Pointer for free movement	Check gauge reading with respect to Oil in Conservator using Dip Stick
15	Earth Resistance	Measure Earth Resistance of Body and Neutral	Take Action if the Value is High. Check Connection at Electrodes
16	OLTC-Diverter Chamber	Diverter Switch Contact Resistor Arcing Contacts etc.	Replace if damaged as per Manufacturer's Instructions. Replace Oil Regardless of Condition after Flushing and Cleaning the Diverter Switch Chamber
17	Conservator	Once in 2 Years	Inspect Internally Clean and Refill with Clean Oil
18	Flushing Transformer Core and Winding Assembly	Visual inspection & good cleaning with Oil JET	See Note - 1 on Page - 23
Karnataka Power Transmission Corporation Limited			



Maintenance Schedule For Sub-Stations

Page No. 18

Revisions RO

IR MEASUREMENT AND POLARISATION INDEX VALUE (PI) :-

Measurement of Insulation Resistance reveals the condition of Insulation (degree of dryness of Paper Insulation), presence of any foreign contaminations in oil and any gross defect inside the Transformers.

For Transformer winding with voltage ratings 11 KV and above 2500 V megger shall be used and for EHV Transformers preferably 5000 V megger shall be used (Motorised).

This test should be carried out during shut down period. Ensure the isolation of Transformer from High Voltage and Low Voltage side (including tertiary) by physically inspecting the concerned Isolators/disconnectors. Disconnect the jumpers and Lightning Arrestors connected to the Transformer.

PRECAUTIONS :-

- 1) Clean the bushings and porcelain by wiping with a piece of dry cloth.
- 2) Transformer windings possess a substantial capacitance and therefore electric parts can only be touched after discharging. Lead wires from the bushings, tank earth to the megger shall be as short as possible without joints and shall not touch tank or each other.

TESTING PROCEDURE :-

IR measurement shall be taken between each winding and tank. The rest of windings being earthed and between windings.

Record date and time of measurement, Sl. No, make of megger, Oil Temperature, weather condition, IR Values at 15 seconds and 60 seconds shall be recorded. Line terminal of the instrument shall be connected to winding.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No. 19

Revisions RO

EVALUATION OF RESULTS :

IR Value may be compared with values in manufactures/precommission report and these values may be used as bench mark for IR monitoring in service. For comparison of IR Values the readings shall be converted to common Temperature base by using the following correction factor.

<u>DIFFERENCE IN TEMPERATURE °C</u>	<u>CORRECTION FACTOR</u>
5°C	1.23
10°C	1.50
15°C	1.84
20°C	2.25
25°C	2.76
30°C	3.35
35°C	4.10
40°C	5.00

As the values vary with temperature of the insulation, it is necessary that correct temperature of oil be taken and hence the oil temperature indicator should be in good working condition for correct comparison of IR Values.

The megger values for comparison shall be calculated at a common temperature of 30°C. For conversion from higher temperature to lower temperature i.e. if the megger values are taken at say 50°C and for conversion to 30°C, the values obtained should be multiplied by the constant corresponding to (50°-30°=20°C) i.e. 2.25 —

Conversely for conversion from lower temperature to higher temperature base the megger values obtained should be divided by the correction factors corresponding to the difference in temperature

Maintenance Schedule For Sub-Stations

Page No. 20

Revisions RO

POLORISATION INDEX VALUES :-

The P.I. is the ratio of the 10 min to 1 min Mega Ohm readings when taken with motorised megger at constant voltage. The following are the guidelines for P.I Value to evaluate Transformer Insulation.

P.I. VALUE

< 1

CONDITION

Dangerous

1 - 1.25

Poor

1.25 - 2

Fair

> 2

Good

However incase motorised megge 0 seconds to 15 seconds
IR Values may be taken for computing P.I. Value with hand operated Meggers

OIL LEAKAGE :-

Check joints for leakage of both welded joints and joints with gaskets. If any doubt of leak, the area must be cleaned of oil using solvent (ethyl Alcohol) and apply wet chalk. This will give a good indication of exact location of leak. If leak is in the gasket, joints must be tightened evenly. If it is at a welded joint, tap the weld material into the pin hole by using small ball pane hammer and apply sealing compound. Other area to be checked are drain plugs, valves in oil piping.

SILICAGEL

When 1/2 to 2/3 of the silicagel becomes saturated and turn pink in colour, it is to be changed/reactivated by heating upto 130°C until the entire mass turns to bright blue. If the temperature exceeds, the Crystals may become black & hence cannot be used. Use only large size crystals (3to5 mm)

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No.

21

Revisions

RO

COOLING SYSTEM :-

Cooling System in a Transformer is very important for keeping the temperature rise of oil & winding under limits when the transformer is in service for various load conditions. Without proper cooling system the transformer will not be able to take full load & the following are to be checked & rectified:-

- 1) Check radiator top and bottom valves are fully open.
- 2) Ensure air passage between fins is clear by cleaning any foreign objects present.
- 3) The temperature at top and bottom is uniform in all the radiators.
- 4) All the fan blades, guard etc. are clean and fan rotation and speed are in order.
- 5) The Bearings are free and if not lubricate the same using grease gun. Bearings to be replaced if unusual noise is heard.
- 6) Check for correct rotation, unusual noise, abnormal vibration of cooling pumps. If necessary replace rotor/bearing.
- 7) Check for correct direction of oil/air flow.

8) CHECKING OF OIL TEMPERATURE INDICATOR

Remove the OTI bulb from the pocket on the Transformer lid and insert it in an oil bath along with an external thermometer. Both indicator readings should tally (both, with heating of oil bath and while cooling).

- 9) Winding temperature indicators to be calibrated once a year as per the manufacturers test procedure of the temperature indicator.
- 10) Check the operation of Bucholtz relay, alarm and trip contacts by pumping air through the air release cock after closing the valves on either side of the Bucholtz Relay. Alternatively after closing both the valves, drain the oil in Bucholtz Relay by opening the drain cock and check operation of Alarm and trip contacts of mercury switches.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No. 22

Revisions

GENERAL

- 1) Tan-Delta and Capacitance testing of Transformers and Bushings and oil test as per IS - matter to be referred to R & D Centre. — Yearly.
- 2) Periodical testing of all relays and meters - matter to be referred to MRT Division — Yearly.
- 3) Take Safety Precautions as per safety manual.
- 4) Keep records of all the equipment along with nameplate details, precommissioning test reports and equipments manuals for all equipments.
- 5) Maintain Registers for station equipment indicating Name Plate details.
- 6) Maintain Separate Register for recording Periodical Maintenance Works and test results.
- 7) Maintain Cumulative record of tapchanger operation for replacement of oil/ overhauling after prescribed no. of operation as per manufacturers recommendation.
- 8) Whenever released equipment from other sub-stations are installed the previous history of performance and test results shall be recorded and maintained further.
- 9) While filtering Oil, take care to see that the temperature of Oil does not exceed 70°C at the Transformer. It should be continuously monitored and hourly readings to be recorded.
- 10) For filtering, Oil should be drawn from the bottom valve of the Transformer and Hot Oil after filtration to be taken to top valve of the Transformer.

Karnataka Power Transmission Corporation Limited

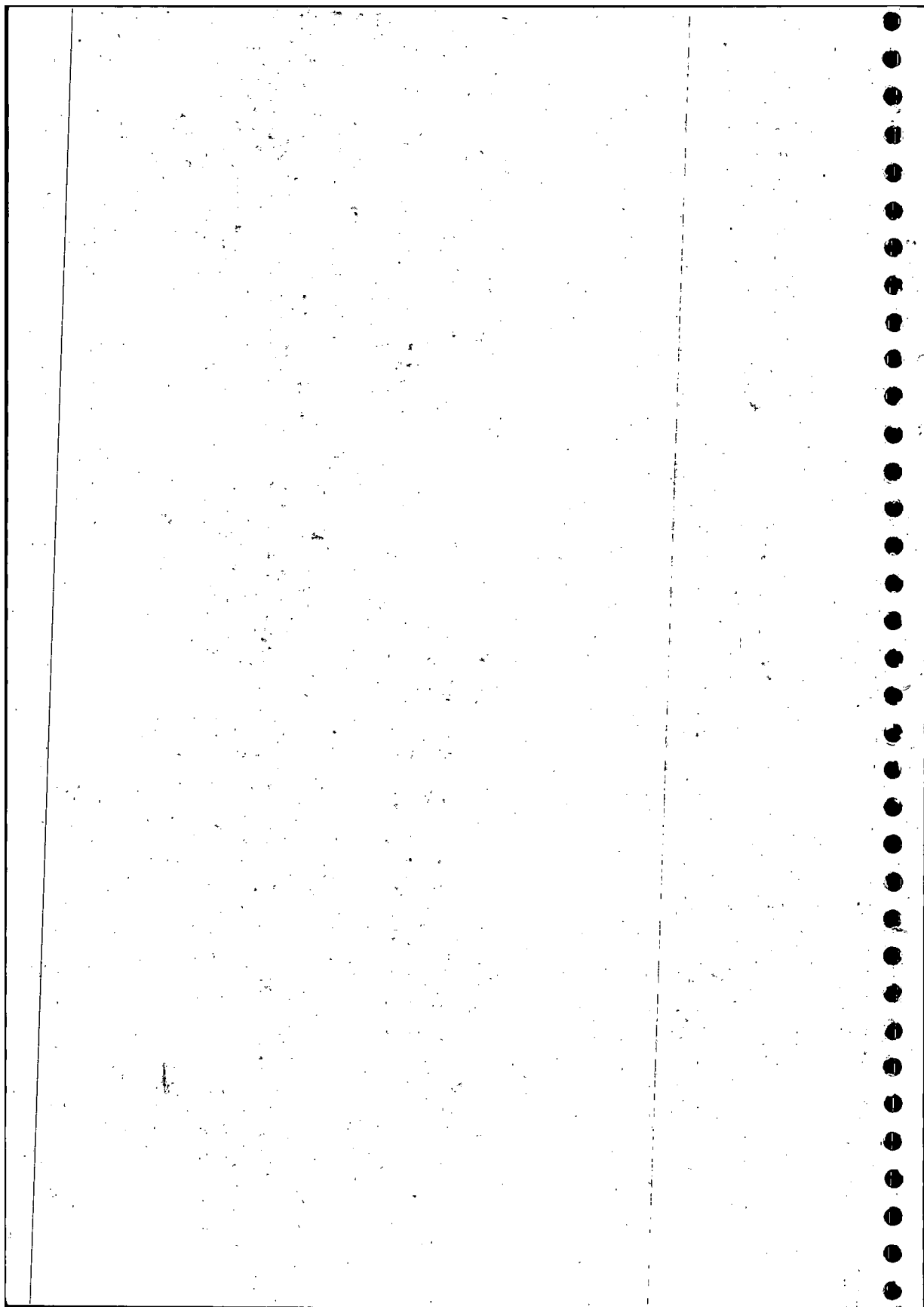
Maintenance Schedule For Sub-Stations

Page No.	23
Revisions	RO

NOTE

1. It is recommended by all transformer manufactures that the transformer core and winding assembly should be inspected every 10 years and washed by hosing down with clean dry oil.
2. No Indian Standard specifies the minimum IR values upto which the transformer can be retained in service. The IR values of the transformer are likely to fall in comparison to the values obtained at the time of commissioning. It is observed that the IR values of the transformer depend on the characteristics of the insulating oil and insulating materials. If the IR values of the transformer are low and the values of BDV, water contents, Tan-Delta and Resistivity of the transformer oil are beyond the limits, the IR values of the transformer are likely to improve in case the dehydration of the transformer oil is carried out.
 - 2.1 If the IR values of the transformer are low and water content of the transformer oil is well within the limits but the Tan-Delta and Resistivity of the oil are beyond the limits, then the IR values of the transformer are likely to improve only after the replacement of the transformer oil with new EHV grade oil.
 - 2.2 If the IR values of transformers are low and if the oil parameters are within limits, the reduction in the IR values of the transformer may be due to the aging of the insulation and in that case, the IR values of the transformer are not likely to improve even if the dehydration of the transformer is carried out or the transformer oil is replaced. In such case matter is to be referred to manufacturer and to the controlling officers immediately.
3. The operational check of gas operated OLTC Relay can be carried out by injecting air with the cycle Pump as in case of main Buchholz relay. However, some of the transformer manufactures provide MR make oil surge relay which can only be tested by pressing the designated push button on the relay. M/s. NGEF provide a switching device on the diverter switch. The switching device can be actuated by lifting the shifting blade manually and actuating the switching device which is wired to trip the breaker.
4. Refer Appendix-D for method of Chemical Analysis of gas collected in Buchholz Relay.

Maintenance Schedule for Sub-Stations		Page No.	24
		Revisions	RO
DETAILS OF MAINTENANCE OF CT's, PT's & CVT's			
Sl.No.	Items to be Inspected	Inspection	Action Required, if inspection shows unsatisfactory condition
A			
B			
1	Insulators	Check for cleanliness & cracks	Remove dust
2	Clamps & connectors	Check for tightness & damages	Tighten loose nuts & bolts. Replace damaged/defective clamps/connectors/conductor
3	Primary connection strips if provided externally	Check for tightness & damages	Tighten if loose. Replace if damaged
4	Oil level & oil leakage	a) Clean the oil level indicator externally and check the oil level b) In case of ABB make CT's with bellow, check for damage or leakage	a) If low, investigate & take remedial measure to stop leakages. Top up oil with new fresh filtered oil as per IS 335. b) In case of ABB make CT's having damaged or leaking bellows, arrange for replacement.
5	Corona ring, if provided	Check for tightness	Tighten, if loose
6	Paint work	Shall be inspected for rust	Repainting or retouching should be done, as required
7	Secondary terminals of instruments, transformer & junction box. (Work under shutdown)	Check tightness of the connections of secondary terminals of instruments, transformer. Also check the tightness of connections in junction box. Check Star point Earthing	Tighten the loose connections. Replace defective/damaged terminal blocks. Loose connections in CT secondary connections can cause saturation of core. Open circuit in CT secondary connections can cause damage to the CT.
8	Earthing	a) Check equipment earthing & see that both ends of the earthing are tight & intact. b) In case of CVT's check that the HF terminal is earthed if not in use for PLCC c) Check that the neutral of the secondary winding is earthed.	Take remedial action if the earthing is loose or not intact.



Maintenance Schedule for Sub-Stations

		Page No.	25
		Revisions	RO
9	<p>Insulation resistance</p> <p>Measure insulation resistance values after removing lumps & isolating the instrument transformer from all other equipments in system & after cleaning the insulators. Also see note No. 1</p> <p>The IR values of primary to earth of 11 KV instrument transformers shall not be less than 200 Mega ohm and the IR values of secondary to earth shall not be less than 2 Mega ohm. In case of 11 KV PT's in which primary neutral is earthed inside the tank, change oil & carry out dehydration of PT every 5 years</p> <p>IR Values with 2.5/5 KV Megger shall be around 2 mega ohms/KV at 60°C</p>	<p>Note No. 1:-</p> <p>a) IR values between primary winding & earth shall be measured with 2.5/5.0 KV Megger.</p> <p>b) IR values between secondary winding & earth shall be measured with 500 V Megger. The earthing of the neutral/open delta should be opened before making this measurement. It should be reconnected & tightened after the measurement.</p> <p>c) For measuring the IR Values of Electromagnetic potential Transformer, earthing of neutral end of primary winding is required to be disconnected if provided. The earthing shall be promptly reconnected after the measurement of IR Values of Electromagnetic potential Transformer. If the potential Transformer is taken into service without connecting the earthing of the neutral end of the primary winding, the potential Transformer will get damaged.</p> <p>If IR values are below the limiting values take following action:</p> <p>i) Check BDV of oil 30 KV for 11 KV 40 KV for Higher voltage. If less replace with fresh new tested oil as per IS 335 BDV not less than 60 KV</p> <p>ii) If IR values do not improve even after above action replace with good oil</p> <p>iii) In case of epoxy cast instrument transformer if the values are below the limiting values, cleaning and drying will improve the results</p> <p>iv) If either of the two readings of the IR Values is below the limiting values given, replace the CVT. Also refer the matter to MFT/Manufacturer for rectification of defective CVT.</p>	

Maintenance Schedule For Sub-Stations

Page No. 26

Revisions RO

NOTE No. 1

A steady fall of the insulation resistance values over a period of time is a more reliable indication of the deterioration of insulation than a relatively low value which remains constant.

NOTE No. 2

All defective instrument transformers which have been replaced due to damaged insulator or low IR Values or core saturation should be got repaired locally or from the manufacturer so that these are again available for use.

Maintenance Schedule For Sub-Stations

Page No. 27

Revisions RO

MAINTENANCE OF BATTERY SET & BATTERY CHARGERS IMPORTANT INSTRUCTION

1. Float Charge should always be kept on (even after the battery set is boost charged).
2. a. While Boost Charging gas vent plug on the cells should be kept open.
2. b. In case of failure of AC supply to the battery charger for more than two hours, the battery set should be boost charged at the equalising current rate given at item No. 3 a (ii) for the number of hours the AC supply remained failed.
3. The exhaust fan should be in working condition in the battery room. Equally sufficient air inlet should be provided to the battery room to prevent any negative pressure developing in the room. The door of the battery room should always be kept open when the exhaust fan is running. The door can be kept closed if sufficient in-let for air is provided in the door itself.
4. Add only distilled water to maintain cell electrolyte level. NEVER ADD ACID.
5. Temperature correction for specific gravity $[SG(27^{\circ}C) = SG(t) + 0.7(t - 27^{\circ}C)]$
Where t is actual temperature of cell

Example

- a) Suppose the temperature of battery cell is $32^{\circ}C$ and the reading of hydrometer is 1205, then corrected specific gravity at $27^{\circ}C$ will be $1205 + 0.7 \times (32-27) = 1208.5$
- b) Suppose the temperature of battery cell is $22^{\circ}C$ and the reading of hydrometer is 1205, then corrected specific gravity at $27^{\circ}C$ will be $1205 + 0.7 \times (22-27) = 1201.5$
6. If inspite of repeated charging, the specific gravity or voltage of some cell(s) does not improve, these are to be considered weak cells. These should be removed from the battery set one at a time and charged independently at the specified recharging current as given at item No. 8 until gassing starts (Approximately 2.4V/Cell). The recharging current is reduced to the finishing current as given at item No. 8 till the cell appears to be fully charged, i.e. the specific gravity of the electrolyte becomes constant for 3 readings at 1200 (corrected). Then charging should be stopped for an hour and then be resumed at finishing current rate until free gassing again takes place. A further stop of one hour duration should be made and charge should again be resumed at the finishing current rate and should be repeated until gassing starts simultaneously with switching on of the charging current. If inspite of this special charge, the cells do not pick up the specific gravity or voltage, the cells are to be replaced.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No. 28

Revisions RO

7. During charging, if the temperature of the electrolyte tends to rise beyond 45°C, reduce the current to one third the value. If necessary, charging can be suspended for some time to allow the temperature to come down.
8. Adjustment of specific gravity should be done only after the battery set has been given a long duration boost charging as at item No. 8 and the cells show sign of being charged. The specific gravity should be adjusted only near the end of such charging, by adding distilled water in cells having high gravity or replacing electrolyte in cells having low gravity with electrolyte from cells having high gravity.
9. If the float voltage is correctly maintained as specified at item No. 1, the charging of the battery set at the equalising current rates as at item No. 3 a (ii) is required once in every three months.
10. Progressive lower values of the specific gravity during floating indicate that the floating voltage is set low. Check accuracy of the voltmeter in the charger panel and take remedial action if necessary. Grounded circuits also circulate leakage currents thereby discharging the battery. Check for the leakage of the electrolyte or grounding of current-carrying conductors in the charger as well as in the battery circuit.
11. Continuous lowering of the electrolyte level may be due to leakage of electrolyte or loss of water in electrolyte because of evaporation by too high a floating voltage or excessive charging. Replace container immediately in case of leakage. After replacing the container the cell is to be charged as detailed in item 6.
12. While cleaning the intercell connector the cells between which terminal connector is to be removed, is bypassed so that the battery voltage will be available to meet the D.C. load.
13. Never store acid i.e., electrolyte of specific gravity higher than 1.200.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule for Sub-Stations

Maintenance Schedule for Sub-Stations		Page No.	31
		Revisions	RO
A	B	C	D
4	Battery Cells	<p>b) Check the electrolyte level.</p> <p>c) The specific gravity and the cell voltages shall be taken with charger switched off (Monthly)</p> <p>Check for cleanliness & dust/moisture deposits and leakages</p>	<p>(i) If the electrolyte level is below the given mark, top up with only pure distilled water. NEVER ADD ACID. Whenever distilled water is added to any cell, battery set should be given a boost charging at the current given at 3'a (ii) above until distilled water and electrolyte get mixed thoroughly</p> <p>(i) Clean all the cell containers, stand and insulators and attend leakage if any. Apply Vaseline/petroleum jelly on terminal, intercell connectors and nuts and bolts wherever necessary</p> <p>(ii) Ensure that the rubber seal at the base of the terminals and on cell lid is fitted properly. Replace if damaged</p>
5	Battery set Capacity status (Monthly)	<p>Switch off the float charger for one hour, observe drop in battery voltage. The battery voltage should not drop below 107 V for 110 V battery set and below 214 V for 220 V battery set</p>	<p>Rapid fall in voltage could be due to loose connections or corroded terminals. Switch on battery charger. Clean corroded parts and tighten loose connections</p> <p>Switch off float charge again for one hour. If the battery voltage still drops below the limits given, recharge the battery set as per instructions given at item No. 8 below.</p>

Maintenance Schedule for Sub-Stations		Page No.	32
		Revisions	RO
A	B	C	D
6	Corroded terminals	<p>a) Check for sulphate deposits on terminals of cells and intercell connectors and nuts and bolts.</p> <p>b) Check for corroded/damaged terminals, intercell connectors, nuts and bolts.</p> <p>c) Check bolts and nuts for tightness.</p> <p>d) Check vent plugs.</p>	<p>a) For removing sulphate deposits, temporarily by pass the intercell connector using robust & reliable connection. One intercell connector should be attended at a time. The intercell connector which has been by passed should be then removed & cleaned, dried & fixed in place & then coated with Vaseline/petroleum jelly. Refer Appendix D.</p> <p>b) Replace damaged intercell connectors, bolts and nuts after providing by-pass arrangement as at (a) above only lead coated bolts & nuts to be used.</p> <p>c) Tighten bolts and nuts found loose.</p> <p>d) Wash all vent plugs by immersing in a bucket of water wipe them clean and refix.</p>
7	Battery Charger	<p>i) Check for cleanliness & loose connections.</p> <p>ii) Check operation of float charger by putting it in manual mode and slightly raising the float output voltage. The charge/discharge ammeter should show current on charge side. Return charger to auto mode.</p> <p>iii) Check the operation of the boost charger by switching on the boost input and output switches/ MCB and slowly increasing the boost output voltage, till the charge/discharge ammeter shows current on the charge side.</p>	<p>(i) Clean with blower. Tighten loose connections.</p> <p>(ii) If the charge/discharge ammeter does not show current on the charge side then the float charger is not giving output. Defect should be located and corrected. In case of failure of float charger, the boost charger can be used as float charger. Now the boost charger should be switched on and output voltage adjusted and maintained near about the voltage given at item No. 1 above.</p> <p>(iii) If the charge/discharge ammeter does not show the current on the charge side, then the boost charger is not giving output. Defect should be located and rectified.</p>
Karnataka Power Transmission Corporation Limited			

Maintenance Schedule for Sub-Stations

Page No.	33	Revisions	RO																											
A		C	D																											
<p>8</p> <p>Curative discharge (to be conducted if condition permit shut down of substation and after arranging back feed supply for recharging battery). (Once in 2 Years)</p>	<p>After switching off the float charger, discharge the battery at its 10 hour rate discharge current (10 amps for 100 AH, 20 Amps for 200 AH, 40 Amps for 400 AH capacity battery set respectively) for a period of 2 hours. Recharge the battery at the recharge current till the cells start finishing rate and charge until the specified value of specific gravity is attained and remain constant for three consecutive hourly readings. Also refer instruction No. 9</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Sl. No.</th> <th>Make</th> <th>Recharge Current</th> <th>Finishing Specific Gravity</th> </tr> </thead> <tbody> <tr> <td>(i)</td> <td>Standard 400 AH Cap.</td> <td>40 amp</td> <td>20 amp 1210+/-5</td> </tr> <tr> <td>(ii)</td> <td>Standard 300 AH Cap.</td> <td>30 amp</td> <td>15 amp 1210+/-5</td> </tr> <tr> <td>(iii)</td> <td>Standard 100 AH Cap.</td> <td>10 amp</td> <td>5 amp 1210+/-5</td> </tr> <tr> <td>(iv)</td> <td>Amco 400 AH Cap.</td> <td>56 amp</td> <td>28 amp 1200+/-5</td> </tr> <tr> <td>(v)</td> <td>Amco 300 AH Cap.</td> <td>42 amp</td> <td>21 amp 1200+/-5</td> </tr> <tr> <td>(vi)</td> <td>Amco 100 AH Cap.</td> <td>14 amp</td> <td>7 amp 1200+/-5</td> </tr> </tbody> </table>	Sl. No.	Make	Recharge Current	Finishing Specific Gravity	(i)	Standard 400 AH Cap.	40 amp	20 amp 1210+/-5	(ii)	Standard 300 AH Cap.	30 amp	15 amp 1210+/-5	(iii)	Standard 100 AH Cap.	10 amp	5 amp 1210+/-5	(iv)	Amco 400 AH Cap.	56 amp	28 amp 1200+/-5	(v)	Amco 300 AH Cap.	42 amp	21 amp 1200+/-5	(vi)	Amco 100 AH Cap.	14 amp	7 amp 1200+/-5	<p>By this discharge, the battery set has a higher probability of longer life. The discharge and charging helps to correct some imbalances also.</p>
Sl. No.	Make	Recharge Current	Finishing Specific Gravity																											
(i)	Standard 400 AH Cap.	40 amp	20 amp 1210+/-5																											
(ii)	Standard 300 AH Cap.	30 amp	15 amp 1210+/-5																											
(iii)	Standard 100 AH Cap.	10 amp	5 amp 1210+/-5																											
(iv)	Amco 400 AH Cap.	56 amp	28 amp 1200+/-5																											
(v)	Amco 300 AH Cap.	42 amp	21 amp 1200+/-5																											
(vi)	Amco 100 AH Cap.	14 amp	7 amp 1200+/-5																											

Maintenance Schedule for Sub-Stations

Page No. 34		Revisions RO	
A	B	C	D
9	Battery Stand and Room (Yearly)	(vii) Exide 40 amp 20 amp 1200 +/- 5 400 AH Cap. (viii) Exide 30 amp 15 amp 1200 +/- 5 300 AH Cap. (ix) Exide 10 amp 5 amp 1200 +/- 5 100 AH Cap.	Replace/repair damages: Paint stand, if required, with anti acidic paint for stand and room.

Maintenance Schedule For Sub-Stations

Page No.

35

Revisions

RO

MAINTENANCE OF

D. G. SETs :-

- a. Inspection of water in radiators.
- b. Circulation of oil in crank case and oil level check.
- c. Battery charger and Battery voltage check up.
- d. Run daily for at least 10 Minutes.
- e. Check up oil and fuel filters replacement.
- f. Check up V-Belts.
- g. Check up Alarm and AMF Panel.
- h. General cleaning and visual inspection of Control Panel.

(For details of Maintenance Refer Manufacturers Manual)

1. OIL FILTER SETS :-

- a. Cleaning of filters, Replacement of filter papers.
- b. Checking of heaters.
- c. Check up and topping up of oil in vacuum pump.
- d. Checking up of Vacuum gauges, Thermometers, Thermostat & Electrical wiring etc.
- e. Periodical overhauling.
- f. Checking of leaks in oil piping.

(For details of Maintenance Refer Manufacturers Manual)

2. COMPRESSORS :-

- a. Cleaning and lubrication of bearings.
- b. Check cylinder oil level.
- c. Check safety valve operation.
- d. Tightning of all bolts and nuts.
- e. Tightning all gasket joints.
- f. Tightning of foundation bolts.
- g. Check cleanliness of air filter.
- h. Check cleanliness of cooling fins.

(For details of Maintenance Refer Manufacturers Manual)

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations		Page No.	36
		Revisions	RO
3. OVERHEAD CRANES :-			
ACTIVITY	QLY.	H/ LY.	YLY.
A. Periodical inspection of fasteners		✓	
B. Check up of wear of following i. Gears — First reduction stage ii. Wheels — Flange iii. Groove rim thickness		✓	
C. Check up of all Electrical Connection	✓		
D. Check up of all Motors, Brushes, Slipping and greasing of Bearings			✓
E. Replacement of oil in gear box			✓
F. Greasing of i. Nipples of Wheel Axle, Hook Block etc ii. Wire ropes and open bearing		✓	
G. Vacuum cleaning of Motors			✓
H. Measurement of Insulation resistance of Motors			✓
I. Inspection of Brakes i. Check up clearance between brake shoe & brake drum surface, adjust if required. ii. Check up stroke of E.M. Brake iii. Replacement of Oil in EH Thrustor Brakes (For details of Maintenance Refer Manufactures Manual)	✓		
Karnataka Power Transmission Corporation Limited			

Maintenance Schedule For Sub-Stations

Page No.	37
Revisions	RO

DO's

1. Do check for continuity of D.C. Supply for efficient operation.
2. Do check for physical healthiness of battery cells and their connections.
3. Do ensure or satisfy for electrolyte level in cells if level is low fill with distilled water.
4. Do ensure for proper operations of battery charger & satisfy with regard to D.C. Fuses etc.
5. Do check frequently for tripping & closing of equipment through relays and switches.
6. Do check and provide efficient ground connection to all D.C. equipments and provide if possible earth leakage relays for efficient D.C. Supply.
7. Do check for proper earthing connections for equipments like L.A.s, PTs, Transformers, Circuit Breakers and CTs etc.
8. Do check for smooth and easy operations of Circuit Breakers and G.O.S. etc.
9. Do check the following during the shut downs and record their values
Meggering of L.A.s, Power Transformers, Circuit Breakers, U.G Cables, CTs, PTs, Earth Mat, and Earth Electrodes.
10. Do check all the equipments during shut down for dust etc. from both inside and outside as the case may be.
11. Do provide proper illumination in the O.D.S. Yard and Control Room.
12. Do keep fire fighting device intact and ready to use in position.
13. Do keep a vigil on over voltage & over loading of equipments like Power Transformers, CTs & PTs etc.
14. Do ensure that all the contacts on bus bar, O.C.B., CTs, PTs, Battery Charger, Panel Boards and Tap Changer are O.K.
15. Do keep Circuit Breakers open whenever D.C. Supply failure is observed till it is rectified.
16. Do check to see that all fuses are intact with proper ratings.
17. Do check for working condition for proper operation of motors & other equipments with provision of safety device such as single phase preventer, over load protection etc.
18. Do provide control & MCB for A.C. Circuits.
19. Do provide HRC fuses (Rated Capacity) for +ve and link on -ve of D.C. Circuits.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub Stations

Page No. 38

Revisions RO

DON'Ts

1. Do not open any G.O.S. on load, without opening Circuit Breaker.
2. Do not close any G.O.S. before opening the Concerned Circuit Breaker.
3. Do not open G.O.S. before tripping the concerned C.Bs. for issuing L/C on 11 KV feeder/line/transformer/capacitor.
4. Do not operate Breakers when air and gas pressure are below operating value.
5. Do not operate G.O.S. and Circuit Breakers Manually without wearing Safety Gloves etc.
6. Do not close earthing G.O.S. unless respective C.B. and G.O.S. are open and authorities requiring L/Cs. require so and the line is de-energised and ensure no back feeding on the line.
7. Do not keep Power Transformer in charged conditions during abnormal records of winding and oil temperature.
8. Do not charge any Power Transformer without being satisfied with respect to neutral connection being perfectly earthed with two numbers of minimum separate earth connections.
9. Do not allow specific gravity of lead acid cells to below 1.200 (+ or - 5%) and cell voltage below 1.8 volts per cell.
10. Do not allow workmen to attend any work without line clear and with the equipment being perfectly earthed and if necessary with discharging the equipments (such as L.As Capacitor, U.G. Cables etc.) duly taking precaution that safety devices are used.
11. Do not issue L.C. on EHV lines without obtaining NFBC from the other end.
12. Do not keep any CTs in charge conditions without its secondaries in closed circuit or short circuited.
13. Do not use bare fingers or hands to determine whether a circuit is live.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No. 39

Revisions RO

LIST OF TOOLS AND PLANTS REQUIRED FOR SUB - STATION MAINTENANCE

1. Earth Resistance Tester
2. Portable (Mobile) Oil pump (1/2 Hp Air Pump 500 to 1000 gallons)
3. Telescopic ladder aluminium 6 mtr. Height
4. Ring spanner set
5. Tube spanner set
6. Pipe wrench 24 inch
7. Pipe wrench 18 inch
8. Hydraulic crimping tools up to 1000 Sq.mm (One per Station-Maintenance Division)
9. Threading die set for pipe threading (One per Station-Maintenance Division)
10. Welding Machine (arc welding) 10 KVA (One per Station-Maintenance Division)
11. Rubber hand gloves (15 KV tested)
12. Five and three celled torch
13. Insulated cutting plier 12 inch & 8 inch
14. Live line tester
15. Screw drivers of Sizes from 6" to 18"
16. Hammer 8 lbs
17. Hammer 2 lbs
18. Chain pulley block 5 ton
19. Hydraulic jack 5 ton
20. Pipe derrick
21. Allen keys
22. Box spanners
23. D.E. Spanner Set
24. Transil oil dielectric breakdown test kit
25. Insulation Megger 2.5 - 5 KV

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No. 40

Revisions RO

26. Insulation Megger 500 V.
27. SF6 gas leak detector.
28. Multimeter Electromechanical.
29. Multimeter Electronic.
30. Digital Tongtester.
31. Hydrometers.
32. Hydrometer syringes suitable for vent holes.
33. Specific gravity correction chart.
34. Wall mounting type holder for hydrometer and thermometer (teak wood make).
35. Cell testing voltmeter (3-0-3V) confirming Is: 1248.
36. Rubber apron.
37. Pipette.
38. Protective goggles.
39. Acid resisting jars (4 pint capacity).
40. Rubber shoes (knee height).
41. Glass funnel.
42. Miscellaneous items like rubber mats, first aid box, danger boards, shock treatment charts, water filter, door locks, fixograph.
43. Earthing Rods with wires.
44. Manila and Nylon Ropes.
45. Single and Double Sleeve pulley.
46. Phase sequence Indicator.
47. Nylon Faced Wooden Hammer.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule For Sub-Stations

Page No. 41

Revisions RO

LIST OF CONSUMABLE MATERIALS FOR SUB - STATIONS.

1. Rubber hand glove
2. Rain coat and Hood
3. Cotton waste
4. Insulation tape
5. Distilled water 50 ltr. Can
6. Grease
7. Petroleum jelly
8. Torch cells
9. Dettol
10. Engine Oil
11. Diesel
12. Cleaning solvent (CTC/Acetone)
13. Cloth Emery (zero) Metal
14. Cheese cloth
15. Cora cloth
16. HRC Fuses (Various Ratings).

APPENDIX - A

**METHOD FOR DETERMINATION OF ELECTRIC STRENGTH
OF INSULATION OIL (IS : 6792-1972)**

(Gap between the electrodes to be 2.5 ± 0.1 mm)

1. The test consists in applying to the electrodes an increasing AC Voltage, the rate of increase of the voltage being uniform and equal to approximately 2 KV starting from zero up to the value producing breakdown.
2. The circuit is opened manually if a transient spark (audible or visible) occurs between the electrodes automatically if an established arc occurs.
- 2.1 The breakdown voltage is the voltage reached during the test at the time the first spark occurs between electrodes, whether it be transient or established.
3. The test shall be carried out six times on the same cell filling.
- 3.1 The first application of the voltage is made as quickly as possible after the cell has been filled, provided there are no longer any air bubbles in the oil, and at the least 10 minutes after filling. After each breakdown, the oil gently stirred between the electrodes by means of a clean dry glass rod, avoiding as far as possible the production of air bubbles. For the subsequent five tests the voltage is reapplied one minute after the disappearance of any air bubbles that may have been formed. If the observation of the disappearance of air bubbles is not possible, it is necessary to wait for five minutes before a new breakdown test is started.
- 3.2 The electric strength shall be the arithmetic mean of the six results which have been obtained.

APPENDIX - B

**METHOD FOR SAMPLING OF TRANSFORMER OIL
FOR TESTING AS PER (IS : 9434 - 1992)**

1. SAMPLING BY SAMPLING TUBE
 - 1.1 The Sampling tube (See Fig. 1), may be of glass or metal and of volume 1 Litre. It may be closed by valves.
 - 1.2 The Sampling tube is connected to the sample point by tubing. The cocks on the sampling tube are opened and the sampling valve on the equipment carefully opened, so that oil flows through the sampling tube to waste.
 - 1.3 After the sampling tube has been completely filled with oil, about 1 Litre are allowed to flow to waste.
 - 1.4 The oil flow is then closed by shutting off firstly the outer cock, then the inner one and finally the sampling valve.
 - 1.5 The sampling tube is then disconnected.
 - 1.6 The method is to be compulsorily adopted for taking samples for DGA.

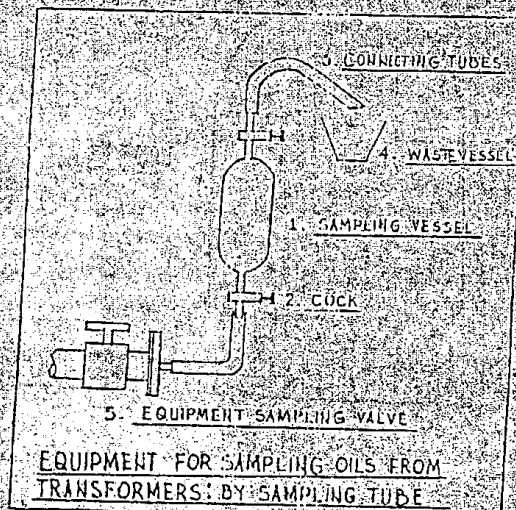
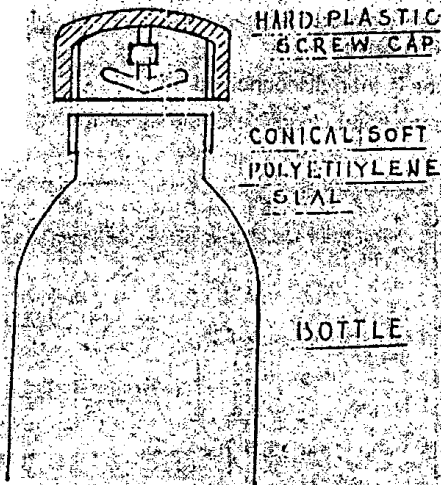


Fig. 1

2. SAMPLING BY BOTTLES

- 2.1 The method requires the use of bottles or container capable of being sealed gas tight. Suitable bottles have screwed plastic caps holding a conical polyethylene seal, as shown in Fig - 2
- 2.2 The connection to the sample point may be made by oil proof plastic or rubber tubing about 5 mm diameter.
- 2.3 The Sampling valve is opened and about 1 Litre of oil allowed to flow to waste through the tube. The end of the tube is then placed, with the oil still flowing, at the bottom of the sampling bottle and the bottle allowed to fill. After allowing about one bottle volume to overflow, the sample tube is gently withdrawn with the oil flow continuing. The bottle is then tilted, allowing the oil level to fall to 1 mm to 2 mm from the rim and the bottle cap is placed in position. The sampling valve is then closed.



SEAL CAP FOR SAMPLING BOTTLE

Fig - 2

APPENDIX - C**METHOD FOR CHEMICAL ANALYSIS OF GAS COLLECTED IN
BUCHHOLZ RELAY AS DETAILED IN IS : 3638 -1996.
FOR ALTERNATE METHOD REFER IS : 3638 - 1966.**

In the event of operation of main buchholz relay, the transformer is to be isolated. The gas collected in the relay should be checked to identify the nature of the fault. The following is to be checked

- 1.1 Colour of gas helps in finding the affected material as follows

COLOUR OF GAS	IDENTIFICATION
1) Colourless	Air
2) White	Gas of decomposed paper & cloth insulation
3) Yellow	Gas of decomposed wood insulation
4) Grey	Gas of over heated oil due to burning of iron
5) Black	Gas of decomposed oil due to electric arc

- 1.2 **COMBUSTIBILITY OF GAS** :- A small amount of gas drawn through the top pet cock is flame tested. If the flame brightness, then it can be inferred that the actuation of buchholz relay is due to collection of gas. Incombustibility indicates air

- 1.3 **CHEMICAL ANALYSIS OF GAS** :- Two solutions are prepared as detailed below. The best results are obtained with freshly prepared solutions. However, these solutions can be stored in deep brown colour glass bottles for a period of 12 months

Maintenance Schedule For Sub-Stations

Page No. 46

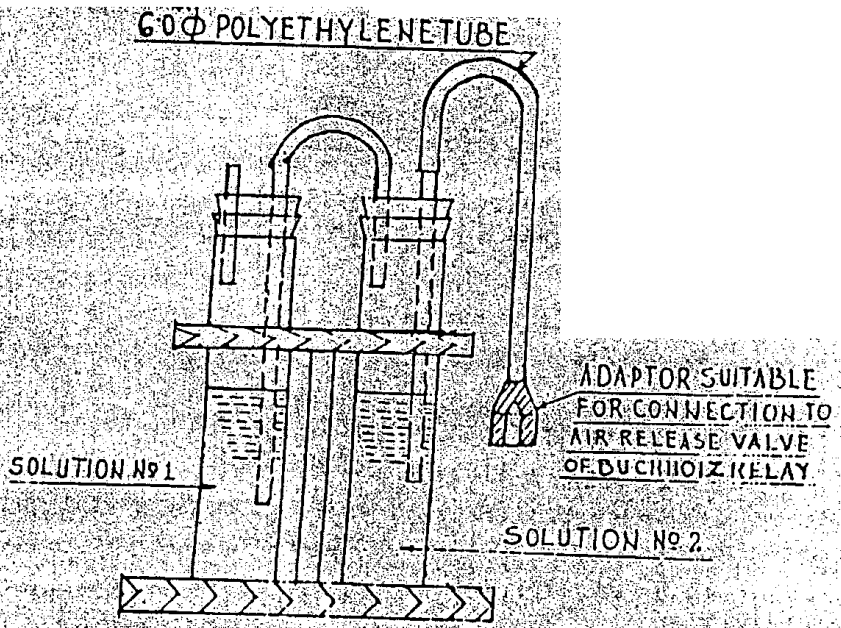
Revisions RO

SOLUTION No. - 1. Five grams of Silver Nitrate (AgNO_3) dissolved in 100 ml. of distilled water.

SOLUTION No. - 2. A weak solution of ammonia in water is slowly added to 100 ml. of solution No. 1, until a white curdled precipitate, which forms first, disappears in the mixture. The Gas Analyser loaded with these solutions is then connected to top petcock of the Buchholz Relay. Small quantities of gas collected in the relay is allowed to pass through the Solution No. - 2 first and then through solution No. 1 as illustrated.

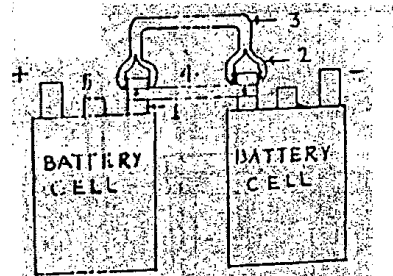
The results are identified as follows

- | | |
|---|---|
| a) Both Solutions are clear | Gas in air |
| b) Solution No. - 1 : White precipitate turning brown on exposure to sunlight | Gas of oil decomposition |
| c) Solution No. - 2 : Turning to dark brown precipitate | Gas of decomposed paper, cotton or wood insulation. |



APPARATUS FOR GAS ANALYSIS

APPENDIX - D



- 1- BATTERY TERMINAL
- 2- HEAVY DUTY GRID CLIP
- 3- HEAVY DUTY CABLE
- 4- INTER CELL CONNECTOR
- 5- VENT PLUG