INSPECTION AND SAFE PRACTICES
DURING OVERHAULING ELECTRICAL EQUIPMENT

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INSPECTION AND SAFE PRACTICES
DURING OVERHAULING ELECTRICAL EQUIPMENT

Prepared by

COMMITTEE ON
INSPECTION AND MAINTENANCE OF ELECTRICAL EQUIPMENT

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Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stakeholders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director
Oil Industry Safety Directorate
FOREWORD

The Oil Industry in India is 100 years old. Due to various collaboration agreements, a variety of international codes, standards and practices are in vogue. Standardisation in design philosophies operating and maintenance practices at a national level were hardly in existence. This, coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the then Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly OISD constituted a number of functional committees comprising of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present standard on "Inspection and Safe Practices during Overhauling Electrical Equipment" was prepared by the Functional Committee on "Inspection and Maintenance of Electrical Equipment". This document, based on the accumulated knowledge and experience of industry members and the various national and international codes and practices, is meant to be used as a supplement and not as a replacement for existing codes standards and manufacturer's recommendations.

It is hoped that the provision of this standard, if implemented objectively, may go a long way to improve the safety and reduce accidents in the Oil and Gas Industry. The users of this document are cautioned that no standard can be a substitute for a responsible and experienced engineer.

Suggestions are invited from the users after it is put into practice to improve the document further. Suggestions for amendments, if any, to this standard should be addressed to:

The Coordinator,
Committee on
"Inspection And safe practices during overhauling electrical equipments"

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These documents are intended to supplement rather than replace the prevailing statutory requirements.
# COMMITTEE ON INSPECTION AND MAINTENANCE OF ELECTRICAL EQUIPMENT

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In addition to the above, several other experts from Industry contributed in the preparation, review and finalisation of this document.
# INSPECTION & SAFE PRACTICES DURING OVERHAULING ELECTRICAL EQUIPMENT

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INSPECTION & SAFE PRACTICES DURING OVERHAULING ELECTRICAL EQUIPMENT

1.0 INTRODUCTION

Safety of electrical system is ensured only when the system is efficiently maintained and properly operated. The maintenance function involves the provision and up-keep of good physical and safe working condition of an equipment. A meticulous maintenance can prolong the period of safe and effective service of an equipment.

What standards plant maintenance must achieve is clear by the very definition of the word 'Maintenance' meaning "to hold or to keep in a particular good and safe working condition or as good as new machine". In real sense this can be achieved only by a systematic preventive maintenance inspection and period overhauling. Inspection requirements were already dealt in the earlier OISD publication (OISD-STD-137). The present document discusses recommended practices and procedures during periodic overhauling major electrical equipment. Compliance with these recommendations will go a long way for ensuring safer plant operation. For overhauling, complete technical details of the equipment should be well documented. The manpower engaged for the overhauling should be competent to understand all the technical details pertaining to the equipment. Since design of electrical equipment changes from manufacturer to manufacturer and from time to time, there should be a standard check list for inspection items during overhauling. The checklists provided in this document supplement the requirement laid down by manufacturer/supplier of the equipment.

2.0 SCOPE

This document recommends safe practices and procedures for overhauling major electrical equipment (such as Large Motors, Transformers, Generators, HT/LT circuit breakers and Switchyard Equipment) which are presented in the form of checklist.

3.0 DEFINITION

"Overhauling" as mentioned in this document means capital overhauling where each and every part of the equipment is inspected (after its complete dismantling) and abnormalities whatever observed are rectified with the view to bring back the equipment to its original condition for totally troublefree and safe operation. It differs from routine preventive and breakdown maintenance where inspection is limited to important part or parts which are likely to fail or have failed.

4.0 GENERAL REQUIREMENTS

Before commencement of overhauling activity, the following preparatory jobs & availability of facilities in working condition should be completed/ensured:

i) Operation/maintenance instruction manuals, as built installation/ interconnection drawings and other documentation of the equipment are available.

ii) Detailed scheduling of jobs listing out all activities and resource requirements.

iii) Right type of instruments, testing equipment, tool & tackles, and consumables (such as white spirit, solvents, tintless muslin cloth etc.) should be arranged as per jobwise requirements, based on instruction manuals.

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iv) Test procedures and Pre-commissioning checks as specified in OISD-137 should be followed.

v) Testing instruments such as milli-volt, milli ohm meters, doctors, motorised megger, High Voltage Testing Kit etc.

vi) Lifting facilities such as overhead crane, slings etc.

vii) Stands for keeping generator and exciter rotors.

viii) Planning and scheduling the jobs with other groups (such as Mechanical) to avoid any interference.

ix) Spares (such as gaskets, carbon brushes, insulating materials, insulation varnishes etc.)

x) Temporary site office with facility to record all the measurements, test results, consumption of man-hours, spares and consumables etc. for future reference.

xi) Other preparatory items such as rotor lifting beams and other special tools as recommended by manufacturer.

xii) Jigs, fixtures and such devices required for overhauling.

xiii) Personnel engaged to handle the job are experienced and skilled.

xiv) Usage of spring washers and double nuts for securing locking of terminals.

xv) In case of water cooled equipment, cooling water is isolated and cooler drained.

xvi) Disconnect the fire extinguisher system integral to the generator.

xvii) Whenever paint has come off or pulled off or any signs of corrosion observed all such metallic structures should be painted.

xviii) All valves (such as drain/sampling and isolation valves) should be serviced for proper operation.

xix) Incoming electric power and auxiliary supplies are de-energised and are positively isolated (from all possible sources) locked out (through a permit system) throughout the duration of overhauling work and a caution board indicating the nature of work should be displayed near the isolating point.

xx) While using flammable materials (such as solvent), following precautions should be taken:

   a) No hot job is going on nearby.
   b) Area is well ventilated
   c) Winding is protected from such inflammable materials.
   d) Other precautions such as periodic tests to ensure absence of gas concentration.

xxi) The fitting of antifriction bearing shall be carried out by process of controlled heating only(preferably by induction heating).

xxii) Oil, grease lubricant specified shall be of proper grade and free of contamination.

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xxiii) All works should be carried out with covered enclosures for weather and environment protection, to avoid entry of moisture, contamination, dust etc. in the equipment being overhauled. The work should not be planned in open, in rainy season and in the water logged areas.

xxiv) Use of any combustible material like bamboos, coir rope and tarpaulin should be avoided.

xxv) Fasteners should be checked before use and be replaced if necessary.

xxvi) Additional checks as required depending upon are quenching medium of Breakers, such as SF6, vacuum etc. as per manufacturer’s recommendations.

xxvii) All safety and operational interlocks should be checked for proper operation. Control circuit operations shall be checked by simulating fault conditions.

xxviii) In case of equipment used in hazardous areas during overhauling only approved types of gaskets, fasteners, seals and other accessories should be used, appropriate to the area classification.

xxix) Frequency of overhauling shall be generally as recommended by manufacturer. However as a guideline, following frequency may be followed:

- Generator : after every 32,000 operating hours.
- Motors : after every 20,000 operating hours.
- Switchgear: for Panels, after every 3 years. In case of Breakers it should be after every 3 years or after clearing 5 successive (short circuits) faults, whichever is earlier.
  a) Transformer : after every 10 years.

Note: After dismantling of the equipment, all components be visually inspected and abnormalities observed be recorded, and corrective action taken. Thereafter during overhauling the sequence of activities and checks as listed under following sections/sub-sections should be adhered to.

5.0 GENERATOR AND AUXILIARIES

General requirements detailed in 4.0 should be taken care of before commencing overhauling activities.

5.1 PRE-SHUTDOWN JOBS AND PRELIMINARY CHECKS

i) Record vibration level at various loads.

ii) Other relevant parameters/operation records be collected when the turbine is brought down after cutting off from busbar.

iii) Note the insulation resistance of the generator immediately after putting the machine on barring gear and repeat the same every six hours till winding temperature is stabilised.

iv) Megger the DC system after removing slipring brushes and record the value. Use only 500/250 Volt megger.

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5.2 EXCITER

i) Remove protection cover and blow off dust with dry compressed air.

ii) Measure air gap at Main pole and Aux-pole.

iii) Open terminal connections and mark polarity.

iv) Mark the brush staggering holder alignment and neutral position and remove carbon brushes and brush holders.

v) Decouple exciter from the Generator and open the foundation bolts. Lift the exciter body and place the same at the working place.

vi) Open the bearing cover and remove the bearings.

vii) Remove rotor (Armature) from the stator(field) and takeout the coupling flange.

viii) Clean the winding of the rotor, using dry compressed air, finally with approved cleaning agent.

ix) Measure and record diameter of Commutator. Check if commutator has become oval. If there is abnormal pitting on the surface arrange turning if necessary. Under-cutting the mica and chamfering bars of the commutator will be necessary after turning.

x) Varnish the rotor after heating it. Use Flood light/Oven/Infra red lights for heating and use recommended grade of varnish only. Dry up the rotor.

xi) Remove end cover of Stator (field). Take out the insulating sleeve for the brush arm and clean with approved cleaning agent.

xii) Check for any abnormality on the poles, field winding and inter pole windings and clean the coil with brush/cloth, approved cleaning agent, if necessary, to remove dust from the winding.

xiii) Check tightness of connection, measure and record winding resistance for the main and inter pole windings.

xiv) Paint the exciter body and its protection cover.

xv) In case of brushless exciters, inspect and clean diode wheels, fuses and plug connections, if any, besides the stator and rotor.

5.3 GENERATOR ROTOR REMOVAL

i) Remove slipring brush holder assembly, measure and record diameter of both positive and negative rings. Check for any abnormal wear/pitting on the surface.

ii) Replace the shaft seal at outer covers.

iii) Disconnect and tag the slip ring terminals.

iv) Measure air gap between the stator and rotor at 4 points diametrically opposite and at right angle. This should be done for both turbine end and exciter end.
v) Open bearing cover. Check for clearances and abnormality, if any, on the bearing surface.

vi) Decouple the generator and record alignment readings.

vii) Remove bearings after ensuring that stator is not injured by threading out of rotor by inserting packing material (such as leatheroid etc.)

viii) Remove and place the rotor on the stand specially provided for.

ix) Check the rotor for any sign of overheating, mechanical abrasion, loose wedges etc. and clean it with compressed air and cloth.

x) Check the rotor end rings for any damage or crack by ultrasonic inspection method, or any other Non-destructive method.

xi) Check fan blades and hubs for erosion and cracks.

xii) Check that balancing weight is secured firmly.

xiii) Measure Insulation resistance of the rotor winding and compare it with design data.

xiv) Clean the rotor, and apply finish coat as recommended by the manufacturer. Dry up the rotor.

xv) While measuring IR values, electronic circuits, if any, should be kept isolated.

5.4   REMOVAL OF GENERATOR FROM FOUNDATION

i) Ensure that the base channel of the Generator and the body have matchmarks for reference alignment.

ii) Open/Remove the foundation bolts.

iii) Disconnect the main cable/flexible links and tag them.

iv) Remove RTD and space heater connections and remove thermometers if any.

v) Lift the Generator using appropriate lifting device provided for the purpose and shift to working place.

5.5   GENERATOR STATOR

i) Measure the Insulation resistance, Polarisation Index, Winding Resistance and Tan Delta (for generator of 6.3 KV and above) of stator.

ii) Clean stator windings and ventilating ducts with dry compressed air.

iii) Inspect for defects like

   a) Discolouration of winding(for hot spots)
   b) Loose missing slot wedges
   c) Intercoil spacers on overhangs.
   d) Broken overhang coil bindings for end supports.
   e) Protective coatings on the core steps at slot ends.

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5.6 BRUSH ASSEMBLY

i) Dismantle Brush Holder & clean it thoroughly.

ii) Check for any damaged Holder, worn-out spring and replace with new ones.

iii) Check and adjust spring tension.

iv) Clean Brush-arm with white spirit and put a coat of varnish. Measure Insulation Resistance between Holder and Arms.

v) Clean End Cover with cloth and petrol and paint if necessary.

5.7 GENERATOR ASSEMBLY

i) Arrange heating to improve Insulation Resistance of the winding using approved method of heating such as by welding generator or infrared lamps. Turn the rotor every hour to avoid localised heating. Measure temperature and insulation resistance (IR) every half an hour. Restrict temperature upto 80 deg. C. Stop heating if IR value is stabilised. In case welding generator is used, the heating current should be regulated only through regulator of welding generator and not through any switch. The drying out activity should be taken-up as a last activity just prior to final assembly.

ii) A coat of air drying varnish of recommended type shall be applied.

iii) Place the generator on the foundation after placing material in the bottom of stator.

iv) Insert rotor inside the stator carefully. Put packing material (such as leatheroid etc.) in the air gap between stator and rotor for protection.

v) Ensure that the Bearing has been cleaned, uneven surface, if any, has been removed by scrapping, and Bearing insulation is taken care, wherever provided.

vi) Align the Generator with Turbine. Check air gap and ensure it tallies with original gap. Box up the bearings.

vii) Check the pedestal pipe flange insulation and also the same for pipe connection & bolt. Replace if necessary, Box up the bearing.

viii) Connect all RTD, Thermometer, Generator terminals, Slipring connections and spaceheaters.

ix) Fix inner and outer End Cover.

x) Reassemble Slipring Brush Assembly and replace the carbon brushes with new duly grinded ones.

5.8 EXCITER ASSEMBLY

i) Insert the armature in the field taking due care. Adjust air under main & inter pole.

ii) Check the pedestal pipe flange insulation and also the same for pipe connection & bolt. Replace if necessary. Box up the bearing.

iii) Align and couple the Exciter with Generator. Make cable connection taking care of polarity.

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iv) Fix up the Brush Assembly taking care of staggering need. Measure gap between the Commutator and Brush holder. Fix up carbon brushes after proper bedding.

v) Check Neutral axis electrically by standard method and adjust the arm accordingly.

5.9 AIR CHAMBER AND BUS DUCT

i) Check for any leakage of water and other abnormality and clean the chamber.

ii) Clean Air Cooler. Test the cooler for any leakage by pressure test as recommended.

iii) Open the Busduct and clean, check tightness of connection. Now, meger the Busduct and the Cable between Bus duct and Generator Breaker separately. In case of low IR value, meger the insulators/CTs and PTs separately and find out defect and rectify.

iv) Check the condition of gaskets of bus duct covers and replace if necessary.

v) Water drainage and seal should be checked for proper functioning.

vi) Check Space Heaters if provided in the bus duct and ensure their proper working.

vii) Check Space Heater of Generator inside air duct and ensure the interlock.

viii) Check all other interlocks also, if provided.

ix) Paint the Busduct if necessary.

x) Make connections of the cable with bus duct and generator flexible link and take combined Insulation Resistance followed by High Voltage Test conducted at working voltage.

xi) Check the CO2 piping and nozzles and clean them if necessary.

5.10 FINAL CHECKING

i) Check RTDS (Resistance Temperature Detectors), if any, for proper functioning.

ii) Ensure that the relays have been checked by secondary injection method. Check the protection and interlocks by simulation test.

iii) Measure the IR (Insulation Resistance) value.

   If IR value is below permissible limits, drying out operation should be carried out. This drying out operation should be carried out by short circuit method. A coat of air drying varnish of recommended type can be applied if necessary.

iv) Carry out open circuit and short circuit characteristics tests and compare results with original one.

v) Check for final Tan Delta and PI (Polarisation Index) values.
6.0 MOTOR

After the compliance for General requirements detailed in 4.0, the following activities and checks should be carried out.

6.1 INITIAL JOBS

i) Ensure all incoming power and control cables to motor and auxiliary terminal boxes are disconnected and tagged.

ii) Before disconnecting power cables, phase sequence connection to be noted and recorded.

iii) Check that all external fittings such as thermometer etc. are removed.

iv) Check and record the Insulation Resistance and PI value of stator, winding resistance and inductance.

v) Check and record air gap values, wherever facility exists.

vi) Dismantle the motor as recommended by manufacturer. While removing the rotor, care should be taken to avoid damage to stator.

6.2 STATOR

i) Visually inspect for foreign particles, oil grease, sign of overheating and general condition. Check end rings for any damage.

ii) Check condition of the terminal box and the terminal insulators for any corrosion and overheating, pitting of terminal strips, tracking on insulators.

iii) Check space heaters in the stator.

iv) End shield having insulating ring should be checked for soundness.

v) Check for any crack/damage to stator body and foundation legs.

vi) Rebind loose fastening, if any, of the stator windings to bandage ring, inter coil spacers and packing between overhand portion of the winding.

vii) Tighten slot wedges by putting additional packing strips underneath the wedges.

viii) Blow off dirt and dust carefully by compressed air from winding overhang and ventilation ducts.

ix) Check that earthing terminals are in proper condition.

x) Water cooler should be checked for corrosive effects, if any, and corrective action be taken as needed.

6.3 ROTOR

i) Check condition of rotor for any hot spot.

ii) Check for cleanliness of ventilation ducts.
iii) Check balance weights for tightness, and take corrosive action if needed.

iv) Check fan blades for any cracks/damages and check for tightness of the shaft.

v) Check rotor bars and short circuiting rings for any crack and rectify, if necessary, as recommended by manufacturer.

6.4 ANTIFRICTION BEARINGS AND SHAFT

i) Check for visible sign of corrosion, overheating, damage due to fretting or creep & replace if necessary.

ii) Check wear of roughness by hand rotation for corrosion, pitting in inner/outer race, deformation in the cage and measure radial internal clearance.

iii) Check condition of rotor shaft for any wear by measurements where bearing is fitted. In case of ovality and looseness, rebuild and machine to proper size.

iv) Check the key way of the coupling half for any loose fitting/cracks.

v) Check for cleanliness and proper functioning of Grease nipple/pipe.

6.5 SLEEVE BEARING

i) Check condition of the shaft journal or sleeve surfaces for any damage and scoring which may be removed by scrapping.

ii) Check contact area and clearances of bearing. For serious damage re-babbitting of sleeve is necessary.

iii) Refilling of oil of proper grade should be done after flushing and cleaning the surface/housing.

iv) Check for cleanliness of oil level gauge, if any.

v) Check for cleanliness and cracks of bearing end covers. Also, check condition of oil, clearances and contact area.

vi) For motors with insulated bearings/ pedestals, the insulation sleeve should be checked and reinstated while assembling.

vii) In big motors, Insulating sleeves and gaskets used in the oil piping wherever provided are to be put back in position in the lube oil system.

6.6 ASSEMBLY AND FINAL CHECKS

i) Replace all old gaskets and packings.

ii) Check all internal accessible points for any foreign objects inside.

iii) Use recommended sealant in terminal block, end cover, shaft and housing as recommended by manufacturer.

iv) Check tightness and locking of all the bolts.

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v) Check the rotor for freeness to rotate.

vi) Check the IR value of the assembled motor.

### 7.0 TRANSFORMER

#### 7.1 INITIAL JOBS

After the compliance for General Requirements detailed in 4.0 the following activities and checks should be carried out:

i) Check and record oil dielectric value, acidity, resistivity, moisture content, and dissolved gas analysis.

ii) Check condition of all oil drain valve gland/gaskets.

iii) Check and record IR value and Polarisation Index.

iv) Check for visible oil leakage on all parts of transformers and mark them for attending to them during overhauling.

**Note:**

Based on the above, decision should be taken on the nature and quantum of work involved, such as drying out, oil changing and filtering and required facilities should be planned for.

v) Check Terminal Box for:

   a) Condition of end terminal epoxy/compound
   b) Sign of any hot spot
   c) Gasket of terminal box
   d) Bushing for any oil leakage
   e) Loose connection, cracked bushings, hot spot etc.

vi) Check Oil Level/Temperature Gauges for:

   a) Calibration
   b) The capillary tubing for tightness and the dial glasses for mechanical damages, if any
   c) Explosion vent diaphragm for any damage and also whether wire mesh provided at the mouth of the explosion vent is in tact.

vii) Ensure the following before untanking:

   a) Working personnel do not carry loose items on their person which are likely to fall inside.
   b) Availability of spare gaskets for the top cover before lifting it.
   c) All accessories and cable connectors are dismantled so that cover is free for lifting.
   d) Core earthing is disconnected as per manufacturer’s recommended procedure.
   e) Pipe work from the cover of he conservator has been removed including explosion vent pipe.

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f) CT secondary leads are disconnected and marked.

g) Switch handle assembly of Off Load Tap Changer has been dismantled.

h) The lifters are rigidly fixed to core clamps before lifting core and winding.

Note:

1) Oil-filled Bushing should be stored in vertical/inclined position only. Oil may come out if stored in horizontal position.

2) HV bushings are generally hermetically sealed. On inside the bushing shall have very low tan(delta). There is normally a pressure injection system through which oil sample can be taken and tested.

7.2 CORE & WINDING

i) Check that the oil passages are not clogged due to deposition of any sludge in the winding block.

ii) Check for tightness of core bolt & condition of core bolt insulation.

iii) Check that winding coils are not distorted or discoloured. Also ensure winding insulation paper remains tightly wrapped.

iv) Check all separators between windings are firmly in position and have no damage/discolouration.

v) Check that the core is not apparently distorted.

vi) Check for any slackness of winding and if necessary tie rod/coil clamping screw may be tightened.

vii) Check and clean sludge etc. from the bottom of the tank.

viii) Check for any corrosion on the tank interval and clean and apply protective coating if necessary.

Note:

Care should be taken that air release valves/plugs be kept open while filling oil in to transformer, and filling to be from bottom only.

7.3 BUCH HOLZ RELAY, CONSERVERATOR, RADIATOR AND EXPLOSION VENT

* Check for any sludge and other impurities in the conservator and flush it with clean transformer oil.

7.4 ON-LOAD TAP CHANGER (OLTC)

7.4.1 Selector Switch Unit

i) Check fixed and moving contacts. If worn out, replace with new contacts.

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ii) Check that all nuts, screws and circlips are secure.

iii) Check that the insulating oil conforms to IS : 335. The oil should be filtered after every 30000 operations. The electrical withstand strength of oil should not be less than 30 KV at any time. The Selector Switch should be tested every 6 months.

Note:

At regular intervals preferably during filtration, the Switch Unit should be washed with clean oil and all traces of carbon removed.

7.4.2 Drive Mechanism Unit

i) Replace the grease (special long life grease) of all ball and roller bearings.

ii) Check that cam faces, gear rollers and wiping surfaces are lubricated with proper quality grease.

iii) Check for any breakage in the torque limiting shear pins. If damaged, replace with new ones in which case ensure synchronisation between Tap Changer Position Indicator and actual position of Tap Changer.

iv) Check for the proper functioning of Heater circuit with its ON-OFF switch, provided in the drive mechanism to eliminate any condensation due to changes in ambient temperature.

v) Check the condition of Air Filters

Note:

No oil should be applied to any part of the mechanism.

7.4.3 Functional Checks

i) Check for proper electrical and manual operation of OLTC and ensure that limit and directional sequence switches, motors, contactors, and connected linkages of driving mechanism are functioning as per design, for all tap positions in both RAISE & LOWER modes. Ensure correct response in both local and remote control operations.

ii) Ensure voltage readings for each tap position correspond with nameplate values. Also the Indicator in the remote Relay panel should tally with OLTC's mechanical tap position indicator physically.

iii) Check that Buchholz Relay Operation is satisfactory, by injecting air through lower level petcock.

iv) Check the diaphragm of the Explosion Vent fitted at the exposed end for any mechanical damage.

v) Level gauge in the conservator tank shall be cleaned.

vi) Check that oil level is up to the fill level or approx 2/3 of the Level gauge after opening the valve between Conservator Radiator and Buchholtz Relay.

vii) Ensure that transformer body has been earthed before filling oil.

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7.5 ASSEMBLY OF TRANSFORMER

i) After cleaning and painting of tank, core may be inserted (while inserting core, care shall be taken to avoid damages to core and winding).

ii) All internal connections shall be restored.

iii) All the flange joints shall be thoroughly cleaned and gaskets shall be shaped and fixed for proper sealing.

iv) The busducts shall be fixed back (with phase segregators wherever provided) after thorough inspection and cleaning.

v) It shall be ensured that neutral earthing conductor is insulated from tank body and other supporting structure.

vi) Put back the Covers Insulators, Cable Box, Marshalling Box. (All the unsealed openings in Marshalling Box shall be sealed).

vii) Wheel stoppers should be put back in position.

viii) All earthing connections shall be restored.

ix) Before oil filling, all inspection and operation checks (which includes tap checking) should be carried out (in case of OFFload Tap Changer).

x) Before tanking OLTC, operation of OLTC should be checked with indications (both local & remote).

xi) Painting of the transformer should be carried out.

7.6 DRYING OF WINDINGS AND RECONDITIONING OF OIL

i) Check all gasket joints, valve glands for any leakage of oil.

ii) Check that IR value has become constant before stopping filtration.

iii) During filtration ensure that the earthing of the transformer coil is disconnected.

**Note:** If IR value is very less, drying out by short circuit method should be carried out. Ensure rise in oil temperature is less than 10 deg. C per hour and maximum oil temperature does not exceed 60 deg. C.

7.7 PRE-TEST INSPECTION

i) Check that trapped air is released through air release plugs & valves fitted for the purpose on radiator, bushings caps, tank cover and Buchholz relay as well as gas relay on the OLTC tank.

ii) Check whether gas operated relay is mounted at an angle by placing a spirit level on the top of the relay. Ensure for proper direction of oil flow. (The contact operation may be checked by manual testing key provided).

iii) Check alarm and trip contacts by simulation of Winding Temp Indicator, Dial Thermometer, Magnetic Oil Gauge etc. and reset to normal setting.

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iv) Check that off load switch handle is locked at the desired tap position.

v) Check that all valves except drain, filter and sampling valves are opened (such as radiator valves, Buchholz relay pipe line etc.)

vi) Check the condition of silica jel in the breather and if necessary replace/ reactivate.

vii) Check that transformer oil is filled in the silica jel breather upto the required level.

viii) Check that external electrical connections to bushings, are tight.

ix) Check Arcing Horn gap on bushings.

x) Check that neutrals are effectively earthed.

xi) Check and record winding resistance for HV, LV, and tertiary windings.

xii) Check protection devices and circuits of the transformer for correct operation.

xiii) Conduct core balance and ratio tests as per IS IS:2705/IS:2706

xiv) Check final IR value alongwith cable before charging the transformer.

8.0 SWITCHGEAR

General requirements detailed in 4.0 should be taken care of before commencing overhauling activities. The sequence of activities and checks as listed below should be adhered to

8.1 MINIMUM OIL CIRCUIT BREAKER (MOCB)

i) Check for sign and any oil leakage from the Pole assembly.

ii) Check for any sign of overheating on the incoming and outgoing contact. Replace the worn out contacts with new ones.

iii) Check the condition of gaskets, oil seals, spring washers etc. and replace with new ones.

iv) Check the condition of arc chamber, and switching levers.

v) Check the main contact and arc shield, and if necessary replace with new ones.

vi) Check for breakage of Pins, Spring dowel sleeves, spring circlips, bolts and nuts of the breaker mechanism assembly.

vii) Check for any crack/damage on the insulator.

viii) Check the carbon brush and commutator of spring charging motor.

ix) Check that the tripping levers and trip shafts are lubricated with recommended grease.

x) Check condition and cleanliness of rollers and lubricate them with neutral vaseline.

xi) Check tightness of plug-in connections.

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xii) Check if all the 3 contacts are making at a time by slow closing of the breaker, wherever feasible.

xiii) Check milli volt drop and resistance of each pole pair and compare with specified values in the manual.

xiv) Check the insulation resistance between poles and also between pole and earth and record the same. (If IR is below acceptable value, manufacturer's recommended drying operation shall be carried out).

xv) Check that all 3 pole female contacts have firm contact with bus's male contact. Use prussian blue to check area of contact.

xvi) Check closing and tripping of breaker on all impulses by simulation.

xvii) Note operation counter reading, wherever provided.

8.2 BULK IN CIRCUIT BREAKER (BOCB)

i) Close & open the circuit breaker both manually and electrically in test position few times & check that it is operating properly.

ii) Check for any crack/breakage of the contact mounting porcelain bushings.

iii) Check for signs of overheating of the isolating contacts.

8.2.1 Circuit Breaker Tank

i) Check for any sign of oil leakage through the tank cover.

ii) Check the condition of the tank gasket and replace with new one if there is evidence of burning or their damage.

iii) Clean interior of tank with lint free cloth and ensure there are no damages in the tank lining. Also, check that screws are fixed tight.

iv) Replace with tested new oil.

v) Check condition of Explosion Vent for cleanliness.

8.2.2 Turbulator/Arc Control Pot (Arc chute)

i) Examine thoroughly for any burning and if badly burnt, replace these items with new ones.

ii) Examine liners and washers and if damaged replace these, with new ones.

8.2.3 Contact

i) Check arcing tips/contacts for metal globules formed by arcing. Using a small file carefully remove the globules. If the arcing tips/contacts are severely eroded replace these, with new ones.

ii) Check that all the 3 poles are making contact at a time by slow closing.

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8.2.4 Closing Mechanism

* Check closing mechanism for proper operation and lubricate all bearing and pivotal points with recommended lubricating oil.

8.2.5 Carriages

* Check for free movement and lubricate lifting gear and wheels of circuit breaker.

8.2.6 Shutter Mechanism

i) Check for proper functioning of the shutters and associated mechanisms and lubricate the bearing points and the pivotal points.

ii) Check operation of breaker on all impulses by simulation.

iii) Record operation counter reading, if available.

8.2.7 Auxiliary Switch

i) Check for proper operation and contact of rotary auxiliary switch contacts. Silver plated contacts do not require any cleaning.

ii) Copper or copper alloy contacts should be cleaned and smeared with a thin film of vaseline. If contacts are badly burnt replace with new ones.

iii) Clean the secondary contacts.

8.2.8 Tripping Mechanism

i) Check tripping circuits to make sure that trip coil plungers more freely and trip the circuit breaker. Lubricate the tripping mechanism pivotal points.

ii) Check for tightness of all nuts and screws.

8.3 SWITCHGEAR PANEL

i) Check for proper clearance and electrical isolation.

ii) Check initial IR values of the three phases and record them.

iii) Check the vermin proofness and cleanliness of the panel.

iv) Check condition of cable end termination.

v) Check for any hot spot/flash on the conductor or insulator.

vi) Check for any crack on the insulator and replace if necessary.

vii) Check for tightness of connections.

viii) Check the condition of joints between copper and aluminium and ensure that there is no corrosion due to bimetallic reaction.

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ix) Check for any wear on the main bus male contacts and replace if necessary.

x) Check the condition and alignment of shutters in the panel.

xi) Check the condition of rails on which breaker moves.

xii) Check the alignment and condition of carriage limit switches.

xiii) Check the tightness of control wiring and soldering of multipin socket. Check IR value of the control cables.

xiv) Check the condition of indicating lamps and Panel meters

 xv) Check the safety interlock for proper functioning.

xvi) Check the final IR value of the bus.

xvii) Check the protection system by Secondary Injection test.

xviii) Check IR value of the power cable of the panel before charging.

xix) Check corrosion on the panel and paint if necessary.

xx) Check condition of Explosion Vent for cleanliness.

xxi) Check Spaceheater for its proper functioning.

Note:

If IR value is observed to be low, manufacturer's approved dryout method should be carried out and the final IR value should be corrected to acceptable value.

9.0 SWITCHYARD

General requirements detailed in 4.0 should be taken care of before commencing overhauling activities. Thereafter, following activities and checks should be carried out. Corrective actions have to be taken wherever needed.

9.1 SWITCHYARD EQUIPMENT

9.1.1 Lightning Arrester

i) Measure Insulation Resistance value before and after cleaning Insulator surface and compare with available data/standard values.

ii) Check tightness of line and earth connections.

iii) Measure earth resistance

iv) Check for crack in the insulator body.

v) Check leakage current and monitoring device if any.
9.1.2 P.T/C.T

i) Measure Insulation Resistance and compare with available data/standard values.

ii) Check oil level. Clean insulator surface.

iii) Check for cracks in the insulator bushings and replace if necessary.

iv) Check tightness of primary connections. Apply thin layer of vaseline.

v) Check secondary contacts for proper tightness and clean. Apply thin layer of vaseline.

vi) Check dielectric strength and resistivity of oil and replace the oil if required, with new tested oil.

vii) Secondary winding resistance is to be checked.

9.1.3 Isolator

i) Open & close the isolator a few times and check for proper contact of the moving, fixed and auxiliary contacts.

ii) Check interlock of earth switch and main switch operation.

iii) Clean contacts and smear with a thin film of vaseline.

iv) Lubricate the hinge mechanism and cam devices.

v) Check for cracks and damage to isolator parts.

vi) Measure Insulation Resistance and check for proper earthing.

9.2 OVERHEAD LINE

9.2.1 Pole and Insulator

i) Check for corrosion at ground level for Steel and Wooden poles. Scrap away the earth from around the pole at the ground level to a depth of about 15 cm & determine extent of corrosion, on the pole and take corrective action.

ii) Check for effective earthing connections to the metallic poles.

iii) Check for leaning of the pole and take corrective action as necessary.

iv) Check for rigid connection of the ground rod & ground wire & examine the ground wire for corrosion effects.

v) Check guy and stay wires for corrosion/damage and replace if required. Check also the condition of insulators and replace if necessary.

vi) Check that base of the pole is cleared for all grass, weeds and ensure that no flammable material or chemical is stored around the base.

vii) Check for broken, cracked, badly leaning, swinging or flashed insulators.

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viii) Check for bent or broken pins.

ix) Check for missing name plates, identification tags, anticlimbing devices, and replace as required.

x) Check for Danger/Warning caution boards.

9.2.2 Cross Arm and Conductor

i) Check for loose, broken or missing bolts and nuts, pins, braces, in cross arms.

ii) Check conductors and jumpers for broken strands, burnt spots, undue or uneven sagging.

iii) Check for foreign objects such as kites, pieces of wire, tree branches hanging on dangerously near any conductor.

iv) Check condition of cradle guards and their effective earthing.
10.0 REFERENCES

The following Codes, Standards and Publications have either been referred to or used in the preparation of this document and the same shall be read in conjunction with this document:

* IS : 2705
* IS : 100028
* IS : 2706
* OISD-STD-137

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