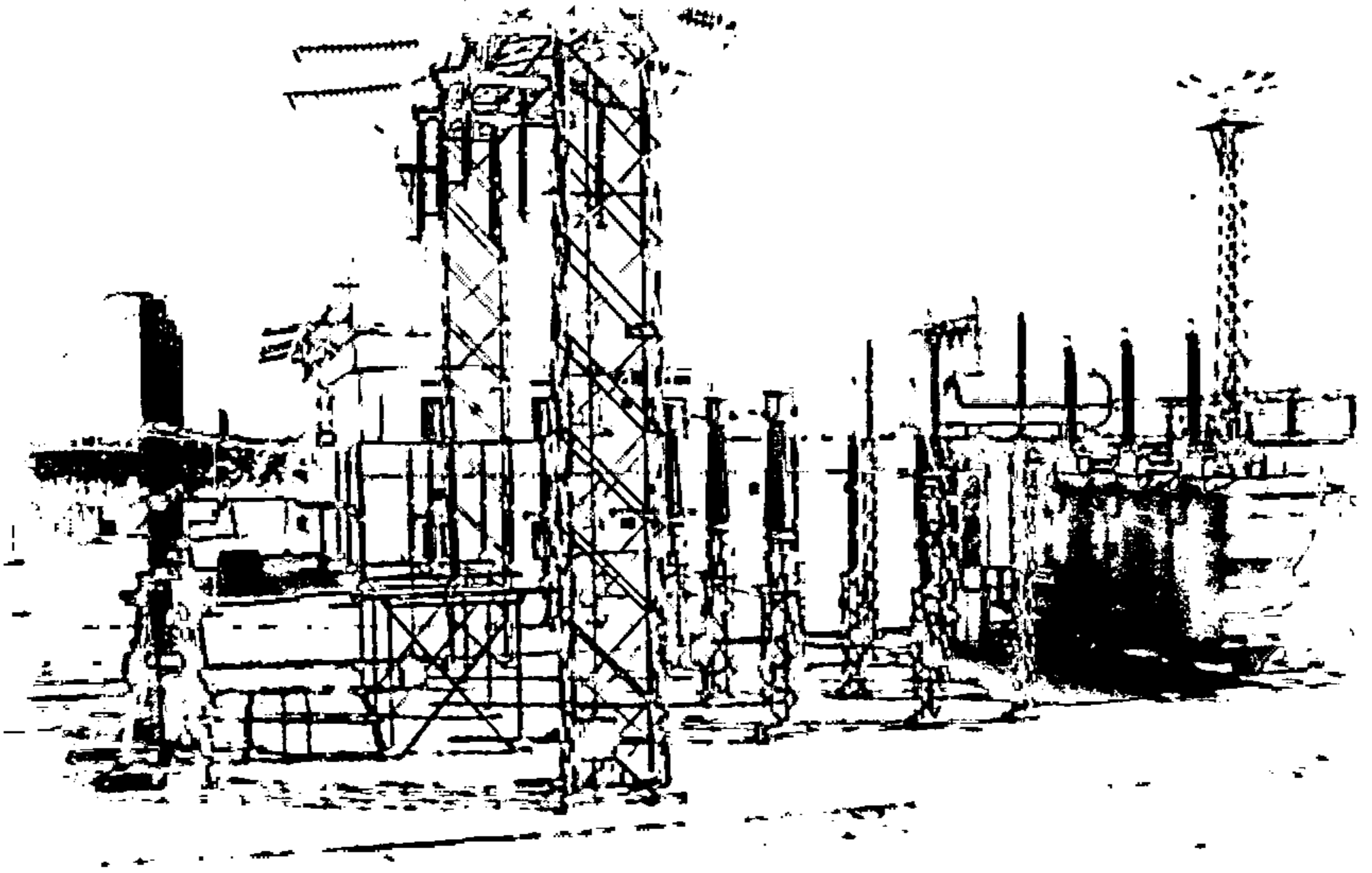


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KARNATAKA POWER TRANSMISSION CORPORATION LIMITED

MAINTENANCE SCHEDULE FOR SUB-STATIONS JULY - 2004



Chief Engineer, Elec. (Planning & Co-Ordination)
Kaveri Bhavan , Bangalore

KPTCL AT A GLANCE

(As on 31-03-2004)

EHT SYSTEMS

Total Area of the State	191791	Sq. Kms
Total Population of the State	52733958	Nos.
Number of Consumers	12495407	Nos.
Peak Load (Restricted)	5445	MW's
Energy Purchased (2003-2004)	31240	MU's
Maximum Energy Handled Per Day(24-3-04)	105.527	Mu's

Installed Capacity of Generation

Karnataka Power Corporation Limited	4366.00	MW's
Visveswaraiah Vidyuth Nigam Limited	348.40	MW's
Central Generating Stations	971.00	MW's
Private Generation (IPP's)	1159.33	MW's
Total	6844.73	MW's

Sub-Station

Voltage Class	No. of Stations	Transmission Lin in CKM's
400kV	4	1976.84
220kV	52	8281.79
110kV	166	6891.31
66kV	282	7073.31
Total	504	24223.25

No. of Sub-Stations & Transmission Lines Added during 2004 - 2005 (upto July-04)

400 kv	-	1.00
220kv	-	66.72
110kv	3	0.92
66kv	1	19.00

Distribution Network Data

Total Length of HT Lines	158527	Kms.
Total Length of LT Lines	404530	Kms
Total Distribution Transformers	195592	Nos.

Maintenance Schedule for Sub-Stations	Page No.	01
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**KARNATAKA POWER TRANSMISSION
CORPORATION LIMITED**

Maintenance Schedule for Sub-Stations

Manual No. : KPTCL - 03/SS.

Issued on : 2004.

Edition No. : 02.

Registered Office:
Kaveri Bhavan,
Bangalore - 560 009

Phone : 22210685
Fax : 22218930

Karnataka Power Transmission Corporation Limited

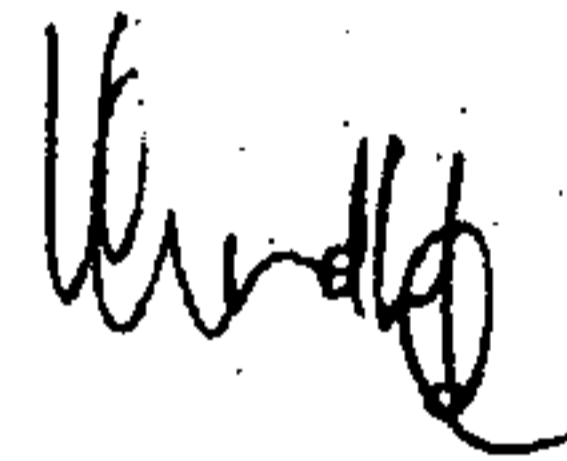
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FOREWORD

Maintenance Schedule for Substations was prepared and issued during 1999. In this manual Maintenance schedule of stations of voltage class 33KV to 110KV was covered. It was felt that maintenance schedules for 220KV and 400KV receiving stations should also be included in the manual to help maintenance personnel in adopting standard practices.

The Committee constituted by the Corporate office to revise and update the existing maintenance manual has finalized the same after deliberations and feedback from field officers.

It is emphasized that the guidelines given in this manual be strictly followed by the concerned maintenance Engineers which can minimize the failures in substations to a great extent.



**Managing Director KPTCL
&
Chairman, Escoms**

Karnataka Power Transmission Corporation Limited

P R E F A C E

A Working group consisting of the following members was constituted to revise the existing maintenance manual and also to include maintenance schedule for 220KV and 400KV receiving stations in KPTCL grid.

- | | |
|-----------------------------|--|
| 1. Er. B.S. Hanumanthappa | Chief Engineer, Elec., (P&C) & Chairman. |
| 2. Er. K.R. Lakshmikanth | General Manager (Tech) & Member. |
| 3. Er. S. Pratapkumar | Chief Engineer, Elec., Transmission, Bangalore & Member. |
| 4. Er. Mujeeb Ahmed | Chief Engineer, Elec., Transmission, Mysore, & Member. |
| 5. Er. K.S. Katagihallimath | Suptdg. Engineer, Elec., Technical & Member(Convener) |
| 6. Er. B. Lingashettar | Suptdg. Engineer, Elec., Planning & Member. |
| 7. Er. K.T. Narayana Swamy | Suptdg. Engineer, Elec., (P&M) & Member. |
| 8. Er. B.M. Ramesh | Suptdg. Engineer, (Ele), Trans (M), BMAZ & Member. |
| 9. Er. M.R. Narasimhachar | Suptdg. Engineer, (Ele), RT Circle, Bangalore & Member. |
| 10. Er. Vasantha Kumar | Suptdg. Engineer, (Ele), Trans (M), BRAZ & Member. |
| 11. Er. B.K. Sumithra | Suptdg. Engineer, (Ele), R&D & Member. |
| 12. Er. Prafullachandra | Exe. Engineer (Elec), Hoody (M) div. & Member. |
| 13. Er. Gopalakrishna | Exe. Engr. (Elec), 400KV Stn Nelamangala & Member. |
| 14. Er. Girish | Asst. Exe. Engr. (Elec), Hoody (M) div. & Member. |

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The Draft Manual prepared by the Working Group was discussed and finalised by the Corporate office.

I sincerely thank all the Members of the Working Group and the Core Group for their efforts in bringing out the Manual.

It is hoped that the guidelines given in the Manual would be useful to the Maintenance Engineers of Sub-Stations and if followed scrupulously, it is bound to reduce interruptions and failures resulting in substantial economy by way of reduced replacement costs and increased revenue.



*Chief Engineer, Electy.,
P&C, KPTCL,*

Karnataka Power Transmission Corporation Limited

Mission Statement

The Mission of the Karnataka Power Transmission Corporation Limited is to ensure reliable quality power to its customers at competitive prices.

The Karnataka Power Transmission Corporation Limited is committed to achieving this mission through :

- ✓ Encouraging best practices in transmission and distribution.
- ✓ Ensuring high order maintenance of its technical facilities.
- ✓ Emphasising the best standards in customer service.

To be the best electricity utility in the Country, the Karnataka Power Transmission Corporation Limited pledges to optimise its human and technical resources for the benefit of all its customers.

Karnataka Power Transmission Corporation Limited

Maintenance Schedule for Sub-Stations

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REVISION RECORD

DATE	PAGE NO	REVISION No.	NATURE OF REVISION
27-9-03	08	R1	<p>Clause: Daily, Quarterly Re-arranged as Daily, Weekly, Monthly, Quarterly, Half yearly and Yearly.</p> <p>Clause: A Item 1. Modified 6. Shifted to half yearly</p>
	09	R1	<p>Clause: A 6.b. shifted to half yearly & modified 7 - shifted to yearly Clause: B Item 3 - Modified and shifted to yearly 4- Shifted to weekly 7 - Shifted to weekly 8 - Shifted to half yearly 11- Shifted to half yearly 13- Shifted to half yearly</p>
	10	R1	<p>Clause: E- Item 5 added</p> <p>Clause: F- Items 6 & 8 added</p>
	11	R1	<p>Clause: A- Item 1 modified</p> <p>Clause: B Item 4 shifted to weekly Item 8 & 9 added</p>
	12	R1	<p>Clause: C- Item 5 added</p> <p>Clause: D- Item 5 modified</p>

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MAINTENANCE SCHEDULE FOR SUB - STATIONS	PAGE NO.	07.a
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REVISION RECORD

DATE	PAGE NO	REVISION No.	NATURE OF REVISION
27-9-03	13	R1	Clause: F- Item 10 - Modified
	17	R1	Item No. 18- Deleted New Item -18 19&20 Added
	18	R1	Testing Procedure added
	20	R1	Under Polarization Index values last para deleted
	28	R1	Item 14 & 15 added
	37	R1	Item No 20 added
	40	R1	Item No 48 to 59 added
	41	R1	Item No 17 to 27 added
	49	R0	New item included
	50	R0	New item included

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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 in Breathers. Silicagel in Breathers shall be reconditioned if found necessary.
- 4) Recording the No. of OLTC Operations in the Day and recording cumulative No. of operations.
- 5) Observing any abnormal change in transformer humming.
- 6) Cleaning of Out Door Yard, Earth Electrode Pits etc.
- 7) Inspection of ODY for any Arcing/Oil Leakages.
- 8) Operation of D.G. Set if provided & to run for 10-minutes for its Battery Charging.
- 9) Review of Log Books/Reports of Shift Engineers.

WEEKLY

- 1) Inspection of Level of Electrolyte in Batteries & Top - up with Distilled Water if necessary.
- 2) Inspection of Level & Condition of Oil in Air Compressors.
- 3) Draining of condensed water in the Air receiver tanks of breakers as and when required.
- 4) Checking of Auto Start/ Stop of Compressors/Pumps of breakers.
- 5) Checking of Alarm & Lock Out for Air/Gas in breakers.

MONTHLY

1. Cleaning & Applying Petroleum Jelly for battery terminals.

QUARTERLY

A) TRANSFORMERS :-

- 1) Cleaning of all HV/LV Bushing, Checking Bushing Oil Level and earthing cap of capacitor bushing for tightness by taking necessary line clear.
- 2) Checking of Cooling Fans, Pumps, Oil Coolers wherever provided for 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.
- 5) Air Release in Main Tanks, Bucholtz Relays, Bushing turret, etc.- during shutdown period.

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<p>6) Checking of Transformer Alarm Circuits/Trip circuit.</p> <p>7) Transformer Neutral Earth Connections at both ends & Tightening of Connectors.</p> <p>8) Check for pressure in Nitrogen Injection fire protection system.</p> <p>B) <u>BREAKERS</u> :-</p> <ol style="list-style-type: none"> 1. Maintenance as per manufactures manual / recommendation to be done. 2. Check Compressed Air and SF6 Gas Pressures, if any Leaks, Rectify (In each pole for 220 KV Breakers). 3. Checking of Oil Leaks & Rectification. In case of BOCB, MOCB's, Hydraulic Operated Breaker Mechanism, Topping up if necessary. 4. Recording No. of Operation of Counters. 5. Lubrication of Operating & Linkage mechanisms as well as Trip & Close mechanism. 6. Replacing of oil in MOCBs as per manufacturers recommendation. 7. Checking of Breaker status indicator (Mechanical). 8. Tightening of clamps, jump connections, breaker assembly frame, foundation and structural bolts. 9. Tightening of Auxiliary Switches and checking of operating link. 10. Check closing and tripping of breaker through local/remote switch and relays. Check capacitor tripping device operation by removing the DC supply of the breaker. 11. Checking of pneumatic drive, Hydraulic fluid and SCADA operation wherever provided. 12. Checking of anti pumping relay. 13. Check for smooth movement of all contactors and spray of Rustlick for contactor mechanism. 14. Check for Vermin proofing. 15. Check for loose connection in control wiring. <p>C) <u>CT's, PT's & CVT's</u> :-</p> <ol style="list-style-type: none"> 1) Checking for Oil Leaks & Oil Level. (CT, PT & CVT). 2) Visual Inspection of HF Point Bushing for any damage & Earthing if not used for PLCC. (CVT). 3) Measurement of Voltages at Marshalling Box & Control Room in case of PT & CVT. 4) Cleaning. 		
Karnataka Power Transmission Corporation Limited		

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- 5) Checking & Tightning of Secondary Wiring & Vermin proof of Marshalling Box.
- 6) Check Earth Connection of Secondary Circuit.
- 7) Checking & Tightning of Jumps & Clamps (can be avoided if fire wedge connectors are provided.)

D) ISOLATORS(EB OR WITHOUT EB) :-

- 1) Check Linkages for Simultaneous Operation, Operating Mechanism, Stopper Bolts, dash pot etc.
- 2) Checking of Earth Switch Copper flexibles.
- 3) Earth Connections of Earth Blade.
- 4) Cleaning of Insulators & Checking for Cracks in the Insulators.
- 5) Checking of Interlocks.
- 6) Cleaning of Main Contacts, Earth Blade and Spring Assembly.
- 7) Applying Petroleum Jelly to contacts and lubrication of Moving Parts & Bearings.
- 8) Checking and Tightning of Jumps, Clamps.
- 9) Checking of Auxillary Switches and Control Wiring.
- 10) Checking operation of Isolator and indication/remote & SCADA.

E) CAPACITOR BANK :-

- 1) Checking of blown out external fuses.
- 2) Checking leakage of Oil / Bulging of Capacitors.
- 3) Capacitance Measurement and Balancing.
- 4) Checking of Clamps, Jumps and Earth Connections.
- 5) Milliamps meter readings to be recorded. Intimate to RT staff if it exceeds 10mA.

F) GENERAL :-

- 1) Out Door Yard Illumination Checking & Replacement of Bulbs etc.
- 2) Cleaning of Control & Relay Panels(Internal), Vermin Proof for Cable entry, Earth Connections.
- 3) Cleaning of Battery Charger & Checking of Earth Connections
- 4) Weighing of CO₂ Cylinders.
- 5) Checking of Fire Hydrant Extinguishers Systems (Wherever provided).
- 6) Switch off the Nitrogen Injection fire protection system when transformer is taken for maintenance purpose.
- 7) Check D.C. positive and negative voltages with references to Earth to know any D.C. Leakages.
- 8) Check all earth connections of the equipment.

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HALF YEARLY

Transformers

1. Measurement of IR Value's and Polarization Index for condition monitoring.
2. Testing of bottom oil of Main Tank for BDV.

Breakers

1. Changing of Compressor Oil.
2. Measuring IR values of breaker between contacts with breaker in open condition and between contacts and ground.
3. Tightening of Control Circuit terminals.

YEARLY

A) TRANSFORMERS :-

- 1) Testing of Main Tank Oil for DGA, PPM etc. as per IS - 1866 (At Research Centre, Bangalore).
- 2) Replace OLTC oil for every 5000 operations/once in a year whichever is early.
- 3) Check for Transformer Alarms, Trip Circuit for Bucholtz Relays, PRV, OLTC, Diverter etc. after switching off Nitrogen injection fire protection system.
- 4) Check Oil Level in OTI, WTI Sensor Pockets.
- 5) Tan - Delta and Capacitance Measurement (In association with R & D Centre).
- 6) Check Operation of Bucholtz Relay by external Air Injection for Alarm & Trip.
- 7) Check the Contactors for OLTC, Fan, Pump Control & Tightening of terminals & Vermin Proof of Marshalling Box.
- 8) Oil Temperature reading comparison with external Thermometer in OTI Pocket.
- 9) Checking Arcing Horn Gaps of Bushings.

B) E.H.V. BREAKERS :-

- 1) C.B. Timing Checks (In association with RT/Research).
- 2) Contact Resistance (In association with RT/Research).
- 3) Pole Discrepancy Relay Check including Checking of Alarm.
- 4) Operation of Lock Out Checks.
- 5) Measurement of Tan - Delta & Capacitance wherever applicable (Research & Development Centre)
- 6) Earth Connections Check.
- 7) Detailed Checkup of Breaker Operating Mechanism & Compressors/Lubrication of drive mechanism/Pneumatic drive.
- 8) Over hauling of breaker mechanism – as per manufactures recommendation
- 9) Over hauling of breaker interrupter – as per manufactures recommendation

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<p>C) <u>CTs, PTs, CVTs</u> :-</p> <ol style="list-style-type: none"> 1) Check Earth Connections. 2) Measure IR Values for Record & Comparison with Previous Values. 3) Checking of Primary Jumper Clamps & Primary Connections in C.T's. 4) Vermin Proof of Marshalling box and Secondary terminal box. 5) Measurement of Tan – Delta and capacitance for 220KV and above only <p>D) <u>LIGHTNING ARRESTORS</u> :-</p> <ol style="list-style-type: none"> 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. (Note the initial reading of leakage current. If the current measured is twice the initial reading, clean the LA. If the measured current does not decrease, replace the LA.) <p>E) <u>OUT DOOR YARD</u> :-</p> <ol style="list-style-type: none"> 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(Aluminium Strands not cut). 5) Apply Petroleum Jelly and tightening of Spacers in case of double conductor bus. 6) Incase of Rigid bus, tightening of clamps and expansion joints. <p>F) <u>GENERAL</u> :-</p> <ol style="list-style-type: none"> 1) Cleaning of Auxillary Transformer, Checking of HV/LV Connections, Neutral & Earth Electrode. 2) Checking of DC Emergency Lamps in Control Room. 3) Tightning of Cable, Connections, Breakers, Checking LT-AC Breaker, Operation, Vermin Proof for Cable Entry. 		
Karnataka Power Transmission Corporation Limited		

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- 4) Tightening of Cable Connections, Cleaning of Bus Bar, Panels, Vermin Proof of Cable Entry in DC Panels.
- 5) Painting of Transformers, Breakers, CTs, PTs, Isolators, Switchgears, Structures etc. as and when required.
- 6) 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.
- 7) Replenishing of Fire Extinguishers after every usage or if not operated, Once in a Year.
- 8) Painting of Name Plates and Phase Indications and Bay Indications and Earth Electrodes.
- 9) Earth Resistance testing of all equipments especially of Transformer Neutral and L.A.'s. (See. Appendix-E)
- 10) Calibration of relays and meters(by RT wing) Yearly.
- 11) Whenever 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

MONTHLY

1. Check Healthiness of VCB (Booklet to be referred for VCB).

QUARTERLY

1. Checking of tightness of DC and control circuits in the switchgear.
2. Check closing and tripping of breaker through control switch and tripping through relays, check for alarm indication and annunciation.
3. Measurement of IR values of breaker under open and close conditions and also 11KV bus.
4. Applying petroleum jelly for Auxiliary switches.

HALF YEARLY

- 1) Vermin Proof of all Cable Entry.
- 2) Cleaning of Mechanism & Lubricating, Tightening of all Bolts & Nuts.
- 3) Oil & Breaker Main & Auxiliary Contacts checking & Replacement if necessary whenever required in MOCB, BOCB.

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Maintenance Schedule for Sub-Stations

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- 4) Tightness of Cable Connection and IR Values of Cables.
- 5) Check for Earthing of Cable Sheath at D.P. Structure and connected Electrodes (in case of only 3 core cables).
- 6) Check for Earth connections of single core cable sheath either at Transformer end or Switchgear end (to be earthed at only one end).
- 7) Testing of SF₆ Gas Pressure Switches
YEARLY
 1. Checking Earthing of Switchgear, potheads, CTs, PTs, Isolators, Cables and D.P. structures.
 2. Bus Bar Cleaning, IR Values & tightening of Bus Bar Connections.
 3. Calibration of Relays and Meters (To be done in association with RT wing).

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Maintenance Schedule for Sub-Stations

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DETAILS OF TRANSFORMER MAINTENANCE :-

Sl. No.	Items to be Inspected	Inspection	Action Required
A	B	C	D
1.	Oil level.	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.	Top-up with Good New Tested Oil if Oil level is Low. If Low, Investigate and take Remedial Action. Top up Oil if Bushing is not Hermetically sealed.
2.	Testing of Oil	a) Check for BDV, min Values as per IS 1866 (2.5 mm gap) i) 145 KV and above: 50 KV <u>once in</u> ii) 72.5 - 145 KV : 40 KV <u>6 months</u> iii) Below 72.5 KV : 30 KV b) Oil Samples to be sent to R & D Center Once in six months for 220KV equipments. For other equipments once a year for test as per IS 1866.	Take action to restore quality of Oil, procedure for testing BDV as per Appendix - A. Sampling Method as per Appendix - B.
3.	Relief vent	Check for damage to Diaphragm	Replace if damaged.
4.	Breather	a) Check Oil Level in Cup. b) Check Colour of Silicagel. c) Ensure that the Air Passage is free in the Breather.	a) Fill Oil up to 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.

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5.	OLTC Counter (D)	a) Check Reading of Counter and verify its Working record the cumulative total of operations.	Rectify/Replace if Faulty. If not replaced 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 Bucholtz 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				

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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 and temperature to be compared with conventional Hg Thermometer.	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	Inspect Diverter Switch Contact, Resistor Arcing Contacts etc. for 25,000 operations	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 5Years	Inspect internally, Clean and Refill with clean oil.	
18	Painting	As and when required		
19	Cooler control cubicle, OLTC Marshalling box, drive mechanism	(Cleaning & making vermin proof)		
20	Tan-delta capacitance of bushing & windings	As per R&D advice		
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IR MEASUREMENT AND POLARISATION INDEX VALUE(PD) :-

Measurement of Insulation Resistance reveals the condition of Insulation (degree of dryness of Paper Insulation), presence of any foreign contamination's 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 :-

Sl. No.	No. of windings in the Transformer under test	Test terminals	IR value in MΩ	Temp. of winding	IR value in MΩ after effecting temp. correction.
1.	Two winding	(HV) to (Tank+LV) (LV) to (Tank+HV) (HV+LV) to (Tank)			
2.	Three winding	(HV) to (MV+LV+Tank) (LV) to (HV+MV+Tank) (HV+MV) to (LV+Tank) (HV+MV+LV) to (Tank)			
3.	Auto	(HV+MV) to (LV+Tank) (LV) to (HV+MV+Tank) (HV+MV+LV) to (Tank)			

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 1 Minute to 10 Minutes shall be recorded - Line terminal of the instrument shall be connected to winding.

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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°C-30°C=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.

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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

CONDITION

< 1

Dangerous

1 - 1.25

Poor

1.25 - 2

Fair

> 2

Good

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 (Methyl 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 130⁰C 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).

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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) Air passage between fins is to be cleaned to remove foreign objects.
- 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, 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 the 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.

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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 RT Division -- Yearly.
- 3) Take Safety Precautions as per safety manual.
- 4) Keep records of all the equipment along with nameplate details, pre-commissioning 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 70⁰C 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.

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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 Buchhotz 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 Bucholtz Relay.

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GUIDE LINES FOR RELEASING SAMPLE OF OIL FROM THE EQUIPMENTS.

1. Sampling from equipments should preferably be carried out while the equipment is operating normally or very shortly after de-energisation.
2. Use only clean & dry steel or amber colour glass container.
3. Take sample preferably in dry weather and avoid talking with one another while sampling.
4. An umbrella cover be provided in the direction of wind flow while draining sample.
5. Remove all visible dirt & dust from the valves by means of lint free clean cloth and run off sufficient quantity liquid (atleast one litre)
6. Don not use cotton waste or fiber material to clean the valve or container.
7. Rinse the container with the liquid being sampled. Fill the container by allowing the liquid (min/2 litres) being sampled to flow against the side of the container, thus avoiding entering air. It should be ensured that each of the sampling bottle is filled to 95% to 98% of its capacity. In case the steel container is used, ensure that the container is completely filled up.
8. Close the glass container by a cap or glass stopper and seal using insulation tape to avoid entry of air. Do not use rubber cock for any reason. Keep the sample bottle in dark place until the sample is being sent to R & D Centre
9. Before sending it to R & D centre, Verify the details such as name plate details, oil temperature, sampling date, quantity of oil, etc., on the label of the sampling bottle
10. Along with the details furnished under Sl. No. 9. the following details are to be furnished invariably.

A)Year of Manufacture	D)Tap changer if any whether it is integral part of isolated part
B)Date of commissioning of the transformer.	E)Details of Repairs (it any)
C)Last date of Filtration.	F)Any available data on transformer malfunctioning including bucholtz actuation or other relays.

- Important note :** I) Filtration has to be carried out only after recommendation from R & D Centre.
II) In case the oil sample is to be tested at field, after filtration under vacuum ensure that the oil sample attains room temperature, before testing.

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Maintenance for CTs, PTs, and CVTs				
Sl. No.	Items to be Inspected	Inspection	Action required, if inspection shows unsatisfactory condition.	
A	B	C	D	
1	Insulators.	Check for cleanliness & cracks.	Remove dust.	
2	Clamps & connectors.	Check for tightness & damages.	Tighten loose nuts & bolts. Replace damaged/defective clamps/connector/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 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 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 should be done as and when 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. Junction boxes should be made vermin proof	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.	
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9	Insulation resistance - half yearly	<p>Measure insulation resistance values after removing jumpers & 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 transformer 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. 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 one .</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 MRT/ Manufacturer for rectification of defective CVT.</p>
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Maintenance for CTs, PTs, and CVTs.

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.

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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) (Page 30) 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 inlet 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, (Page 33) until gassing starts.(Approximately 2.4V/Cell). The recharging current is reduced to the finishing current as given at item No. 8, (Page 33) 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.

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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 1200.
14. Electrolyte level to be maintained slightly below the maximum level marked.
15. Only lead coated bolt and nuts are to be used for the battery connection.

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MAINTENANCE SCHEDULE FOR STATIONARY BATTERY SET AND BATTERY CHARGER AT SUB-STATIONS.

Sl. No.	Items to be Inspected	Inspection	Action required, if inspection shows unsatisfactory condition.				
A	B	C	D				
1.	Float charger Auto mode.	Float charger out-put voltage should be between the values given: - <table border="0"><tr><td><u>110V Battery Set</u></td><td><u>220V Battery Set</u></td></tr><tr><td>118 V to 121 V</td><td>236 V to 242 V</td></tr></table>	<u>110V Battery Set</u>	<u>220V Battery Set</u>	118 V to 121 V	236 V to 242 V	If necessary charger be operated in manual mode & voltage maintained within specified limits.
<u>110V Battery Set</u>	<u>220V Battery Set</u>						
118 V to 121 V	236 V to 242 V						
2	Battery set connected to load.	Switch off the float charger a) Observe D.C. Voltage: - In case DC voltage disappears as soon as the float charger is switched off or DC Voltage appears less than the required voltage then float charger is to be immediately switched on. b) Check that the battery is supplying the load by observing charge/discharge ammeter, which should show load current to normal value.	This indicates some open circuit or blown fuse in the battery circuit. Investigate & rectify fault. If the battery set is not taking the load, it means that either there is some resistance in the battery circuit or the batteries have become discharged. Investigate & rectify fault.				

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3	Specific gravity, electrolyte level and voltage of all the cells.	a) After switching off the charger [Follow precautions at item No. 2 (a) above], check specific gravity and voltage of all cell and temperature of any 2 cells. b) Return charger to normal operation. Convert specific gravity readings to 27°C [SG 27°C = SG t + 0.7(t - 27°C)]. The values of specific gravity at 27°C & voltage should be as below:-				a. (i.) If specific gravity is higher than upper limit, replace a little quantity of electrolyte by an equal quantity of distilled water by using discretion (See Instruction No.11). a. (ii) If the specific gravity or voltage of any or more cell is lower than the lower limit, charge the battery set as a whole for short duration at the current given below so that the lower specific gravity cells could improve to the required value.		
		Sl. No.	Make	Specific Gravity At.27°C	Voltage	Sl. No.	Make	Charging Current
		i)	STANDARD	1210+/- 5	2.0 V min.	i)	STANDARD	2.5% of AH Capacity
		ii)	AMCO	1200+/- 5	2.0 V min.	ii)	AMCO	4.0 % of AH Capacity.
		iii)	EXIDE	1200+/- 5	2.0 V min.	iii)	EXIDE	4.0 % of AH Capacity.
						a. (iii) If the specific gravity in a majority of cells have fallen below 1195(27°C) for standard make battery cells and below 1185 (27°C) for Exide and Amco make Battery cells or the voltage has fallen below 2.0V, then the battery set should be charged as per procedure at item No. 8 a. (iv) If in spite of charging as given at a. (ii) and a (iii) above, the specific gravity or voltage of some of the cells does not attain required values, then these cells are to be considered weak cells and treated in accordance with instruction No. 6.		

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		<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>b. (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>	
4	Battery Cells	Check for cleanliness & dust/moisture deposits and leakages	<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)	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>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 charger 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>	
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6.	Corroded terminals	<ul style="list-style-type: none"> a) Check for sulphate deposits on terminals of cells and intercell connectors and nuts and bolts b) Check for corroded/damaged terminals, intercell connectors, nuts and bolts. c) Check bolts and nuts for tightness. d) Check vent plugs. 	<ul style="list-style-type: none"> a) For removing sulphate deposits, temporarily by-pass the intercell connector using robust & reliable connection. One intercell connection 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. 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. c) Tighten bolts and nuts found loose. d) Wash all vent plugs by immersing in a bucket of water, wipe them clean and re-fix. 	
7.	Battery Charger	<ul style="list-style-type: none"> i) Check for cleanliness & loose connections 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. 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. 	<ul style="list-style-type: none"> (i) Clean with blower. Tighten loose connections. (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. (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. 	
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8. 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).

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

By this discharge, the battery set has a higher probability of longer life. The discharge and charging helps to correct some imbalances also.

Sl. No.	Make	Recharge Current	Finishing Current	Specific Gravity 27°C
(i)	Standard 400 AH Cap.	40 amp.	20 amps.	1210+/-5
(ii)	Standard 300 AH Cap.	30 amp.	15 amps.	1210+/-5
(iii)	Standard 100 AH Cap.	10 amp.	5 amps.	1210+/-5
(iv)	Amco 400 AH Cap.	56 amp.	28 amps.	1200+/-5
(v)	Amco 300 AH Cap.	42 amp.	21 amps.	1200+/-5
(vi)	Amco 100 AH Cap.	14 amp.	7 amps.	1200+/-5

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		(vii) Exide 40 amp. 20 amps. 1200+/-5 400 AH Cap.		
		(viii) Exide 30 amp. 15 amps. 1200+/-5 300 AH Cap.		
		(ix) Exide 10 amp. 5 amps. 1200+/-5 100 AH Cap.		
9.	Battery Stand and Room(Yearly)	Clean the stand and insulators under the battery cells.		Replace/repair damages, Paint stand if required, with anti acidic paint for stand and room.
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MAINTENANCE OF :-

D. G. SETs :-

- a. Inspection of water in radiators.
- b. Circulation of oil in cranks 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 Manufactures 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 vaccum pump.
- d. Checking up of Vaccum gauges, Thermometers, Thermostat & Electrical wiring etc.
- e. Periodical overhauling.
- f. Checking of leaks in oil piping.
(For details of Maintenance Refer Manufactures 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 Manufactures Manual).

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3. OVERHEAD CRANES :-

ACTIVITY	QLY.	H/Y 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 Manufacturers Manual).	✓		

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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 (if possible).
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.
20. Single core power cable sheath should be earthed only at one end preferably at the source end.

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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 CBs. for issuing L/C on 11 KV on any 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 CB 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.
14. Do not test charge the transformer when the transformer breaker tripped on REFR, Differential relay, buckholtz relay, oil surge relay etc.,

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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 pliers 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. Allign key set.
22. Box spanner set.
23. D.E. Spanner Set.
24. Transil oil dielectric breakdown test kit.
25. Insulation Megger 2.5 - 5 KV.
26. Insulation Megger 500 V.
27. SF6 gas leak detector.
28. Multimeter Electromechanical.

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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 Polypropylene Ropes.
45. Single and Double Sleeve pulley.
46. Phase sequence Indicator.
47. Nylon Faced Wooden Hammer.
48. Bridging clamp (for bypassing individual cell)
49. Thermometer
50. Gas filling equipment with adapters.
51. Vacuum cleaner cum blower.
52. Portable hand drilling machine up to half inch drill
53. Drilling machine stand mounted.
54. Hydraulic type bolt cutter.
55. Bench vice
56. Hacksaw frame
57. Files
58. Torque wrench
59. Measuring tape steel 30 mtrs.

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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).
17. Rust cleaning agent
18. Neoprene gasket sheet of sizes 3mm / 4mm / 6mm thickness
19. Adhesives
20. Spare clamps of various types and sizes
21. Hacksaw blades
22. CRC insulation spray
23. CRC battery terminal coating spray
24. Trichloro-ethylene liquid
25. Transformer oil
26. SF6 gas cylinder
27. Bolt and nuts of various sizes.

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)

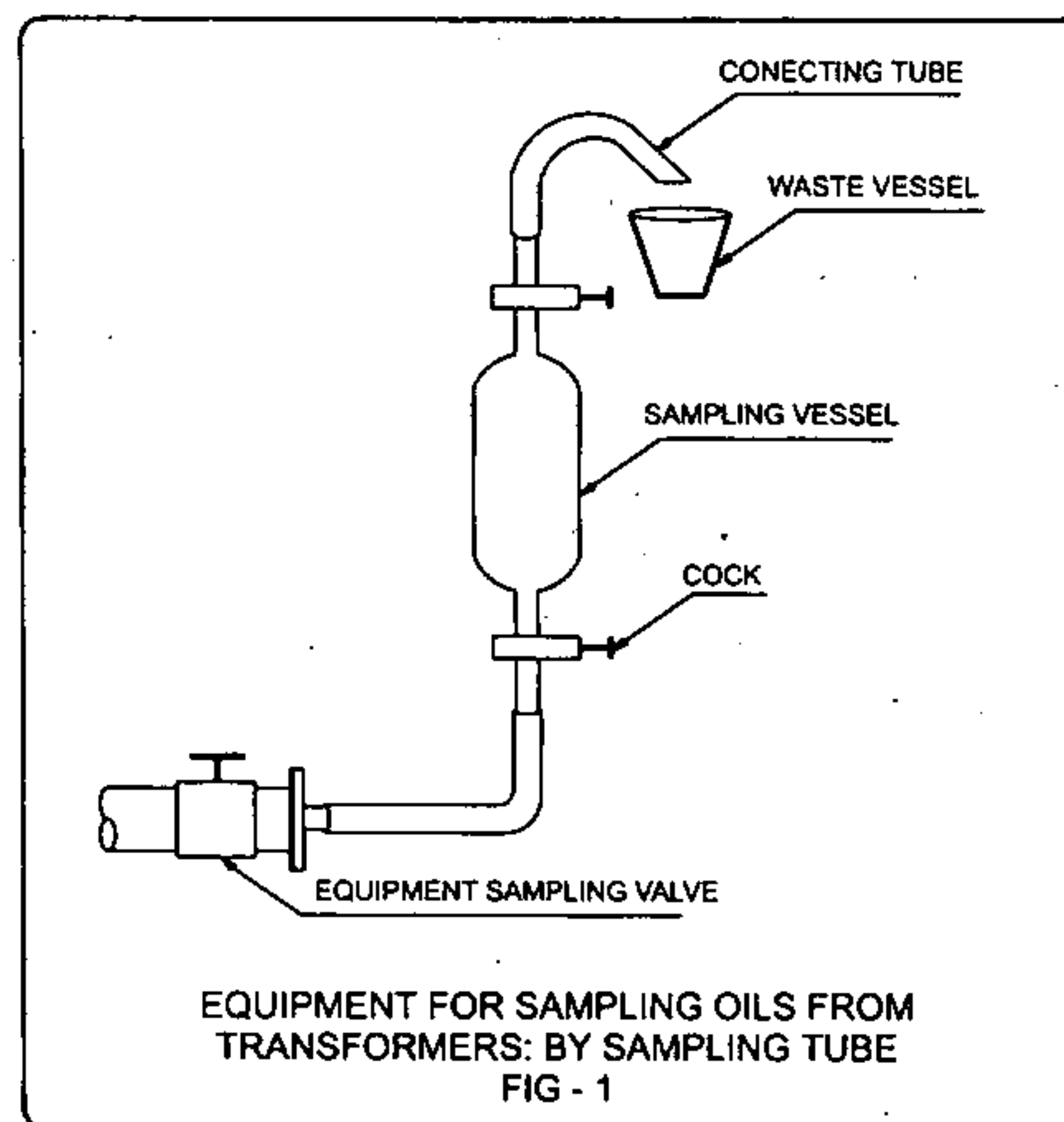
1. The test consists in applying to the electrodes an increasing AC Voltage, the rate of increase of the voltage being uniform and equal to approximately 2 KV starting from zero up to the value producing breakdown.
2. The circuit is opened manually if a transient spark (audible or visible) occurs between the electrodes, and gets opened 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 and gets opened whether it is 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)

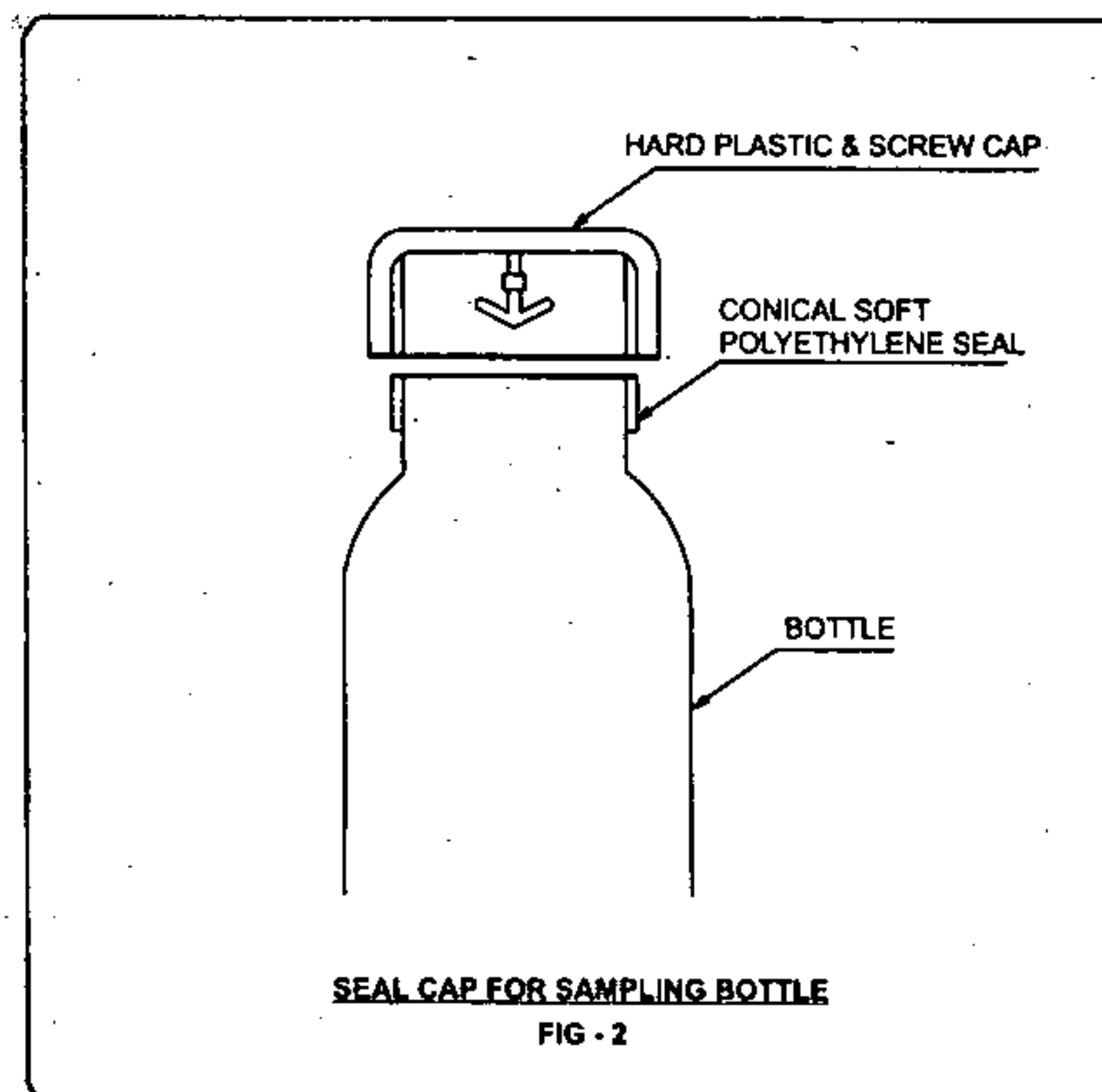
1. SAMPLING BY SAMPLING TUBE :

- 1.1 The sampling tube (see fig-1), may be of glass or metal and of volume 1 liter. 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.



2. SAMPLING BY BOTTLES :

- 2.1 The method requires the use of bottles or container capable of being sealed gas tight. Sampling bottles shall 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 liter 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 1mm to 2mm from from the rim and the bottle cap is placed in position. The sampling valve is then closed.



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

In the event of operation of main Bucholtz 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:

<u>COLOUR OF GAS</u>	<u>IDENTIFICATION</u>
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 Bucholtz 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.

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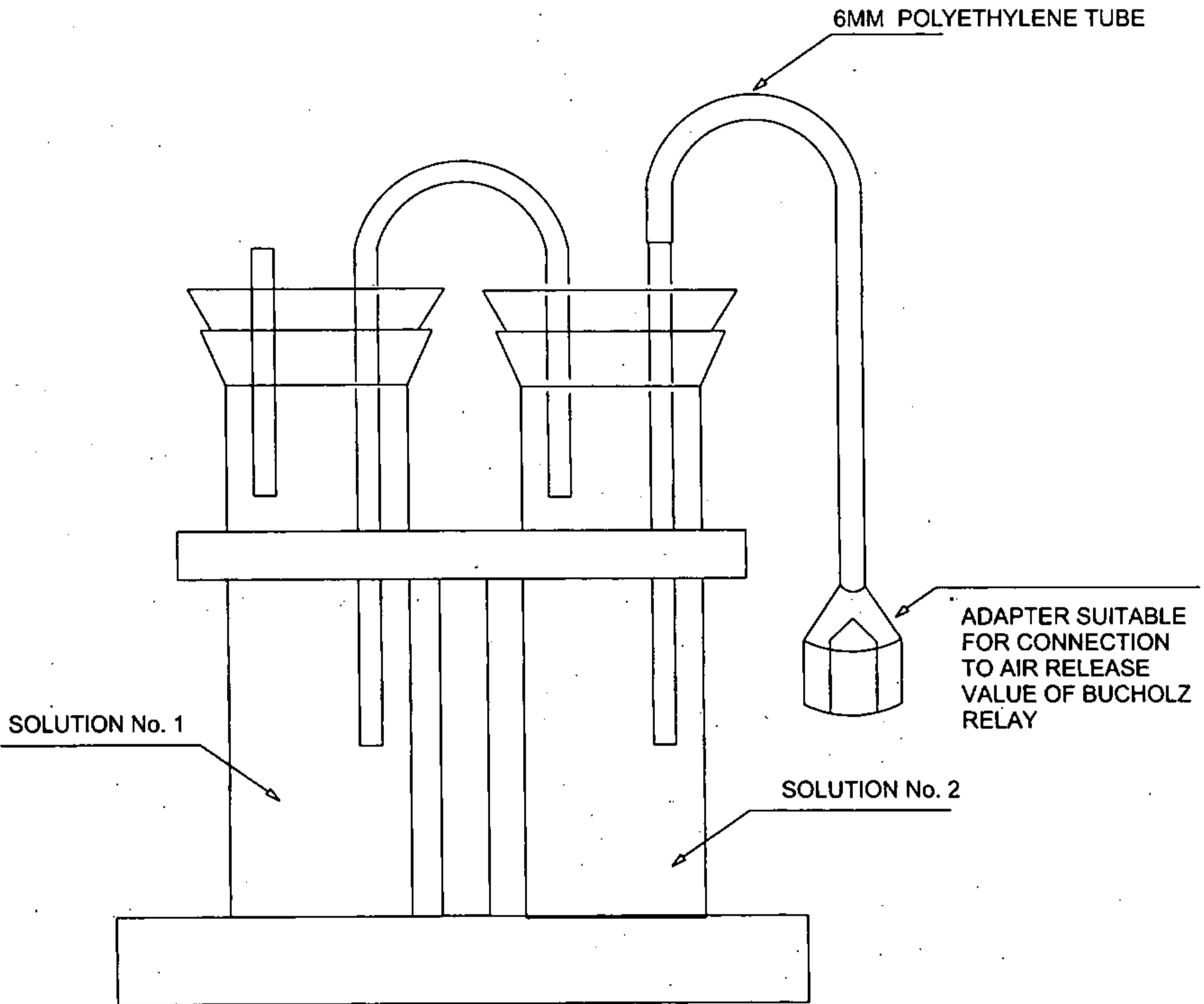
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SOLUTION No. - 1 : Five grams of Silver Nitrate(AgNO_3) dissolved in 100 ml. of distilled water.

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 are allowed to pass through the Solution No. - 2 first and then through solution No. 1 as illustrated.

The results are identified as follows :-

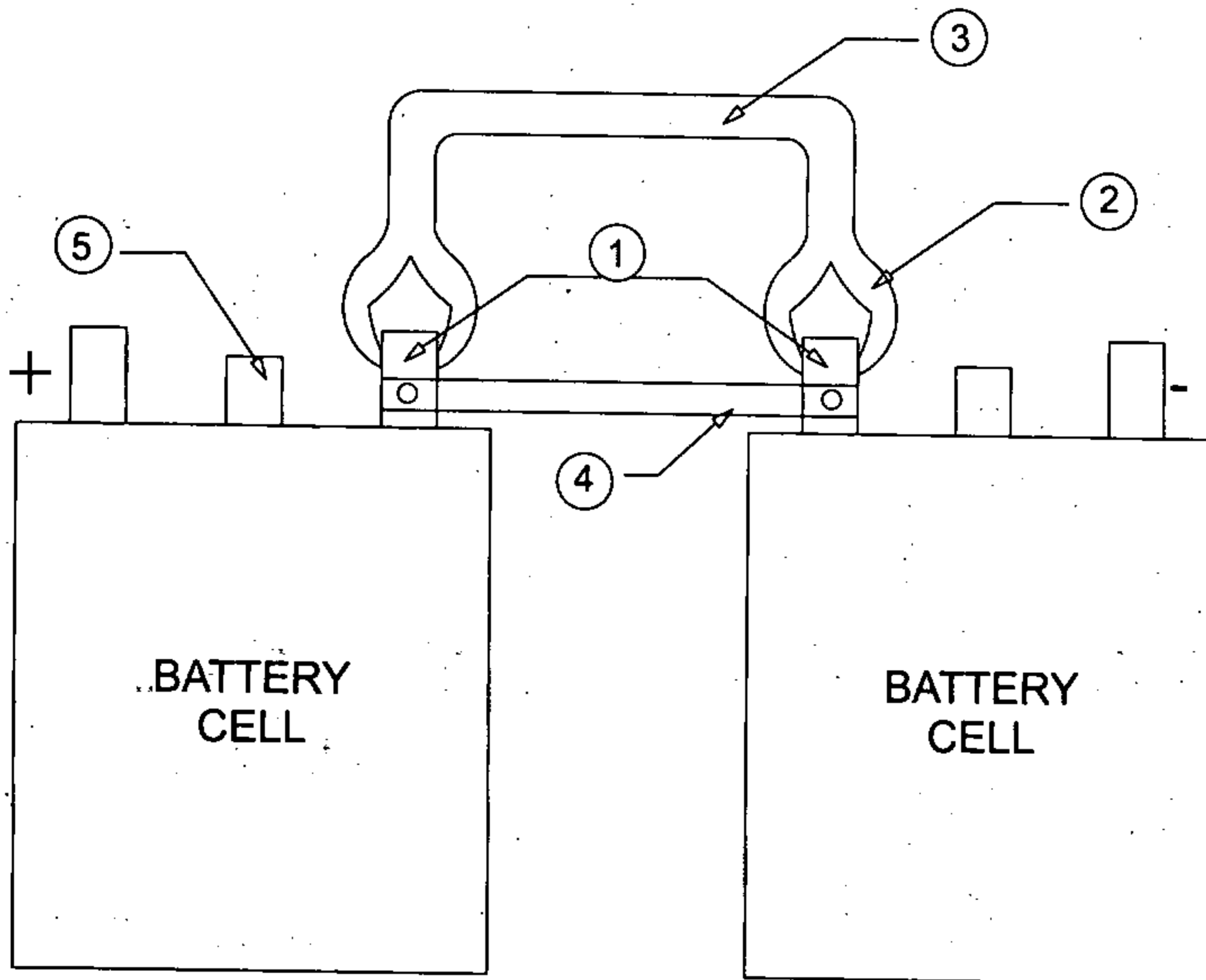
- a) Both Solutions are clear : Gas in air.
- b) Solution No.-1 : White precipitate turning
brown on exposure to sunlight : Gas of oil decomposition.
- c) Solution No. -2 : Turning to dark brown precipitate : Gas of decomposed paper, cotton or wood insulation.



APPARATUS FOR GAS ANALYSIS

FIG - 3

APPENDIX - D



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

FIG - 4

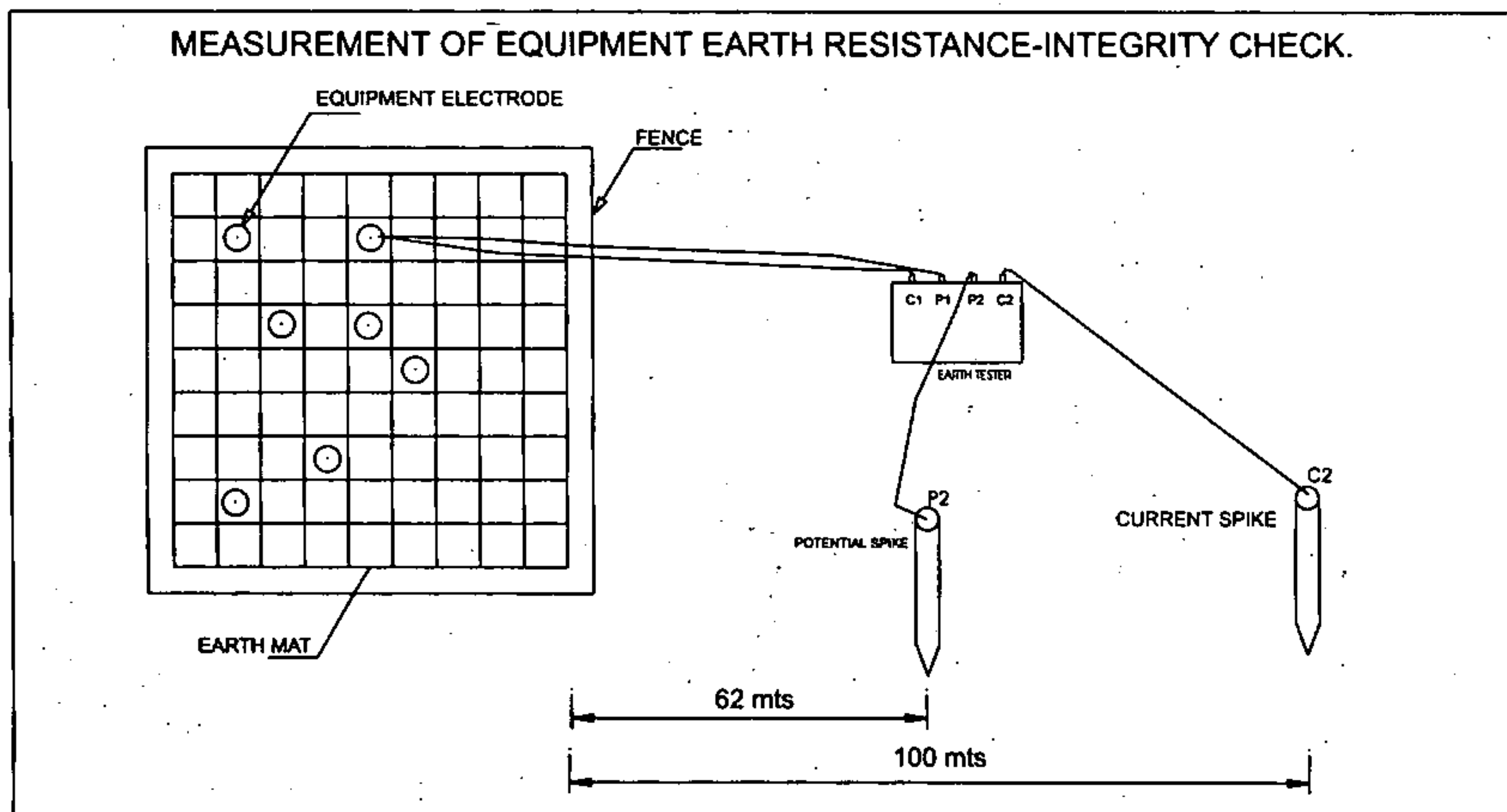
APPENDIX - E

EARTHING INTEGRITY CHECK IN SUBSTATIONS

The equipment earth connection to the substation earthmat play an important role in protecting the equipment from damage and for proper operation of protective relays during fault condition.

An earth connection integrity check can be made with the help of an Analog or Digital type of earth tester

The test set up is shown below.



1. C2 Current spike shall be driven at 100mtr from the edge of the Earthmat and connected C2 terminal of a Earth Tester.
2. P2 Potential spike shall be driven at 62mts from the edge of the Earthmat and connected to P2 terminal of the Tester through a lead.
3. Two separate leads from C1 & P1 terminals of earth tester shall be connected to the equipment earth connection and resistance measured.
4. Then move C1 & P1 lead to other equipment earth connection and record the resistance. Repeat till all earth connection are measured.

If all the readings are in agreement within small percentage variation, then the integrity of earth connections is good.

If some earth connection shows higher values and is not in agreement, then the integrity of earth connection is in doubt.

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The earth connection at the equipment/electrode/earthmat shall be checked for electrical soundness and attended to whenever higher values of resistance are recorded during integrity check. The salient points to be observed with reference to older designs of earthing system and the new design evolved in R& D are as noted below.

Sl. No	Old Earthing System	New Earthing System
1.	In old design copper conductors/strips for earthmat, copper/bunched GI wires for equipment earthing, and GI pipes electrodes for individual equipments are suggested.	In new design, MS flats for earthmat, GI flats for equipment earthing and CI pipes electrodes for individual equipment are suggested.
2.	Bolt & Nut connections at the electrodes should be free from rust and must be tight and electrically sound. Lugs for end termination should be inspected for melting of lead (crimping of lugs is better).	Welding connections at the electrodes should be sound with welding on all four sides and the welded portion shall be applied with 2 coats of thick ACB paint duly removing deposited weld, flux and burr's.
3.	The earthing leads shall be inspected for any rusting/broken condition and replaced wherever required.	The flats provided generally remain intact for its life period, unless otherwise physically damaged, or under extreme Soil/Weather conditions.
4.	GI pipe electrodes might have rusted at the reducing collar or the main GI pipe itself may be totally rusted.	The CI pipes generally do not rust. Welded portion of the split clamp shall be checked for its soundness.
5.	There may be number of joints in the earth wire leads. Avoid joins and as far as possible use a through lead.	As far as possible use continuous MS/GI flats. Avoid joints. If joints are inevitable use lap joints, so that the overlap length is equal to a minimum of the flats width. The overlap portion shall be welded on all four sides by continuous welding and apply ACB paint as explained in (2).

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