STANDARDS / MANUALS / GUIDELINES FOR SMALL HYDRO DEVELOPMENT

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MINISTRY OF NEW AND RENEWABLE ENERGY
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GUIDELINES FOR OPERATION AND MAINTENANCE OF SMALL HYDROPOWER STATION

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SECTION – I

GUIDELINES FOR OPERATION OF SMALL HYDROPOWER STATION
SECTION – I

GUIDELINES FOR OPERATION OF SMALL HYDROPOWER STATION

1.0 INTRODUCTION

Operation of Hydropower plant involves understanding of operation of hydraulic features and equipments. All features may not be included in every plant and will depend on type of plant water source, turbine & generator installed and power evacuation arrangement and will generally consists of following:-

1.1 CIVIL & HYDRAULIC STRUCTURE

- Lake/pond/river/canal as main water source
- Dam/Diversion weir/Diversion barrage
- Head regulator
- Power channel/tunnel
- Desilting arrangements
- Fore Bay
- Bye pass/Spillway
- Trash racks
- Intake Gates with Hoist
- Siphon intake
- Surge Tanks/Spilling pipes
- Penstocks

1.2 POWER HOUSE

(i) Mechanical
- Main inlet valve (Butterfly/Spherical valve)
- Bye pass valve
- Inlet bend and branching pipes
- Drain valve
- Pressure reducing valve for cooling water system
- Cooling water system
- Turbine and its auxiliaries
- Draft tube
- Draft tube gates
- Governor, associated OPU and guide apparatus
- Station auxiliaries such as:-
  (i) EOT cranes/hoists
  (ii) Station compressor
  (iii) Drainage & Dewatering system
  (iv) D.G. Set

(ii) Electrical
- Hydro generator and auxiliaries
• AVR & Excitation system
• Generator protection/relay and control panel
• A.C. auxiliary supply
• D.C. control supply, batteries & battery charger
• TG start up panel
• Synchronizing panel
• Generator transformer
• Station transformer
• Unit auxiliary transformer (if applicable)
• Relay and control panel

1.3 SWITCHYARD

• Switchyard structure
• VCBs Isolators
• CTs
• PTs
• LA
• Lineside Isolator
• Surge counters
• Outgoing lines

1.4 OTHER SYSTEMS

• Lighting system, emergency lighting
• Station earthing, lightening protection
• Communication system
• Fire fighting and hydrant system
• Safety tagging & safety interlocks

2.0 GUIDELINES FOR OPERATION OF POWER PLANT

Guidelines for operation of power plant shall have two elements:-

• Water operation
• Operation of Power Plant

2.1 WATER OPERATION

Just like operation of Turbine Generator set or a transformer, efficient water operation forms an important part of hydro power plant be it large storage plant or small run of river plant. Water operation means operation of following systems of the hydro plant in such a manner that efficiency of plant is maximum. It is generally reflected in kWH/cumec.

2.1.1 Catchment Area

The area gives the run off into the lake/pond/river during rainy season. Run off rate cubic metre/mm should be known to operator to adjust generation accordingly.
2.1.2 Lake/Storage/Pond

The operation of lake based plant means keeping the level such that during rainy season the over flow chances are minimum. In case of diversion type plants it is essential to keep the gates during flood conditions open to avoid flooding and lower them only when rain is low or over. In such plant it is essential to check that there is no leakage from the gates or stop log gates. If operator notes that the leakage is more, he should pass on his observation to higher authorities to ensure corrective measures in the interest of having more generation.

2.1.3 Run of River Type Plants

Availability of water is more important factor in operation of hydro power plants. It is therefore, essential to generate continuously to its full capacity during monsoon season. Failure of a machine during monsoon can cause a substantial generation loss. All operation staff must, therefore, be very vigilant during this period. In lean season diversion barrage gates/diversion weir gates are checked for leakage, corrective measures are taken as soon as possible so that there may not be any generation loss on this account.

2.1.4 Power Channel/Duct/Canal

The operation of open channel/duct is critical to water operation and efficiency of plant. Depending upon the length, condition of lining, head on head regulator, time required discharge to reach forebay and to the machine. As per this discharge guide vane opening is calculated. Any time delay or change in opening will affect water reaching the TG unit causing change in generation. The time taken by water to reach the turbine will depend on many factors and only experience will make the operator perfect.

2.1.5 Forebay

Forebay is a essential part of any water conductor system with open channel. It serves the purpose of connecting penstocks with gates and acts as tank. It takes care of small variation in generation, water supply and acts as desilting basin. The operation of forebay is important during picking up load and at the time of tripping of machines. Actual over flow, through bye pass, is always recorded to calculate water wasted during over flow, specially during lean season.

2.2 OPERATION OF POWER STATION

The operation of power station requires that its staff is trained and well versed with all necessary technical as well as basic trouble shooting knowledge. As a brief description to bring out some details of operating a SHP, the following checks are to be made before starting of machine:-

- Shut down clearance
- Water restriction, if any
- Permission for ALDC
• Permission from nearest grid substation
• Proper working of
  ➢ Communication system
  ➢ AC Power
  ➢ DC Power
  ➢ Firefighting system
  ➢ Cooling water system
  ➢ Drainage & dewatering system
  ➢ H.S. lubrication system
  ➢ L.P. & H.P. compressed air system
  ➢ Protection system

2.2.1 Check List for Starting of Machine

The staff responsible for the operation should be well conversant with technical details and importance of following:-
• Intake gates by pass gates & forebay
• Inlet valves
• Turbine
• Generator
• Generator Transformers
• Switchyard
• Synchronizing with grid
• Closure of machine
• Emergency closing of machine
• Importance of log sheets

2.2.2 Mechanical

On Intake
• Check by pass gate are not mechanically locked and all valves are in okey position
• Check position of intake gate
• Check position of stop log gates
• Check filling line valve of penstock
• Check supply to gates is O.K.

Inside P.S.
(i) Inlet valve:-
• AC power for pump operation
• HP compressed air
• Locking pin position
• Level and pressure in OPU

(ii) Others:-
(a) Check valves:
• Check spiral drain valve is closed
• Check D.T. drain valve is closed
• Position of stainer valves ensure water flowing in cooling pipes
• Gland seal valve open
• Air seal valve closed
• Top cover drain system okey

(b) Check levels:
• Pressure accumulator (OPU)
• Turbine Guide bearing
• Lower Guide bearing
• Upper Guide bearing
• Thrust bearing

(c) Check pressures:
• Spiral casing
• OPU
• Stator cooling water pressure
• Thrust bearing UGB, LGB
• Sealing water pressure
• Servo motor Pr. Gauge
• Air pressure (brakes)

(d) Check working of systems
• Top cover drain
• Oil leakage unit
• Oil cooling unit
• Oil pressure unit
• Brakes
• Position of CO₂ batteries
• Guide vane lock on or off
• Check jacking/dejacking of m/c
• Check flow relays
• Check emergency slide valve reset
• Check working of ventilation system
• D.C. System
• Grid Power
• DG Set power
• Event logger
• Disturbance logger

2.2.3 Electrical

Check list of Generator
• Brake system
• Cooling water for bearings
• Generator fire fighting
• AVR condition
• DC supply for field flashing
• Oil levels in bearings
• IR values
• Jack position
• H.P. lubrication condition
• Check earth link for bus duct
Check list for Transformers
- Cooling water system
- Firefighting system
- Transformer cooling oil pump position
- Buchholz relay
- Oil level in conservator
- Colour of silica gel
- IR of winding and core
- BDV of oil

Check list for Switchyard
- Compressed air in case of ABCB
- SF₆ gas pressure in case of SF₆ breaker
- Earthing switch position
- Isolator position – close
- Breaker position – off
- Line isolator position

2.2.4 Operations

(i) Inlet Valve Opening
- Put oil pumps on ‘auto’ mode
- Open compressed air valve
- Open bye pass manual valve
- Give opening command to bye pass auto valve
- Check water pressure for equalizing
- Give opening command to inlet valve
- When inlet valve is fully open oil pumps must be stopped

(ii) Turbine Operation
- Put oil pumps on auto mode
- Open HP compressed air valve
- Open LP compressed air valve
- Open cooling water for bearings
- Open shaft seal water
- Put brake on auto mode
- Release lock pin
- Fix GV opening limit
- Put machine on auto mode

(iii) Generator Operation
- AVR on manual mode
- Cooling water for transformer on
- Oil circulation of transformer on
- Keep fire fighting system alert
- On D.C. supply for excitation flashing
- At 30% of generator voltage D.C. supply from battery cuts
- Now generator excitation supply get from excitation transformer
• Start command initiated

(iv) Synchronization
(a) Synchronization checks
- Line protection
- PLCC
- Give clearance for line back charging
- Close line isolators
- Close line breakers
- Now circuit is charged upto switchyard from remote end
- Start machine on auto mode

(b) Synchronization
- Close field breaker
- Now m/c will run at rated speed and rated voltage
- Check line voltage & frequency
- Check generator voltage & frequency
- Reduce or increase generator voltage & frequency to match with line voltage & frequency.
- At equal line & generator voltage and frequency close generator breaker.
- Now generator is synchronized with grid.
- Take minimum prescribed load immediately

(c) Checks after synchronizing and taking load
- Unit control board supply is changed to unit Aux. Transformers.
- Transformer “Motor for Cooling Water Supply” started.
- All parameters in control room are matching and correct.
- General check up of machine and other unit auxiliaries at all floors.

2.2.5 Checks at the Time of Shift Change Over (Machine Running on Load)

(i) Turbine & Governor

- Check Temperature of following
  - Thrust bearing
  - Upper guide bearing
  - Lower guide bearing
- Check following in normal working condition
  - Cooling water flow and pressure of all bearings at inlet & outlet
  - Sealing water flow and pressure
  - Stator cooling flow and pressure
  - Grease pump
- Check oil level in housings of all bearings
- Check if, there is vibration or abnormal sound in OPU pumps
- Check grease in the container of centralized grease lubrication system
- Check working of following
  - OPU pump 1 & 2
  - OLU pump
- Drainage pump & Dewatering pumps
- Governor compressor
- General purpose compressor
- Ejector system for top cover drains
- Cooling water strainers
- Check sealing water pressure & air seal pressure
- Check running and vibration of machine and ensure nothing is abnormal
- Check working of top cover drainage system
- Check water, oil and air flow indicators
- Check physical appearance of various system such as man holes, valves, indicators etc.
- Check G.V. Servomotor stroke & R.B. angle is normal
- Check general house keeping is in order and all panels, mountings on wall are clean and in order.

(ii) Generator, AVR & Excitation System

- Watch running and vibration of machine and ensure nothing is abnormal.
- Check for any sparking from the brush of slip ring.
- Check temperatures of winding & core. Ensure that these are with in limit.
- Check that all instruments and indicators mounted on unit control board, governor panel, AVR & excitation panel are in OK condition.
- Check all indication lamps are glowing.
- Check with test push button that all fault indication lamps are OK.
- Physical check of all sub distribution boards installed in P.S.
- Check all inlet exhaust fans are working.
- Check all batteries are physically in good condition.
- Check battery chargers are in normal working conditions.
- Check for any abnormality, sound, chattering in bus duct, generator barrel, neutral cubicle.
- Check all AC supply boards installed in Power House are okey.
- Check air conditioning plant is working satisfactorily.

(iii) Control room

- Check that all parameters indicated on various panel are matching.
- Check all indicating lamps are glowing. Also check annunciations are OK.
- Check movement of all pointers & reset them.
- Check all instruments mounted on panels are in working order.
- Check all facias & relays are reset.
- Check rear of all panels and mounting on this side for OK condition.
- Check emergency lighting system is OK.
- Check position of circuit breakers for out going lines.
- Check grid voltage & frequency.

(iv) L.T. room

- Check all indication lamps are glowing.
- Have general look on instruments and relays mounted on board.
- Check various switches are in correct position.
Check whether supply to various distribution boards are OK.

(v) DC Distribution Board, Battery Charger & Battery sets
- Check D.C. voltage is correct.
- Check D.C. supply is healthy by making momentarily float off. This would ensure that batteries are connected with load.
- Check both batteries are on float.
- Check all the switches on DC board are in correct position.
- Check that both chargers are functioning correctly.
- Check all cells of battery bank are healthy. Their sp. Gravity and cell voltage is correct.

(vi) Main Transformers
- See that oil level is OK & there is no leakage from anywhere.
- Check that oil pressure and water pressure are normal.
- Check that oil temperature and winding temperature are normal.
- Check silica gel colour is normal.
- See that oil and water flow indicators are normal.
- Carry out following checks for healthy condition of Mulsifyre system:
  - Compressor
  - Power
- Oil level in conservator is normal.

(vii) Switchyard
- Have general look at switchyard including bus bars, jumpers etc. Ensure that there is no sparking anywhere and everything is in order.
- Check compressed air system in case of ABCB, is OK.
- Check SF₆ gas pressure in case of SF₆ breaker.
- Check position of all breakers, isolators & line isolator and cast a look on all CTs, PTs, LAs, Surge counters, wave traps and coupling capacitor and ensure that everything is in order.

(viii) Routine maintenance to be carried out during each shift
- Cleaning of all panels, instruments and equipment installed in power station.
- Oiling and greasing of all equipment as per instructions.
- Topping up of oil in bearings, OPU sump.
- Replacement of lamps, fuses etc.
- Cleaning of trash racks.
- Inspection of forebay, bye pass gates, intake gates.
- Any other work as assigned.

Work carried out during each shift shall be logged in daily in control room log book.
2.3 GUIDE LINES FOR PREPARING OPERATION MANUAL

Every plant shall have an operation manual for guidance of operating staff. Generally it should include following subjects:

- **General**
  - General information about the project.
- **Salient features of the Project**
- **Equipment data**
- **Plant operation procedure**
  - Normal Start
    - (a) Prestart checks
    - (b) Starting procedure
      - Auto
      - Manual
    - Synchronizing and taking load
    - Normal shut down
    - Emergency shut down
    - Dead bus synchronizing
    - Taking D.G. set in service
- **Problems during plant operation**
- **Planned plant outage procedure**
  - Water conductor system outage
  - Taking main transformer out for maintenance
  - Taking turbine generator set out of work
  - Plant outage for maintenance of machine
  - Outage request form
  - Plant outage instructions
  - Procedure for operation personal for giving planned plant outage.
- **Essential Drawings (Enclosure)**
  - Plant layout
  - Hydraulic layout
  - Main single diagram
  - Plan of different floors
  - Transverse section thru unit
  - Longitudinal section thru centre line of units
  - Station earthing layout
  - List of panels
  - List of circuits
- **Operation of Auxiliaries and other system installed in P.S.**
  - Turbine Governor Oil Pressure Unit
  - Cooling water system
  - Drainage & Dewatering system
  - AVR & excitation system
  - Generator neutral grounding system
  - Station compressors
  - Station illumination & emergency lighting
  - Station D.C. control system
  - Generator fire extinguishing system
  - EOT cranes
- Intake gates, bye pass gates, D.T. Gates
- MIV
• Safety & Fire fighting
  - General fire fighting
  - Electrical safety
  - First Aid
• Duties of staff posted for operation of plant in each shift (Designation wise)
  - Engineer-in-charge of Shift
  - Technician (control room)
  - Turbine operator
  - Attendants/Oilers
  - Intake Gate/Bye pass gate operator
• Trouble shooting of various equipment in plant.

2.4 GUIDELINES FOR PLANT REPORTS AND RECORDS

A vast amount of information is generated by the power station on every aspect of generation. Most of this data is generally compiled on daily basis at the Power Station level and at HQ level for generation of Management Information Reports.

Generally following reports, logs, reading sheets are required to be prepared at different levels of management structure:

Typical Plant Data Sheets:-

(ix) Hourly panel meter readings     Control room
(x) Station event log book     Control room
(xi) Station trouble/fault log book     Control room
(xii) Energy meter readings     Control room
(xiii) Daily generation report     Control room
(xiv) Hydraulic data sheet     Control room
(xv) Daily rainfall, lake level     Control room
(xvi) Monthly generation & aux. consumption report     Plant Manager
(xvii) Monthly water consumption & runoff report     Plant Manager
(xviii) Occurrence and relay tripping report     Plant Manager
(xix) Special event report (eg. Landslide, fire etc.)     Plant Manager
(xx) Accident report (involving human being, animals)     Plant Manager
(xxi) Quarterly safety & fire drill, training imparted at plant     Plant Manager

2.5 GUIDELINES FOR SAFETY MANUAL

(i) Every power plant shall have safety manual, copies of which shall be given to every employee. The safety manual shall contain:

  • Safety policy of the organization
  • Safety during work
  • Outage procedure with safety tags.

(ii) The management shall conduct safety training for operation and maintenance staff on regular basis.
(iii) The safety equipment such as helmet, goggles, hand gloves, insulated T&P for electrical works, earthing chains etc. shall be kept at the location where these can easily be accessed.

(iv) The arrangement to supervise safety tags shall be made at each P.S. The list of tags for every equipment outage must be finalized and given in safety manual.

(v) Guidelines for safety in working are to be given in detail in safety manual.

(vi) Fundamentals on Safety:

Prevention of accidents requires whole-hearted co-operation of all members of the organization. A capable, mentally alert employee will avoid accidents. However an unsafe person is a liability. He is danger to himself, his fellow workers and to the equipment and organization.

- Unsafe acts which may cause accidents:
  - Operations an equipment without authority on warning.
  - Operating or working without proper instructions.
  - Making safety devices in operative.
  - Using defective equipment or its improper use.
  - Working nearby dangerous or live electrical equipment which could conveniently be de-energised.

- Unsafe conditions which may cause accidents:
  - Ungrounded equipment.
  - Defective material or equipment.
  - Improper illumination.
  - Non-standard design or construction.

Hence, accidents are the results of unsafe conditions or unsafe acts or combination of both.

2.6 GUIDELINES FOR DISASTER MANAGEMENT

Disaster management is aimed at ensuring safety of people, protection of environment protection of installation and restoration of generation.

(i) A task force consisting of O&M personnel of different discipline needs to be constituted who will identify the following:

- Source of disaster and steps to contain the same.
- Isolate remaining plant and keep them in safe condition.
- To organize safe shut down of Power Plant.
- To organize all support services like fire fighting system etc.
- Attend to all emergency maintenance jobs on top priority.
- To apprise authorities on all safety related issues.
- To record accident details.
• To arrange for evacuation of man material from affected area.
• Arrangement of ambulance and emergency first aid.

(ii) The disaster management plan for generating stations shall take care of the following:

• Emergency power supply system shall be made operational.
• Back start procedure must be prepared needs to be reviewed from time to time.
• In case of fire, the unit/station needs to be emergency tripped through the emergency push button.
• Ensure immediate shut down affected or likely to be affected portion of P.S., so that rest of the plant remains healthy.
• Fire tenders need to be summoned immediately.
• The fire extinguishing system needs to be automatically cut in and in case of failure of auto system, the system should be manually started.
• The earmarked hospital need to be informed of such emergency.

The units should be restarted as soon as the cause for disaster has been cleared off.

(iii) Action Plan

For effective control and management of disaster an action plan and organization shall be prepared by Power Station In-Charge alongwith responsibilities. This shall consist of following factors:

• Responsibility of employees about first information.
• Responsibility of Emergency Management Manager (EMM) for declaration of emergency (EMM to be nominated by Plant In-Charge).
• Responsibilities of various teams constituted to deal with specific emergency requirement.
• Responsibility of EMM for “All Clear” signal after dibaster has been cleared off

(iv) Essential Staff

In plants immediately affected or likely to be affected efforts will be made to shut down and make other units safe. The plant supervisors and operators will carry out this work without exposing them to any risk. The following staff will also help them:

• Attendants
• First aiders
• Persons responsible for emergency lighting
• Persons responsible for transport
• Persons working as runners, in case communication fails
• Persons manning plant entrance, liaison with police, Fire tenders, Call for emergency vehicles, ambulance, to control traffic leaving P.H. to turn away visitors and non-essential vehicles.

It is responsibility of EMM to identify such staff and form task force to carry out above activities.

(v) Disaster Possibility in Hydro Power Stations

• Disaster due to natural calamities such as floods, earthquake, wind storms which may affect outdoor installations, land slides.
• Areas prone to disaster on account of fire are cable galleries, switchyard, switchgears.
• Over speeding of turbines.
• Failure of underground structures due to inadequate support or geological reasons.
• Following occurrence may cause flooding of P.S.

  a) Failure of top cover studs.
  b) Failure of Draft tube inspection window or near by liner plates.
  c) Entry of water from down stream side windows of P.S. during floods.
  d) Failure of diversion dam gates opening during floods and entry of water from upstream side in Dam Toe power station.

Power station staff should remain always alert for such emergent eventualities. Power Station In-Charge should arrange drills, training for the staff at regular interval specially before rainy season.
SECTION – II

GUIDELINES FOR MAINTENANCE OF SMALL HYDROPOWER
SECTION – II

GUIDELINES FOR MAINTENANCE OF SMALL HYDRO POWER STATIONS

1.0 INTRODUCTION

Experience of running hydropower station reveals that even after detailed project planning/quality control measures taken at various stages from inception to commissioning several unforeseen problems do take place during the operation and maintenance resulting in forced outages/low generation and load shedding etc. causing misery to the consumers and undesired set back to the overall economy. The main reasons which can be attributed to these undesired phenomenon/events(during operation), are that the hydro power station equipments is custom built in construction and tailor made at each discipline viz. design ,manufacturing, erection, commissioning, operation and maintenance etc. The equipment cannot be fully assembled or tested at works. Maintenance exercise at predetermined time interval are therefore, planned to ensure the following objective:

1. Quality and reliable operation of equipment on long term basis through identified periodic inspection /checking of components and subsequent replacement /rectification parts, wherever required.
2. Maximum availability of equipment with least number of shut downs by ensuring that the rate of deterioration of any component does not exceed the life expectancy of the equipment at any stage. Periodic /planned shut downs should be arranged to avoid long term forced shutdowns.

2.0 TYPE OF MAINTENANCE
2.1 REACTIVE (RUN TO FAILURE)

This is sometimes called crisis maintenance or hysterical maintenance. This has been dominant form of maintenance for long time and its costs are relatively high because of unplanned downtime damaged machinery and overtime expenditure. Run to failure should be a very small part in a modern maintenance program. Planned maintenance is preferred over this type so as to reduce downtime of machine and avoid uncalled for outages.

2.2 PREVENTIVE MAINTENANCE

Preventive maintenance is planned maintenance of plant & equipment. It is designed to improve equipment life and avoid any unplanned maintenance activities. Preventive maintenance is the inspection, replacement, repair of any piece of equipment or component based on time and set parameters. It includes painting, lubrication, cleaning, adjusting and minor component replacement to extend the life of equipment and facility. Its main purpose is to minimize break down and excessive deterioration.
2.3 PREDICTIVE MAINTENANCE

This sort maintenance ensures ability to judge when a piece of equipment is going to fail and replace the same before it does. Usually it requires some form of testing and analysis which helps predict an eminent failure. Predictive maintenance can be used in conjunction with preventive maintenance practices. In hydro power station there are many monitoring systems, which can be used to predict problems and possible failures. These include vibration monitoring, oil analysis, temperature, systems ampere readings resistance readings of motors, efficiency in power generation output, leakages of oil and water. All of these things can be captured and tracked by computer system. The analysis of data can predict the future.

2.4 PROACTIVE MAINTENANCE

Most recent innovative in maintenance is called proactive and it utilizes a technique called “root cause failure analysis”. In this type of maintenance primary cause of failure is sought and corrected.

2.5 RELIABILITY CENTERED MAINTENANCE (RCM)

This sort of maintenance is defined as “a process used to determine the maintenance requirements of any physical asset in its operating context”. It is an on going process which determine the mix of reactive preventive and proactive maintenance practices to provide reliability at the minimum cost. It recognizes that all equipments in facility are not of equal importance for generation as well as plant safety. It recognizes that design and operation of each equipment differs and therefore, possibility of failure also differs from equipment to equipment. In this system diagnostic tools and measurements are used to assess when a component is near failure and should be replaced. In this approach basic thrust is to eliminate more costly unscheduled maintenance and to minimize preventive maintenance. In this system unimportant maintenance activities are left to reactive maintenance approach.

3.0 REQUIREMENT OF EFFECTIVE MAINTENANCE

In addition to planning maintenance and allotting suitable time interval on the basis of water supply availability following items also require close watch otherwise it may become difficult to adhere to the schedules.

i) Man power planning and arrangement is most essential as without experienced / skilled staff any maintenance programme may fall.

ii) Planning and arrangement of spares and consumable in advance so that time is not lost I arrangement of the same after taking shut down.

iii) The maintenance engineers should have in his possession al the erection and commissioning log sheet document to establish a record of installed clearances, parameters, alignment results, test characteristics of al the power plant equipment. These may be required at the time o diagnosis of the operational problems as well as defined maintenance purpose.

iv) Log sheets of the previous maintenance exercise carried out on the machines. These may be required to compare with the clearances/ settings/characteristics achieved during present maintenance.
v) History registers of various machines duly recorded with all the abnormalities observed on the machine and details of action taken to provide a guide line for future maintenance exercise must be maintained at the power station.

vi) Logging of the performance characteristics of the power plant on daily basis recording all the abnormalities and misbehaviors (if any) of the total plant observed during its generation programme from one maintenance exercise to another.

4.0 GUIDELINES FOR MAINTENANCE OF SMALL HYDROPOWER STATIONS

In most of small hydro plants preventive maintenance approach is preferred over other approaches. Following inspection checks are done in this type of maintenance:

- Daily checks
- Weekly checks
- Monthly checks
- Quarterly checks
- Half yearly checks
- Annual inspection and maintenance of components of plants
- Capital Maintenance

4.1 PREVENTIVE MAINTENANCE OF HYDRO TURBINE & AUXILIARIES

4.1.1 Daily Checks

1. Foundation parts and Expansion Joints:
   - Checks for any leakage in draft tube manholes, spiral casing manhole, expansion joint.

2. Vacuum Breaking Valve:/ Air Admission Valve
   - Checks the working of both vacuum breaking valve and see that there is no abnormality in the springs, seats etc.

3. Water Seal and Air Seal:
   i) Checks the position of water leakage of the water seal and see that there is no excessive splashing and water level do not rise in top cover
   ii) Note water pressure of water sealing /under sealing.

4. Turbine Guide Bearing:
   i) Checks the oil level(stand still machine /running machine)
   ii) Note the temp. of bearing and check that the temperature of oil and guide bearing pads are within limits.
   iii) Note the maximum and minimum temperature and compare with readings of the previous day.
   iv) Checks for any oil leakage from the bearing housing and check that oil is flowing above the bearing pads.

5. Guide Apparatus:
   - Check any leakage from GV servomotor and its piping
6. Oil Leakage Unit:
   i) Check any leakage from pipe line joints
   ii) Check its satisfactory running on ‘Auto’.

7. Top Cover Drain System:
   i) Main supply of ‘ON’ for DPM.
   ii) Vibration noise in the pump motor.
   iii) Any leakage from the water piping
   iv) Working and water pressure of the ejector.

8. Centralised Grease Lubrication System:
   i) Check for any leakage from grease pipes, unions and nipples.
   ii) Check grease container and fill grease, if required.

9. Oil Header: (For Kaplan)
   i) Check from perpex sheet manhole any splashing of oil from top and bottom bush.
   ii) Check any oil leakage from the joints
   iii) Note the pressure difference of opening and closing side of runner.

10. Oil Pressure System:
    i) Check if there is any abnormal sound in the running of the motor and pump unit of OPU.
    ii) Check the oil level in pressure accumulator.
    iii) Check any oil leakage from oil piping and its valve.
    iv) Check for overheating of motor.
    v) Note the timing of OPU pumps running and compare with previous day running hours.

11. Mechanical Cabinet of Governor:
    i) Pressure in transducer.
    ii) Check any oil leakage from joints of piping.

4.1.2 Weekly Maintenance Checks

1. Greasing of guide vanes and servomotor with centralized grease lubrication system and manually.
   i) Oil in the gear box shall be checked.
   ii) Check for any leakage
   iii) Working of end pressure relay and solenoid valves, if defective, should be reported.

2. Cleaning of OPU filters.
3. Cleaning of throttle filters in the governor mechanical cabinet.
4. Cleaning of governor compressor air filters and checking of oil levels.
5. Checking physically oil of OPU of the running machine, after taking sample through the sampling cock, do the crackle test for detecting presence of water. Take remedial measures.
6. Check oil level of all the bearings
7. Check wobbling of shaft at coupling flange and at oil header servo tube.
4.1.3 Monthly Maintenance Checks

All the checks covered in weekly maintenance as above are carried out monthly also. But while carrying out these checks more attention is paid and short shutdowns, if required, for rectification are taken.

4.1.4 Annual Inspection and Maintenance of Hydro Turbine

After successful running of plant for about one year few weeks are required to be allotted to inspect rotating parts, control equipment and measuring instrument etc. And analyse cause of change in the performance characteristics, if any. Modify / repair / replace (wherever required) the worn out parts in order to prevent forced outages of machine at later date.

After every five years it is necessary to inspect the machine more critically for abnormalities like fatigue defects for excessive wear and tear of some parts or any change in original parameters / clearances etc. This exercise becomes very essential in cases where performance level has been observed to have gone down in 5 years operation.

The checks for annual and five yearly maintenance designed for a hydropower station are enlisted below:

1. Foundation Parts:
   i) Check condition of water path system. The damage due to cavitation and wear to be rectified
   ii) Check painting of spiral casing.

2. Runner:
   i) Check the condition of the surfaces of the runner hub and the blades. The damage due to cavitations & wear to be rectified by welding and grinding.
   ii) Check the runner blade seals by pressurizing the system. Change seals if necessary. No oil leakage is to be allowed (Kaplan only).
   iii) Check the runner sealing for hermetic tightness, leakages of water in the runner hub is not to be permitted (Kaplan only).

3. Guide Apparatus:
   i) Check the presence of rubber sealing cords and the tightness of the rubber sealing between the adjacent guide vanes in fully dosed position of guide apparatus.
   ii) Change oil in the regulating ring.
   iii) Replace damaged shear pins.
   iv) Check cup sealing of guide vane journals and replace, if necessary.
   v) Check the bushes of guide vanes and change the worn out bushes of guide vanes journals.
   vi) Inspect the servomotor and change the seals, if these are worn out.

4. Guide Bearing:
   i) Check the condition of rubbing surfaces of guide bearing. Clean the surface and polish it with the help of chalk powder.
   ii) Adjust the clearances of moving the segment with the help of adjusting bolts.
   iii) Thorough cleaning of housing if necessary.
   iv) Check all the RTDs and TSDs replace damaged one.
5. Shaft Gland Seal and Air Seal:
   i) Check the condition of rubbing surface of sealing rings. In case found damaged change the same.
   ii) Check pipe lines and piping joints for any leakage if any, attend the same.
6. Emergency Slide Valve:
   i) Check the functioning of emergency slide valve and the condition of inner surfaces.
   ii) Swift return of the valve in its original position after emergency operation should also be checked.
7. Centralised Grease Lubrication System:
   i) Check satisfactory working of CGLS system.
   ii) Attend wherever fault is located.
8. OPU:
   i) Check and attend leakage from any valve or flanged joints etc.
   ii) Provide proper lubrication to the bearings of pump motor.
   iii) Check filter and repair, if required.
   iv) Clean oil sump, refill with centrifuged oil.
   v) Check setting of the float relays for proper sequence of operation of pumps.
9. Oil Header
   i) Measure clearances of upper and lower bushes, if found increased get the bushes replaced.
   ii) Clean the oil bath.
   iii) Check the rubber cord fixed below the guide to check any oil dipping on the exciter winding.
10. Oil Leakage Unit:
    i) Check satisfactory working on Auto as well as manual.
    ii) Clean the tank.
    iii) Check the pipeline joints and valve for leakage, attend wherever necessary.
11. Oil Cooling Unit:
    i) Check all the oil and water pipe lines for leakage and attend if necessary.
    ii) Check satisfactory working of all cooling unit.
12. Governor Mechanical Cabinet:
    i) Check filter and throttle if found damaged replace the same.
    ii) Attend leakage of oil through pipe line joints and valves.
    iii) Check auto rod setting, if found disturbed; set the same.
    iv) Alignment of feed back wire rope pulleys.

4.1.5 Capital Maintenance of Hydro Turbine

Overhauling or capital maintenance of hydro set is usually recommended after about 10 years of operation services. The whole unit is to be stripped off during capital maintenance and all the defective/worn out parts/components repaired /replaced with new ones. Then the unit recommissioned as per originally established commissioning practice of the power station. After capital maintenance the unit are subjected to all periodic maintenance exercise outlined above before it reach the next cycle of capital maintenance.

Following check are to be exercised during capital maintenance of a hydro set:

1. Turbine Bearing:
i) Desembly, inspection, cleaning, measurement of clearances, polishing of guide pads, centering of shaft, reassembly, setting of clearances, filling of oil sump with filtered water.

ii) Check the temperature sensing device, if necessary, replace with new ones.

2. Gland Seals and Isolating Air Inflated Seals:
Dessembly, inspection, cleaning and reassembly. Replacing of worn out rubber flaps or carbon segments, if necessary.

3. Clean Water System:
Clean water pipes are dismantled, cleaned, reassembled with new gasket all the valves are attended for any leakage etc.

4. Guide Vane Servomotor:
Dismentling for inspection and cleaning. Reassembling and replacing the seals with new ones, if necessary.

5. Guide Vanes Bush Housing :
   i) Removing, cleaning and inspecting for wear and tear replacing with new ones if found necessary. Replace seals, if necessary.
   ii) Guide vanes are reconditioned.

6. Governor:
   i) Cleaning and checking OPU pumps. Replace bushes, bearings etc. if found worn out. Also attend pump motors.
   ii) Cleaning OPU sump and pressure accumulator and refill with filtered oil.
   iii) Attend oil pipeline flanges and valves for leakages.
   iv) Check setting of pressure switches installed for Auto operation for opu pumps.
   v) Attend Governor Mechanical cabinet for leakages, loose links. Clean main and pilot slide valves. Set Auto rod as per designs Alpha Beta setting may also be checked in case of Kaplan turbine.
   vi) Check electrical circuit. Tightening of all the connections should be done.

7. Under Water Parts
   i) Inspect condition of welded seams of penstock spiral crossing and draft tubes rectify defects by welding and grinding. Penstock filling line valve should also be checked and repaired.
   ii) Cleaning and painting of penstock, spiral casing and draft tube liner.
   iii) Overhauling of spiral drain valve and draft tube drain valve.

8. Runner
   i) Dewatering of draft tube and fabrication of platform in the draft tube for inspection of runner.
   ii) If it is a Kaplan Runner test the same after applying full governor pressure for leakage of oil.
   iii) Replace blade seals if necessary.
   iv) Inspect blades of the runner and make up profile of the blades by welding. Due to erosion, abrasion and cavitations, material of the blade washes away with passage of time. After weld repair heat treatment and dynamic balacing is must before installation.
v) In case the runner is found to be irreparable arrange to replace the same with new one.
vi) In case of Kaplan runner hydraulic test is also required to be done.

9. Turbine Auxiliaries
   1. DPM
      i) Inspect top cover drain system; overhaul the ejector and drainage pumps.
      ii) Check pipe lines and valves. Replace gaskets and other parts, if necessary.

10 Oil Cooling Unit
   i) Overhaul cooling pumps
   ii) Attend all the valves and pipe line for leakage

11 Centralised Grease lubrication System
   i) Overhaul greasing pump.
   ii) Check whole greasing lines. Replace worn out valves and gaskets etc.
   iii) Check all the nylon pipes connected with the guide vane bushes. Replace damaged pipes.
   iv) Check that all the guide vanes are receiving grease properly.

12 Oil Leakage Unit
   i) Check the oil leakage unit overhauls the pumps.
   ii) Clean tank and check that float is properly working.
   iii) Checking all the pipe liens and valves for leakages.

4.1.6 Major Maintenance Problems of Hydro Turbines

Some of the major problems encountered in the hydro turbines are damage in runners due to erosion, cracking and cavitation due pressure pulsation in draft tube, instability of operation at partial gate opening. Failure of turbine bearings, leakages of water through of turbine guide bearings, leakage of water through guide vane seals and turbine gland seals, these problems are discussed in detailed in the following paras.

A. Runner

1. Erosion due to silt

The problem of erosion of turbine runners guide vanes and other under water parts has assumed serious proportions especially in some of the run-of-river schemes, The rivers in the northern region carry enormous silt loads especially during mansoon periods so much so that the power stations has to be closed down to prevent serious damage to the turbines part and water passage. Greater attention should, therefore, be paid to effective desilting arrangement in such power station. Heavy damages have been observed on the runner labyrinth, seals, guide vanes, inlet valve, shaft seals and draft tube cone. The wear due silt occurs so fast that the unit has to be taken out for reconditioning every few years in some stations. The remedy appears to lie in effective desilting arrangements and manufactures of turbine parts with harder and erosion resistant material like stainless steel of popper grade and also design of runner for such conditions.
At surface power stations with open channels following measures of desilting are taken:

i) Silt extruders have been provided near under sluice gates of the barrage.
ii) About half a kilometer downstream of the head regulator a silt ejector has been constructed in the bed of the power channel.
iii) In some projects desilting basin is constructed.
iv) Forebay is also used as desilting baring with flushing conduits.

2. Cavitation & Cracking of Runner

The problem of cracking of runner and Pelton buckets in few power stations has been reported. This can be due to following reasons:

i) Faulty design
ii) Poor metallurgy
iii) Metal fatigue

The cavitation phenomenon occurs due to the vaporization of flowing fluid in a zone of excessive low pressure. Cavitation is inherent even in the best designed turbines and cavitation damage occur under unfavourable operating conditions, limits of metal removal have been specified beyond which cavitation becomes harmful and requires repair. To minimize cavitation following steps are necessary:

i) Periodically (annually) inspect the runner and other turbine parts and take remedial measures.
ii) Operate the machines as per guidelines given by manufacturers. The unit should not be run below certain load to avoid cavitation prone zones.
iii) At design stage itself, ensuring proper submergence use of cavitation resistant material and adoption of optimize runner profile based on mode tests, cavitation can effectively controlled.
iv) As a result of draft tube pulsation and surges at no load or part gate opening excessive nose, vibrations and cavitation is experienced. To minimize pulsation of draft tube following measures must be taken:
   - Air admission through air admission / vacuum braking valve installed at top cover.
   - Provision of fins or flow splitter in draft tube to break the vortex flow.
   - Provision of a bypass arrangement for releasing the pressure built up below the top cover.

Normally the discharge side surface of buckets or blades, areas on the crown on the throat ring and the tip of the blades and the upper portion of the draft tube liner are affected by the action of cavitation. In rare cases, there may be pitting on the pressure faces of the buckets or blades due to a unusual amount of over hung of the guide vanes improper design or unusual operating conditions.

The power House authorities have over the years satisfactory expertise for repair and welding of the runner at site, but it becomes a regular maintenance problem if the cracking occurs too often.

3. Precaution in welding of runners

i) Surface should be prepared by chipping or grinding.
ii) To locate crack etc. die penetration test must be carried.
iii) Preheating of the blade to about 60 °C is necessary.
iv) Avoid any localized excessive heating. It is achieved by welding for a short time in any one particular area and then moving to a diametrically opposite area to continue with the work.
v) The parent material about 70 to 75 mm. form the weld, should not be allowed to get too hot to be touched with bare hand.
vi) Plenty of time should be allowed for the welded area to cool down since forced cooling may cause distortion due to locked in stresses. Hot peening is also must.
vii) A close check should be made at least two to three times per day during the repair of runner to runner chamber clearances.
viii) After welding all the welded areas should be properly ground to match with the desired profiled.
ix) Die penetration tests should once again be carried out to ensure crack free welding. Rectification, if necessary, should be done.

If extensive welding on the runner is required, it will be desirable to do static as well dynamic balancing of the rotating parts and stress relieving before recommissioning to prevent problem of cracking of blades and excessive vibrations in machines.

B. Turbine Guide Bearing

A number of turbine guide bearing designs are in use. These may be classified as follows:
i) Plain water cooled bearing.
ii) Bath type with circular cooling turbines.
iv) Bath type with cooling water tubes embedded in the pads.
v) Grease lubricated bearing.

In the case of plain water cooled bearings, either ferrobestos or rubber lined pads are used against a welded shaft sleeve. The ferrobestos lined bearing have given considerable trouble at one of the power station and these had to be replaced by rubber lined pads.

Small dia cooling pipes embedded in bearing pads have a tendency to clog especially at the time of high silt contents resulting in water starvation. Complaints of excessive oil splashing have been received about the rotating bath type bearing. Grease lubrication bearings have a tendency to clog when in contact with the water and it is very essential to use grease with the right type of properties.

A number of cases of turbine guide bearing failures have come to notice. These are:
i) Starvation of oil in the bath.
ii) Failure of cooling water due to clogging of pipe.
iii) Mal-functioning of instrument like RTDs, TSDs, oil level and flow relays etc.

To avoid failure of bearing due to cooling water tube a new design of turbine guide bearing has been developed by M/s BHEL Hardwar. Two separate oil sumps are located in the top cover in diametrically opposite locations. These sumps, through pipe lines are connected to he oil bath of the bearing. The oil is circulated between sumps and the bath Top cover being stationed just above the draft tube; separate cooling water arrangement for bearing oil is not required. The bearing temperatures with this arrangement never go beyond 40°C to 42 °C.
C. Gland Seals

Normally two types of shaft gland seals are in use in different power stations:

i) Carbon or ferrobestos segment.

ii) Rubber flap type.

1. Carbon or Ferrobestos Segment Type

The seal segment s are housed in the stuffing box. Stuffing box being always in touch with the shaft is subjected to excessive wear and tear. The overhauling of the stuffing box becomes necessary when it is observed that consumption of cooling water has considerably increased or excessive water in top cover appears to be coming. In general maintenance of the seal is required to be done annually.

In the event of breakage or damage to a carbon segment it is advisable to replace the whole set of carbon segments. In very rare case only the damaged segment is replaced care must be taken to ensure that the axial thickness of the new segments falls within the limit size to ±0.002” of the existing ring to which it is to be fitted.

All carbon segments and spacers are fitted to place and match marked on assembly. Whenever any part is replaced it should be ensured that match marking after final assembly is done. Whenever reassembly of the gland seal with existing gland ring or new ring is done it is importance to ensure:

b) All carbon / ferrobestos segments are carefully examined for any chipping or damage.

c) All stainless steel facings are flat and square with the gland sleeve and there are not steps at the facing joints.

d) Stainless steel facing and sleeve are completely free from grease.

e) Ensure proper bedding of segments with shaft sleeve.

f) All segment to segment and segment to stainless steel mating surfaces are perfect.

g) All garter springs are assembled to obtain even tension all around.

h) Alignment of segments in the lower assembly is carefully checked with a hard wood peg for similar device before fitting retaining pins.

2. Rubber flap type

Maintenance of rubber flap type gland seal is comparatively simpler and easier. Only precaution during assembly of rubber gland is jointing of the rubber seal in the proper way.

The quality of rubber used plays a very important role for satisfactory performance of the rubber gland. In one of the recently commissioned power stations rubber gland seal used to fail very frequently. The cause of frequent failure was discussed and analysed to be lying in the quality of rubber. The problem after selection and use of proper quality of rubber is now over.

D. Guide vane servomotor

Normally main source of trouble is rubber cup seals which need to be replaced after a few years. Rubber seals should be replaced during annual maintenance. It is important that all the parts are match marked before dismantling so that reassembly is correctly done.
E. Governor

Different types of governors are in use in different hydro power stations:
- Mechanical governor can be classified as follows
  - Fly ball type
  - Accelero technometric type
- Governor employing magnetic amplifier.
- Governor employing electro hydraulic amplifier.
- The governor may require maintenance because of the following reasons:
  - Chocking of oil parts and throttles.
  - Wearing out of throttles due to which oil leakage becomes more and readjustment of governor becomes essential. In this case governor should be opened and all the throttles etc. Should be cleared. Filters should also be cleaned, and after cleaning and reassembly governor parameters and characteristics should be readjusted so that there is no hunting of the governor.

F. Governing Oil System

The oil sump should be well cleaned and filled with filtered oil. The oil samples should be got tested for verification of the desired properties. Regular centrifuging of oil with the help of De-Laval type oil purifying machine would go a long way in enhancing the life of the oil. In certain cases oil retained its properties even up to 15 to 20 years of continuous use.

During annual overhauling OPU sump and pressure accumulator should be completely emptied and cleaned. The strainers should be inspected and repaired of necessary. The OPU pumps require maintenance when they develop excessive noise or vibration. This may be due to some worn out bearing of the pump which would be replaced.

One more problem which has been faced in different power station is entry of water in the governing oil system. From following two sources the water can enter in the governing oil system.

i) From top cover, through oil leakage pumps which caters leakage of servo motor oil. Its sump being located will below the level of servo motors in the top cover may not be properly sealed, thus providing access to the top cover water which may ultimately be pumped in to the OPU sump.

ii) In case of Kaplan turbine water may enter into the runner hub through rubber seal of blades.

To eliminate first possibility the oil leakage unit delivery was isolated from the OPU sump and connected to a separate tank.
But for the second possibility there is no way except replacing blade seals if excessive water found in the Governor oil.

Daily check of the OPU sump oil sample and test of the same is necessary to keep track of such possibilities.

G. Header

In Kaplan turbine the oil header is required to supply governing oil to the runner servomotor and return oil to the OPU sump. Oil header has an oil guide connected with the rotating and
servo tube. The servo tube has ports to receive return oil to the pipes coming form OPU sump. This tube is guided by three sets of bushes in the oil tube. Due to run out of the shaft these bushes has to press the servo tube. Failure of these had been very frequent in one of the power station.

Monitoring of wobbling of the servo tube with help of dial indicator may provide a guide line and save the bushes from further wearing. Remedial measures to reduce run out of the servo tube must be taken at this stage.

At the time of assembly of various parts of header proper match marking and dowelling is essential so that reassembly may be correctly done.

4.2 PREVENTIVE MAINTENANCE OF HYDRO GENERATOR

Preventive maintenance ensures a long trouble free operation of the generator. Given in the following table are the recommended daily, monthly, once in 3 months, half yearly & yearly maintenance checks to be conducted on the generator. While it is appreciated that it is not always possible to rightly follow this schedule due to generator loading constraints, the recommendation given may be taken as a guide line and these may be altered slightly, based on the past experience.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Periodicity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Stator:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.01</td>
<td>Temperature record on log sheet for core and winding, hot and cold air temperature</td>
<td>Hourly</td>
<td></td>
</tr>
<tr>
<td>1.02</td>
<td>Visual inspection of the overhang parts of the stator winding.</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>1.03</td>
<td>Checking the fixing of winding, condition of winding joints with bus bars etc.</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>1.04</td>
<td>Clean the winding with dry &amp; clean compressed air (2 to 3 kg/cm²).</td>
<td>Once in 3 months</td>
<td>Cleaning to be done such that the dust does not collect in side machine.</td>
</tr>
<tr>
<td>1.05</td>
<td>Check overhang parts of stator winding, bus bars, inner periphery of stator core (if possible), parts of stator winding in slots (specially at sector joint) binding &amp; spacers between the winding bars/ bandage rings.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>1.06</td>
<td>Check looseness of overhang, busbars slot wedges etc.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>1.07</td>
<td>Check the fixing of stator active iron with the frame body in all possible places. If it is necessary, tighten the studs of pressing plates.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>1.08</td>
<td>Check pins &amp; fixing of stator with foundations.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>1.09</td>
<td>Check D.C. resistance, IR &amp; PI value.</td>
<td>Yearly</td>
<td>Record to be maintained</td>
</tr>
<tr>
<td>1.10</td>
<td>Check functioning of RTDs of stator.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>1.11</td>
<td>Blow the winding, active iron and bandage rings etc. with dry &amp; clean compressed air (2</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Periodicity</td>
<td>Remarks</td>
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<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.12</td>
<td>After cleaning apply Red-gel coat on the overhang.</td>
<td>Yearly</td>
<td>Not required during 600 hrs. inspection.</td>
</tr>
<tr>
<td>1.13</td>
<td>In case of excessive wetting of stator winding during conditions such as flooding, drying of winding by passing current is not allowed initially as electrolysis of water may take place. Which is harmful to the winding.</td>
<td>As per requirement</td>
<td>External heating arrangement is to be provided till wetness is removed.</td>
</tr>
<tr>
<td>2.00</td>
<td>ROTOR:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.01</td>
<td>Check rotor winding and insulation details of current carrying leads.</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>2.02</td>
<td>Check the condition of interpolar connectins</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>2.03</td>
<td>Check the condition of damper winding.</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>2.04</td>
<td>Check the locking of pole wedges. If required carryout additional wedging.</td>
<td>Yearly</td>
<td>In case the wedges are loose contact manufacturer before attempting any rectification.</td>
</tr>
<tr>
<td>2.05</td>
<td>Check locking of rim wedges</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>2.06</td>
<td>Check the gaps of spider arms, brake track.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>2.07</td>
<td>Check tightening &amp; proper locking of all fasteners.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>2.08</td>
<td>Clean rotor from dust by blowing compressed air free from moisture (2 to 3 kg/cm²).</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>2.09</td>
<td>Measure D.C. resistance and IR value of rotor winding.</td>
<td>Yearly</td>
<td>Keep a record</td>
</tr>
<tr>
<td>2.10</td>
<td>Check the pole coils for interturn fault.</td>
<td>Yearly</td>
<td>Not required during 600 hrs. inspection.</td>
</tr>
<tr>
<td>3.00</td>
<td>Slipring &amp; Brush Rocker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.01</td>
<td>Check sparking.</td>
<td>Every shift</td>
<td>In case of excessive grooving rectify by grinding.</td>
</tr>
<tr>
<td>3.02</td>
<td>Check pitting &amp; Grooving of slipring</td>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>3.03</td>
<td>Check IR value of rotor through sliprings before &amp; after cleaning sliprings.</td>
<td>Once in 3 months</td>
<td>Keep a record</td>
</tr>
<tr>
<td>3.04</td>
<td>Clean the brush rocker, Brushes, sliprings and the surrounding areas.</td>
<td>Monthly</td>
<td>Special care be taken to clear carbon dust from ‘V’ shaped insulation pieces fitted between sliprings.</td>
</tr>
<tr>
<td>3.05</td>
<td>Check brush wear &amp; spring tension.</td>
<td>Monthly</td>
<td>Use a precision spring balance for adjusting spring tension. The carbon brushes can be</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Periodicity</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------</td>
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<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>3.06</td>
<td>Check for absence of oil or its vapours slipring area.</td>
<td>Every shift.</td>
<td>Oil leakages, if any, to be removed.</td>
</tr>
<tr>
<td>3.07</td>
<td>Check distance of brush holder from slipring and keep it as specified in the drawing.</td>
<td>Monthly</td>
<td>Used till it is not possible to measure/adjust spring tension.</td>
</tr>
<tr>
<td>3.08</td>
<td>New brushes to be used after bedding the brushes. The brush should not be too tight/loose inside the holder.</td>
<td>While replacing</td>
<td></td>
</tr>
<tr>
<td>3.09</td>
<td>Ensure use of same &amp; recommended grade of carbon brushes on one machine.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.10</td>
<td>Check all fasteners of sliprings, brush rocker &amp; current carrying lead.</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>3.11</td>
<td>Check carbon brushes for absence of spittings and severe wear &amp; tear.</td>
<td>Monthly</td>
<td>In case the damage is excessive, replace complete set.</td>
</tr>
<tr>
<td>3.12</td>
<td>Inter change polarity of sliprings.</td>
<td>Half yearly</td>
<td></td>
</tr>
<tr>
<td>3.13</td>
<td>Carryout thorough cleaning of slipring area. Stop oil leakages in this area.</td>
<td>Half yearly</td>
<td></td>
</tr>
<tr>
<td>3.14</td>
<td>In case the original insulating enamel unit is peeling off remove the balance enamel and apply fresh enamel.</td>
<td>Yearly</td>
<td>While cleaning avoid using insulating paint removers.</td>
</tr>
<tr>
<td>3.15</td>
<td>Check wobbling at slip rings.</td>
<td>At the time of installation/during major overhauling</td>
<td></td>
</tr>
<tr>
<td>4.00</td>
<td>Thrust Bearing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.01</td>
<td>Measurement of temperatures of T.B. Pad &amp; Oil by RTD &amp; TSD and record on log sheet.</td>
<td>Hourly</td>
<td></td>
</tr>
<tr>
<td>4.02</td>
<td>Check &amp; record reading of oil level relay.</td>
<td>Once in a shift</td>
<td></td>
</tr>
<tr>
<td>4.03</td>
<td>Analysis of oil from oil bath.</td>
<td>Half yearly</td>
<td>Record to be kept.</td>
</tr>
<tr>
<td>4.04</td>
<td>Change of oil in T.B. oil bath</td>
<td>When centrifuging doesn’t help in improving its quality up to acceptable values.</td>
<td></td>
</tr>
<tr>
<td>4.05</td>
<td>Check level of oil from the gauge glass. Any increase in level may be due to leakage of water in the oil bath coolers.</td>
<td>Once in every shift.</td>
<td>Unit should be stopped in case of leakage from cooling tube, plugging of cooling tubes upto 10% can be done depending upon bearing temperature.</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
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<td>Remarks</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
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<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4.06</td>
<td>Measures insulation resistance of T.B. disc.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>4.07</td>
<td>Check calibration of the TSD’s &amp; RTD’s of thrust bearing.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>4.08</td>
<td>Check the working surface of thrust bearing pads, scrapping, if required,</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>should be carried out with respect to T.B. disc after apply lard (animal fat) on the pads &amp; giving rotation to the unit. Load sharing on T.B. pads and the verticality of the unit is to be checked thereafter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.09</td>
<td>Check the condition of mirror surface of T.B. Disc. Polishing of the surface can be done to remove minor scratches.</td>
<td>During capital</td>
<td>This will require partial dismantling of unit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maintenance</td>
<td></td>
</tr>
<tr>
<td>4.10</td>
<td>Clean all inner surfaces of oil bath from dust, wash them with Kerosene and dry with clean cloth.</td>
<td>Once in Two years.</td>
<td>Oil bath is to be finally flushed with fresh turbine oil; to be discarded after use.</td>
</tr>
<tr>
<td>4.11</td>
<td>Check the condition of weld seam of oil bath &amp; oil pipe lines for leakages visually.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>4.12</td>
<td>Check the condition of insulation of RTD leads.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>4.13</td>
<td>Check if excessive foaming is taking place on oil through gauge glass. This is normally due to mixing of water leaking from oil coolers. If oil level is not rising, the oil may need a defoment. Oil sample to be checked.</td>
<td>As required</td>
<td>Watch carefully for rise in water level to confirm leakage and attend accordingly.</td>
</tr>
<tr>
<td>4.14</td>
<td>Check if any insulating segment over T.B. Disc is displaced.</td>
<td>During capital</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>maintenance</td>
<td></td>
</tr>
<tr>
<td>4.15</td>
<td>Check (in case of problem) the intactness of spherical surface of thrust bolt.</td>
<td>As per requirement.</td>
<td></td>
</tr>
<tr>
<td>4.16</td>
<td>In case of uneven wear of pad, check that the pad eccentricity is correct.</td>
<td>As per requirement.</td>
<td></td>
</tr>
<tr>
<td>4.17</td>
<td>Check for proper seating of pads</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td>4.18</td>
<td>Change rubber seals &amp; woolen felts</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td>5.00</td>
<td>GUIDE BEARINGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.01</td>
<td>Measurement of temperatures of G.B. pads, oil by RTD &amp; TSD &amp; record on log sheets</td>
<td>Hourly</td>
<td></td>
</tr>
<tr>
<td>5.02</td>
<td>Check &amp; note reading of level relay</td>
<td>Once in every shift</td>
<td></td>
</tr>
<tr>
<td>5.03</td>
<td>Analysis of oil from oil bath</td>
<td>Once in 3 months</td>
<td>Record to be kept.</td>
</tr>
<tr>
<td>5.04</td>
<td>Change of oil in T.B. oil bath</td>
<td>When centrifuging</td>
<td>When centrifuging doesn’t help in improving its quality up to</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
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<td>Remarks</td>
</tr>
<tr>
<td>--------</td>
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</tr>
<tr>
<td>5.05</td>
<td>Measures insulation resistance of G.B. pads.</td>
<td>Yearly</td>
<td>acceptable values</td>
</tr>
<tr>
<td>5.06</td>
<td>Check calibration of TSD’s &amp; RTDs of of G.B.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.07</td>
<td>Prior to removal of pads, measure and record guide bearing clearances.</td>
<td>As per requirement</td>
<td>To be readjusted if required, during reinstallation</td>
</tr>
<tr>
<td>5.08</td>
<td>Check each pad for: i) Absence of scratch marks. Scraping to be done with respect to the journal, if required ii) Heavy damage on babbit surface of pads – full set be replaced from spares. The spares set tot be scrapped with respect to it’s respective journal surface by giving rotation to the unit.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.09</td>
<td>Check the centering of the unit vis-à-vis the labyrinth/runner chamber of turbine.</td>
<td>Yearly as per requirement</td>
<td></td>
</tr>
<tr>
<td>5.10</td>
<td>Check the friction surface of the bearing journal. Carryout its polishing, if necessary.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.11</td>
<td>Wash pads &amp; journal with aviation petrol and then carryout assembly of the guide bearing.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.12</td>
<td>Check the condition of welding seems of oil bath &amp; leakages from them and oil pipe liens.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.13</td>
<td>Clean all inner surfaces of oil bath from dust, wash them with Kerosene and dry with clean cloth.</td>
<td>Once in two years</td>
<td>Oil bath is to be finally flushed with fresh turbine oil; to be discarded after use.</td>
</tr>
<tr>
<td>5.14</td>
<td>Change rubber seals and woolen felts.</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td>5.15</td>
<td>Check operation of the level relay and its calibrations.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.16</td>
<td>Check welding of pad support block with oil bath.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.17</td>
<td>Check looseness of pad and pad support bolts.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.18</td>
<td>Check condition of pad insulation</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>5.19</td>
<td>Check looseness of bolts holding ‘Z’ clamps (in wedge type construction of guide bearings).</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>6.00</td>
<td>AIR/OIL COOLERS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.01</td>
<td>Check water boxes for clogging by opening them. In case of clogging clean tubes water boxes with wire/nylon brush. Remove all dirt etc &amp; finally clean with fresh water &amp;</td>
<td>Yearly</td>
<td>This checking may be done frequently if clogging is more.</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Periodicity</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------</td>
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</tr>
<tr>
<td>6.02</td>
<td>Check the gasket between oil cooler &amp; oil bath &amp; between air cooler &amp; stator frame. Gaskets to be replaced if required.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>6.03</td>
<td>When the shutdown exceeds 10 days, water from coolers is to be drained and the coolers kept dry.</td>
<td>As required</td>
<td>This is to safeguard failure on subsequent commissioning of the unit.</td>
</tr>
<tr>
<td>6.04</td>
<td>Coolers are to be immediately attended to as given above at 6.03.</td>
<td>On flooding of the unit.</td>
<td>This is to safeguard failure on subsequent commissioning of the unit.</td>
</tr>
<tr>
<td>6.05</td>
<td>Normally upto 10% of the cooling tubes of coolers can be plugged, if required.</td>
<td>As required</td>
<td>Temperature of the bearing pads/ stator winding to be taken in view while plugging tubes of the coolers.</td>
</tr>
<tr>
<td>7.00</td>
<td><strong>UPPER BRACKET / LOWER BRACKET</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.01</td>
<td>External inspection &amp; tightening of the lock nuts in the radial jacks, if required.</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>7.02</td>
<td>Check fixing of the generator cover plate</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>7.03</td>
<td>Check all fasteners of Upper and lower air baffles.</td>
<td>Once in 3 months</td>
<td></td>
</tr>
<tr>
<td>7.04</td>
<td>Check the value of air gap between air baffles and rotor.</td>
<td>Yearly</td>
<td>These gaps are to be compared with original values during erection and maintained as such, if required.</td>
</tr>
<tr>
<td>7.05</td>
<td>Clean the brackets of dirt &amp; dust.</td>
<td>Yearly</td>
<td>Cleaning can be done more often if possible.</td>
</tr>
<tr>
<td>7.06</td>
<td>Check fastening between upper bracket &amp; stator and foundation plates.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>7.07</td>
<td>Check foundation bolts tightening for stator &amp; lower bracket.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>7.08</td>
<td>Check all fasteners for locking / tightness</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>8.00</td>
<td><strong>Brake pipeline</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.01</td>
<td>Record air pressure available at brake panel.</td>
<td>Every shift</td>
<td>Record on log sheet</td>
</tr>
<tr>
<td>8.02</td>
<td>Check thickness of brake pad</td>
<td>As required</td>
<td>Record to be maintained along with number of braking in the period with Air pressure used for braking.</td>
</tr>
</tbody>
</table>
| 8.03   | Measure:  
1) Time for unit to come braking speed | During first spinning / yearly | Record be kept. In case if this time has... |
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Periodicity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.04</td>
<td>Check if excessive brake dust is generated and find its cause.</td>
<td>Yearly</td>
<td>Clean the affected areas periodically as required</td>
</tr>
<tr>
<td>8.05</td>
<td>During jacking operation lifting of the rotor is to be limited to the specified value (7.0 mm)</td>
<td>During jacking</td>
<td>Limit switch to be suitably mounted to check the rotor lift.</td>
</tr>
<tr>
<td>8.06</td>
<td>Keep the unit on jacks which are mechanically locked during each shut-down of the unit.</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td>8.07</td>
<td>After each jacking operation ensure cleaning of pipe with air under pressure as provided in the system.</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td>8.08</td>
<td>Check no oil leaks from return line during jacking operation</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td>8.09</td>
<td>Check function of the braking system on manual &amp; auto and the operation of the limit switches of brake. Check leakage through pipelines during braking / jacking.</td>
<td>Yearly</td>
<td>Record be maintained. In case of any problem brake panel &amp; brakes are to be checked &amp; rectified as required.</td>
</tr>
<tr>
<td>8.10</td>
<td>Check all fasteners of brakes and brake pipe lines &amp; gaskets wherever provided.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>8.11</td>
<td>Check the condition of brake track and its holding with the rotor.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>8.12</td>
<td>Open brake cum jack assembly. Clean the inner surface of dust with Kerosene &amp; reassemble.</td>
<td>Yearly</td>
<td>Replace the gasket, if required.</td>
</tr>
<tr>
<td>9.00</td>
<td>GENERAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.01</td>
<td>External examination of parts of generator which are accessible.</td>
<td>Once in each shift</td>
<td></td>
</tr>
<tr>
<td>9.02</td>
<td>External inspection of air coolers, oil coolers, pipe lines, sealing &amp; control etc. for leakages.</td>
<td>Once in each shift</td>
<td></td>
</tr>
<tr>
<td>9.03</td>
<td>Ensure cleanliness of all external accessible parts of the generator &amp; wipe with clean &amp; dry cloth.</td>
<td>Once in each shift</td>
<td></td>
</tr>
<tr>
<td>9.04</td>
<td>Check wobbling of the shaft at turbine generator flange/ TGB.</td>
<td>Daily</td>
<td></td>
</tr>
<tr>
<td>9.05</td>
<td>Blow with compressed air the internal</td>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Periodicity</td>
<td>Remarks</td>
</tr>
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<td>----------------------------------------------</td>
</tr>
<tr>
<td>9.06</td>
<td>External inspection of current carrying leads PMG, Bus Bars, Terminal Blocks, Panels etc.</td>
<td>Monthly</td>
<td>To be cleaned if necessary</td>
</tr>
<tr>
<td>9.07</td>
<td>Check the condition of lighting inside the barrel</td>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>9.08</td>
<td>Check the recordings of lighting inside original results.</td>
<td>Daily</td>
<td>Reasons for variance to be investigated</td>
</tr>
<tr>
<td>9.09</td>
<td>Check for proper cleaning of sliprings.</td>
<td>As per</td>
<td>requirements</td>
</tr>
<tr>
<td>9.10</td>
<td>Check the vibrations at TGB, UGB &amp; LGB predetermined points.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>9.11</td>
<td>Check connections of current carrying leads &amp; cables. Tighten the bolts, if required, after removing the insulation.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>9.12</td>
<td>Check the calibration of Electrical measuring instruments i.e. voltmeter, ammeter, Active/Reactive Power meter. Frequency meter, P.F. meter for Stator output, Voltmeter &amp; Ammeter in Field winding circuit, energy meter etc.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>9.13</td>
<td>Check the Sensitivity &amp; Stability of Generator Electrical Protection scheme.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>9.14</td>
<td>Check the working of Fire Extinguishing (CO₂) system without actually releasing the CO₂ gas on manual and on auto operation as per the instructions provided in O&amp;M manual of the Fire Extinguishing System provided by its supplier.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>9.15</td>
<td>Check the characteristics of Static Excitation system in both auto &amp; manual mode and sensitivity of various limits.</td>
<td>As specified in its O&amp;M manual.</td>
<td></td>
</tr>
<tr>
<td>10.00</td>
<td>OIL PIPE LINE/ EXTERNAL OIL COOLING SYSTEM (If applicable)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.01</td>
<td>Check oil pressure at the pump across the filter &amp; point of entry to the bearing.</td>
<td>Every shift</td>
<td>Record is to be maintained.</td>
</tr>
<tr>
<td>10.02</td>
<td>Check the operation of the electrical contact pressure gauge.</td>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>10.03</td>
<td>Check temperature of bearings of the Pump-motor set.</td>
<td>Daily</td>
<td>This temp. is not to exceed the specified limits. In case temp. is excessive check if lubricating grease is filled as required.</td>
</tr>
<tr>
<td>10.04</td>
<td>Check conditions of gland packing of the pump and see that air is not being sucked from here into the system.</td>
<td>Monthly</td>
<td>These are holes in pipes which feed oil in between the pads.</td>
</tr>
<tr>
<td>10.05</td>
<td>Completely clean the oil tank &amp; T.B. oil bath</td>
<td>Yearly</td>
<td></td>
</tr>
</tbody>
</table>
### Table: Guidelines for Operation and Maintenance of Small Hydropower Station

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Periodicity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.06</td>
<td>Clean the oil pipe line after disconnecting it</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>10.07</td>
<td>Check the operation of the valves of the pipe line.</td>
<td>Yearly</td>
<td></td>
</tr>
<tr>
<td>10.08</td>
<td>Check the Operation of D.C. pump motor set (if provided)</td>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>10.09</td>
<td>Remove sludge from oil tank.</td>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>10.10</td>
<td>Check the temperature of cold &amp; hot oil.</td>
<td>Hourly</td>
<td>Keep record in the log sheet.</td>
</tr>
<tr>
<td>10.11</td>
<td>Check the air ventilation cock of the oil tank are open during operation of the unit.</td>
<td>During start of the unit/ during each shift.</td>
<td></td>
</tr>
<tr>
<td>10.12</td>
<td>Check pipe line for leakage of oil.</td>
<td>Once in each shift.</td>
<td></td>
</tr>
<tr>
<td>10.13</td>
<td>Check oil sample for acidity, viscosity, moisture content, foreing material &amp; sludge. Formations.</td>
<td>Once in 3 months</td>
<td>Separate oil sample from each bearing should be sent for chemical analysis &amp; record to be kept.</td>
</tr>
<tr>
<td>10.14</td>
<td>Clean holes for oil entry into the T.B. housing</td>
<td>Yearly</td>
<td></td>
</tr>
</tbody>
</table>

All the above checks and some more checks are again tabulated for daily, weekly, monthly and annual checks and maintenance.
4.2.1 Daily Checks

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Assembly</th>
<th>Item</th>
<th>Check Point</th>
<th>Method</th>
<th>Remark &amp; Remedial Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stator Core</td>
<td>Core Noise</td>
<td>Abnormal noise around stator</td>
<td>Periodic listening</td>
<td>Checking for core looseness especially at frame joints If abnormal add additional paramax paper in core joints</td>
</tr>
<tr>
<td>2.</td>
<td>Wound Stator</td>
<td>Stator core and coils</td>
<td>Core &amp; winding temp.</td>
<td>Temp. scanners</td>
<td>Check cooled air &amp; cooling system</td>
</tr>
<tr>
<td>4.</td>
<td>Bear oil</td>
<td>Oil level</td>
<td>Level gauge</td>
<td>Visual</td>
<td>High- Due to Water Leakage Low- Leakage of Oil From Housing</td>
</tr>
<tr>
<td>5.</td>
<td>Air Coolers</td>
<td>Cooler tubes</td>
<td>Water leakage</td>
<td>Visual</td>
<td>Plug the leaking tubes</td>
</tr>
<tr>
<td>6.</td>
<td>Collector</td>
<td>Brushes</td>
<td>Sparking, Mix of C-Dust/ Oil</td>
<td>Visual</td>
<td>Cleaning</td>
</tr>
<tr>
<td>7.</td>
<td>Brake &amp; Jack</td>
<td>Air Pr.</td>
<td>Pr. Gauge</td>
<td>Pr. Gauge</td>
<td>Check for leakage, pipeline, joints</td>
</tr>
<tr>
<td>8.</td>
<td>D.C. Exciter</td>
<td>Commutator brush gear</td>
<td>Commutation</td>
<td>Visual</td>
<td></td>
</tr>
</tbody>
</table>
### 4.2.2 Weekly / Monthly Checks

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Assembly</th>
<th>Item</th>
<th>Check Point</th>
<th>Method</th>
<th>Remark &amp; Remedial Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weekly</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Collector ring</td>
<td>Cleaning</td>
<td>Accumulation of Dirt</td>
<td>Visual</td>
<td>Clean compare, IR value</td>
</tr>
<tr>
<td>2</td>
<td>Brushes</td>
<td></td>
<td>Sparking, Chattering wear &amp; clearance</td>
<td>Visual</td>
<td>Smoothen collector surface clean adjust brush (5 to 8 mm for 1000 R-hour)</td>
</tr>
<tr>
<td>3</td>
<td>Brake Lining</td>
<td></td>
<td>Air leakage, excessive wear</td>
<td>Visual</td>
<td>Attend leakages More than 4 to 5 mm per 50 OP Reduce application, speed &amp; PR. Check air PR, Clean Track, Change Lining</td>
</tr>
<tr>
<td>4</td>
<td>Brake Track</td>
<td></td>
<td>Clean liners &amp; Oil Sludge/ Moisture Trap</td>
<td>Visual</td>
<td>Clean Drain Trap &amp; Clean Brake Track</td>
</tr>
<tr>
<td>5</td>
<td>Dc. Exciter</td>
<td>Commutator Brush Gear</td>
<td>Commutation</td>
<td>Visual</td>
<td>Brushes are not sticking in their boxes, rough or high spot on commutator smooth surface.</td>
</tr>
<tr>
<td><strong>Monthly</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Stator core</td>
<td>Back of core</td>
<td></td>
<td>Visual</td>
<td>Adjust core packing of jack screws, insert paramax paper</td>
</tr>
<tr>
<td>2</td>
<td>Field wind</td>
<td>Field coil top</td>
<td></td>
<td>Visual Feeler Gauge</td>
<td>Clean Comp. Air</td>
</tr>
<tr>
<td>3</td>
<td>DC Exciter</td>
<td>Commutator, Brush Gear, Air Filter</td>
<td>Visual</td>
<td>Replace brushes, clean com., Risers, clean with detergent sol. Dry.</td>
<td></td>
</tr>
</tbody>
</table>
### 4.2.3 Annual Inspection & Maintenance

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Assembly</th>
<th>Item</th>
<th>Check Point</th>
<th>Method</th>
<th>Remark &amp; Remedial Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Stator</td>
<td>(i) Frame</td>
<td>Joint bolt tightness &amp; Dowel Pins</td>
<td>Hammering</td>
<td>Retighten, if Necessary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Core</td>
<td>Tightness of Core</td>
<td></td>
<td>Check Tightness of core specially at the top &amp; bottom most packets. Any local looseness between punchings can be filled up with asbestos of paramax paper glued with epoxy varnish &amp; core bolts retightened. After repairs spray the top &amp; bottom three packets (both from I.D. &amp; O.D.) with loctite – 290 Marketed By M/s Fit Tite Chemicals Ltd.</td>
</tr>
<tr>
<td></td>
<td>Core Duct</td>
<td>Contamination</td>
<td>Visual</td>
<td></td>
<td>Clean with Dry compressed air</td>
</tr>
<tr>
<td></td>
<td>Stator winding</td>
<td>Cleanliness &amp; general condition</td>
<td>Visual</td>
<td></td>
<td>Clean the end windings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Measure IR values after cleaning</td>
<td></td>
<td>Dryout if IR Value is low</td>
</tr>
<tr>
<td>2.</td>
<td>Field winding</td>
<td>Field coil &amp; rotor</td>
<td>General condition of coil, Pole &amp; cleanliness</td>
<td>Visual</td>
<td>Clean the field coil with compressed air</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Check the coil joints for any cracks overheating etc.</td>
</tr>
<tr>
<td></td>
<td>Field coil &amp; rotor leads</td>
<td>Inter turn faults</td>
<td>Measure impedance of field coils by applying 60 to 100 V AC, 50 Hz supply</td>
<td></td>
<td>If impedance of some coils is very low (say less than 40%) they must be checked for possible inter-turn faults.</td>
</tr>
<tr>
<td>3.</td>
<td>Brushgear and Sliprings</td>
<td>Brushes &amp; Sliprings</td>
<td>General Conditions &amp; Cleanliness</td>
<td>Visual</td>
<td>The slipring is running out, Correct it, any grooves etc to be removed by oil stone for excessive sparking</td>
</tr>
</tbody>
</table>

*Core Duct Contamination Visual Clean with Dry compressed air
Stator winding Cleanliness & general condition Visual Clean the end windings
Field winding Field coil & rotor General condition of coil, Pole & cleanliness Visual Clean the field coil with compressed air
Field coil & rotor leads Inter turn faults Measure impedance of field coils by applying 60 to 100 V AC, 50 Hz supply
Brushgear and Sliprings Brushes & Sliprings General Conditions & Cleanliness Visual The slipring is running out, Correct it, any grooves etc to be removed by oil stone for excessive sparking*
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Assembly</th>
<th>Item</th>
<th>Check Point</th>
<th>Method</th>
<th>Remark &amp; Remedial Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>DC exciter</td>
<td>Core &amp; Winding</td>
<td>Accumulation of dust</td>
<td>Visual</td>
<td>For cleaning the exciter</td>
</tr>
<tr>
<td>5.</td>
<td>Bearings</td>
<td>Top &amp; Bottom Guide Bearing Pads</td>
<td>Clearance</td>
<td>Feeler Gauge</td>
<td>Check guide bearing pad clearance. If pad clearance have to be reset the shaft must be centered first. Examine the condition of guide pads and any slight scouring marks can be attended by water emery paper (GR-400)</td>
</tr>
<tr>
<td>6.</td>
<td>Air coolers</td>
<td>Coolers tubes</td>
<td>Clean inside and outside of air cooler tubes</td>
<td>Checks for any tube leakage by pressurizing to a pressure slightly more than maximum expected working pressure.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Oil coolers</td>
<td>Coolers tubes</td>
<td>Clean inside &amp; outside of oil</td>
<td>Check for any tube leakage by pressurizing to a pressure slightly more than maximum expected working pressure.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>HS Lub. System</td>
<td>HS Lub Motor HP Hose Assembly</td>
<td></td>
<td></td>
<td>Inspect bearing &amp; Grease, if necessary check the condition of the hoses &amp; if necessary replace them.</td>
</tr>
<tr>
<td>9.</td>
<td>PMG</td>
<td>Air gap winding</td>
<td>General condition &amp; cleanliness</td>
<td></td>
<td>Check air gap Clean the stator &amp; field windings check the open circuit voltage and if less than 100 V remagnetise</td>
</tr>
<tr>
<td>10.</td>
<td>Shaft runout &amp; centering &amp; rotor level</td>
<td></td>
<td></td>
<td></td>
<td>Readjustment, if necessary</td>
</tr>
<tr>
<td>11.</td>
<td>Water flow relays, visual</td>
<td></td>
<td></td>
<td></td>
<td>Impact, clean water passages, if necessary</td>
</tr>
</tbody>
</table>

Note: For cleaning stator ducts, stator winding, field coils, rotor leads, brushgear, PMG and DC Exciter, Use cleaning agents as recommended by manufacturer
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Assembly &amp; Flow Indicators &amp; Flow Meters</th>
<th>Item</th>
<th>Check Point</th>
<th>Method</th>
<th>Remark &amp; Remedial Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.</td>
<td>Oil level indicator</td>
<td></td>
<td></td>
<td></td>
<td>Clean rod probe</td>
</tr>
<tr>
<td>13.</td>
<td>Braking &amp; Jacking system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Combinatory unit and air supply pipe line,</td>
<td>Clean the filter element and bowl of filter, similarly clean the bowl of lubricator also, cessation of oil dripping through that sight glass is an indication that cleaning is done</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Brake track fixing</td>
<td>Tightness of Dog clamps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Brake limit switch</td>
<td>Proper Operation &amp; Cleaning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Thrust &amp; top guide bearing</td>
<td>Bearing Oil vapour seal of top bearing</td>
<td>Check IR value of bearing Insulation &amp; replae insulation if damaged. Check IR value of vapour seal insulation and replace, if damaged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Electrical Connections</td>
<td>Pole to pole connections</td>
<td>Tighten all electrical joints</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brushgear connection</td>
<td>Tighten all electrical joints.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>RTD terminal heater terminal connection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Brushgear</td>
<td>Cleaning Insulated parts</td>
<td>Clean the insulated parts by compressed air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Rotor assembly</td>
<td>Tightening of fasteners</td>
<td>Tighten all the approachable fasteners on rotor assembly including tightening pole and rim keys &amp; lock all of them.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Assembly</td>
<td>Item</td>
<td>Check Point</td>
<td>Method</td>
<td>Remark &amp; Remedial Measures</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>-----------------------</td>
<td>------------------------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>Rotor</td>
<td>Shaft vibration</td>
<td>Slipring and coupling</td>
<td>Dial gauge</td>
<td>Check for run out at slipring and turbine coupling and readjust if found more than the specified value. Rebalance if necessary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bracket vibration</td>
<td>Vibration</td>
<td>Balancing equipment</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Rotor pole</td>
<td>Damper system structure</td>
<td>Interconnection between poles</td>
<td>Visual</td>
<td>Tighten and lock properly if supporting structure found loose.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supporting structure for proper tightness</td>
<td>By tapping</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>By shaking</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Visual</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rectify if found damaged.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Top shaft</td>
<td>Current carrying leads</td>
<td>Tightness of clamps General condition</td>
<td>Visual</td>
<td>Repair insulation if found damaged</td>
</tr>
<tr>
<td>21</td>
<td>Generator Auxiliaries</td>
<td>Check for proper operation</td>
<td></td>
<td>Clean that these are in good working condition</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Cooling water valves</td>
<td>Check for proper operation</td>
<td></td>
<td>Clean &amp; replace glands where needed.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Over speed device</td>
<td>Plunger &amp; contact mechanism</td>
<td></td>
<td>Proper operation</td>
<td></td>
</tr>
</tbody>
</table>

**4.2.4 Capital Maintenance of Hydrogenerator**

**Dismantling:**
- Decouple generator shaft and turbine shaft after recording guide bearing clearances air gaps between stator & rotor air gaps of main, pilot exciter & PMG etc if mounted on shaft.
- Dismantling other components one by one in proper sequence till rotor is free to be lifted.
- Rotor should be taken out very carefully and kept in rotor assembly pit duly bolted with base plat. Rotor rim to be supported by block and jacks all around the circumference.
- All stator air coolers are to be dismantled and kept for testing and repair.
- Braking & jacking units to be dismantled
- All cares are to be taken during dismantling to ensure safety of all components, fastners, pins etc.
- Prior arrangement of proper T&P, special T&P, slings, D-shackles etc, is also necessary.

**Maintenance of Stator:**
- Stator Frame
- **Stator core winding**
  - Stator tightness of core specially at the top and bottom most packets.
  - Any local looseness between punchings can be filled up with paramax paper glued with epoxy varnish & core bolt retightened.
  - After repair spray top and bottom three packets with loctite-290.
  - Clean core duct with dry compressed air
  - Clean the ends of winding.
  - Measure IR value of winding after through cleaning; Dry out if IR is low.
  - Carryout Electronic Core Imperfection detection test also to ensure healthyness of core.
  - After rectifying all defect and thorough cleaning the inner bore and overhang portion of winding is to be spray painted. Paint used should be specified insulating paint.

- **Maintenance of Rotor**
  - The rotor is to be thoroughly cleaned with dry compressed air.
  - Check general condition of coil and pole, clean with dry compressed air.
  - Check the coil joints for any cracks due to overheating etc.
  - Check field coils and rotor leads for inter turn fault. Measure impedance of coils by applying 60 to 100 VAC, 50 C/s If impedance of some coil is very low (<4%) they must be checked for possible inter turn faults.
  - Shaft is to be checked specially at G.B. journals for any marks roughness etc. Remedial measures are to be taken if marks, roughness is found.
  - Check top and bottom rotor fans, if found damaged replace the same.
  - Check tightness of all the joints of rotor spider and extension arms
  - Check tightness of rotor rims, pole key rim keys etc.
  - After rectification of all defects and thorough cleaning, spray point the rotor with insulating red gel paint.
  - Keep the rotor covered with asbestos cloth to prevent deposit of dust and fire safety.
  - All safety precautions for external damage, fire etc are to be taken in the service.

- **Maintenance of brush gears and slip rings**
  - Check if there are any grooves, roughness high points use oil stone for rectification
  - Check brush gear connections clean all the insulated parts with dry compressed air.

- **Maintenance of Bearing**
  - **Guide bearings**
    - Check condition of Housing
    - Check condition of Pads, if required, bedding is to be done
    - In case babbit material found damaged or thinned, rebabbit of pads with proper grade of white metal.
    - Check insulation of pads, if found damaged replace the same. Check IR value
    - Check all RTDs & TSDs
  - **Thrust Bearing**
    - Check condition of pads, if found some damage to babbit material, get rebabbiting done
    - Bedding of pads to ensure removal of high points and having desired contact area.
    - Check bearing insulation by measuring IR value. Replace insulation if found damaged.
- **Maintenance of Air Coolers**
  - Clean inside and outside of air cooler tubes
  - Check for any tube leakage by pressurizing to a pressure slightly more than maximum expected working pressure
  - If more than 10% tubes are leaking change full set of tubes otherwise change only leaking tubes
  - After repair paint the body of coolers.

- **Maintenance of Oil Coolers**
  - Clean inside and outside of cooling tubes
  - Check for any tube leakage by pressurizing to a pressure slightly more than maximum expected working pressure
  - Replace full set of tubes if more than 10% of total tubes are leaking.

- **Maintenance of H.S. Lub system**
  - Inspect bearing and grease, if necessary
  - Check the condition of hoses, if necessary replace
  - Check for any leakages and take remedial measures.
  - Check pressure gauges etc.

- **Maintenance of Flow relays, visual flow indicators and flow meter:**
  - Inspect, clean water passages remove silt.
  - All defective meters are to be replace.

- **Braking and jacking system:**
  - Check brake units and clean inside outside of the unit
  - Change seals
  - Carry out hydraulic test
  - Clean the filters, bowl of lubricator
  - Check brake track, tighten dog clamps
  - Check working of brake limit switches.
  - Replace brake lining

- **General checks**
  - Check condition of current carrying leads.
  - Check all water & oil valves for their proper working
  - Check general operational healthiness of all auxiliaries
  - Check proper working of overspeed device.

### 4.3 PREVENTIVE MAINTENANCE OF POWER TRANSFORMERS

The maintenance of transformer is an ongoing process and stress should be on preventive maintenance rather than acting when a fault occurs. A schedule of maintenance activities is drawn and tabulated below. This is applicable to Main, Auxiliary, stator & distribution transformers.
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Item to be inspected</th>
<th>Inspection Procedure</th>
<th>Action required if unsatisfactory condition indicated</th>
<th>Applicable UATS, SSTS and distribution transformers when ticked</th>
<th>√</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Applicable for transformers</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A</strong></td>
<td><strong>Hourly</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Ambient temperature</td>
<td>Take air temperature near the transformer for air cooler transformers. Take water temperature at the inlet to the cooler for water cooled transformers.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Winding temperature indicator reading relation</td>
<td>Check for abnormalities in to ambient temperature and load.</td>
<td>If the temperature indicated is more than envisaged as per loading condition, check: i) That radiator valves or cooler circuit valves are all open. ii) Fans operate at set value of temperatures. iii) Fans/oil pumps are in circuit iv) Winding CT connection and C.T. ratio adopted. v) Check calibration of OTI and WTI.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Oil temperature indicator reading</td>
<td>-do-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Load (amperes)</td>
<td>Check against rated figures</td>
<td>- Reduce load if it exceeds the specified limits.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Voltage</td>
<td>-</td>
<td>Correct tap position in line with voltage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Transformer/ Shunt reactor humming and general vibration.</td>
<td>Check for any abnormality in sound.</td>
<td>- Tighten any looseness in external parts. If abnormal sound still persists, complete checking be done.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B</strong></td>
<td><strong>Daily</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Oil level in transformer / shunt reactor</td>
<td>Check oil level from oil gauge</td>
<td>- Top up if found low. Examine transformer/ shunt reactor for leaks. - Tighten gasket joint at the leak point.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Oil level in diverter switch</td>
<td>Check oil level from the gauge glass.</td>
<td>- If oil leakage found, check sealing gasket between diverter switch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. No.</td>
<td>Item to be inspected</td>
<td>Inspection Procedure</td>
<td>Action required if unsatisfactory condition indicated</td>
<td>Applicable UATS, SSTS and distribution transformers when ticked √</td>
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<td>3</td>
<td>Oil level in bushings</td>
<td>Check oil level from the oil gauge of the bushings in which oil remains separate from the tank oil.</td>
<td>- If low, top up oil. Examine bushing for any oil leakage.</td>
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<td>4</td>
<td>Pipe work and accessories for leakage</td>
<td>Check for oil leaks</td>
<td>- If leakages are observed, tighten evenly the gasket joints. Replace ‘O’ ring or washer suitably. Replace gasket if needed.</td>
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<td>5</td>
<td>Relief vent diaphragm</td>
<td>Check for any crack</td>
<td>- Replace if cracked / broken. If broken, ensure from other protections provided that there is no fault inside the transformer / reactor.</td>
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<tr>
<td>6</td>
<td>Fans/oil pump running</td>
<td>Check that fans/oil pump are running as required.</td>
<td>- Check connections. If found defective correct them.</td>
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<td>7</td>
<td>Oil &amp; cooling water flow.</td>
<td>Check oil and water flow indicators.</td>
<td>- Check opening of valves if restricted flow observed.</td>
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<td>C. Weekly</td>
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<tr>
<td>1</td>
<td>Leakage of water into cooler</td>
<td>Check by opening the end covers of the cooler.</td>
<td>- Plug the tube leaking.</td>
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<tr>
<td>2</td>
<td>Operating sequence of oil pump and the cooler</td>
<td>Change over from one cooler to the other.</td>
<td>- Ensure proper change over.</td>
<td></td>
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<tr>
<td>3</td>
<td>Operation of anti-condensation heater in marshalling box and OLTC motor drive panel</td>
<td>Check anti-condensation heaters are working.</td>
<td>- Set them right if not working</td>
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<td>S. No.</td>
<td>Item to be inspected</td>
<td>Inspection Procedure</td>
<td>Action required if unsatisfactory condition indicated</td>
<td>Applicable UATS, SSTS and distribution transformers when ticked</td>
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<td>D. Monthly</td>
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<tr>
<td>1.</td>
<td>Dehydrating breather</td>
<td>i) Check colour of silica gel</td>
<td>- If more than half of silica gel has turned pink, change by spare charge. The old charge may be reactivated for use again.</td>
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<td>ii) Check oil level in the oil cup and contamination of oil visually.</td>
<td>- Add oil, if required to maintain oil level. Replace oil if contaminated.</td>
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<td>iii) Check that air passages are free.</td>
<td>- Ensure air passages are free.</td>
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<tr>
<td>2.</td>
<td>Maximum pointer of OTI and WTI</td>
<td>Record the maximum oil and winding temperature readings reached during the month.</td>
<td>- Check whether the readings are within permissible limits.</td>
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<td>- Reset maximum pointer of OTI and WTI.</td>
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<tr>
<td>3.</td>
<td>Operation of fans</td>
<td>In mixed cooling in ONAN/ ONAF, if temperature of oil has been less than the fan control setting temperatures, operate the fans manually to check their running.</td>
<td>- Ensure smooth running of fans.</td>
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<td>E. Quarterly</td>
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<tr>
<td>1.</td>
<td>Bushings</td>
<td>Visual inspection for cracks and dirt deposits.</td>
<td>- Clean dirt deposits. If cracks observed, cracked bushing should be rectified / replaced.</td>
<td></td>
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<tr>
<td>2.</td>
<td>Cooler fan bearing and control, pumps</td>
<td>Check contacts, manual control</td>
<td>- Lubricate bearings. Replace worn out contacts. Clean fans and adjust controls.</td>
<td></td>
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<tr>
<td>3.</td>
<td>External earth connections</td>
<td>Check all external connections for discoloration or hot joints.</td>
<td>- Tighten them if loose.</td>
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<td>S. No.</td>
<td>Item to be inspected</td>
<td>Inspection Procedure</td>
<td>Action required if unsatisfactory condition indicated</td>
<td>Applicable for transformers when ticked</td>
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<td>4</td>
<td>OLTC</td>
<td>Examine contacts, Check step by step mechanism operation, end position limit switches and brakes. Check that wiring is intact and all terminals are tight.</td>
<td>- Replace all the worn out and burnt contacts. Set limit switches in position. Clean / replace brake shoe lining. Lubricate all bearing and coupling points suitably. Tighten terminals if found loose.</td>
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<tr>
<td>5</td>
<td>Marshalling box</td>
<td>Check wiring and that terminals are tight.</td>
<td>- Tighten them if found loose.</td>
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<tr>
<td>6</td>
<td>Oil in transformer</td>
<td>Check for dielectric strength and moisture content.</td>
<td>- Take suitable action to restore quality of oil</td>
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<td>7</td>
<td>Oil in diverter switch</td>
<td>Check for dielectric strength and moisture content.</td>
<td>-do-</td>
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<tr>
<td>8</td>
<td>Insulation resistance</td>
<td>Measure IR value between windings and to earth.</td>
<td>- Compare with previous values. The comparison should be done with those values where transformer/ reactor is connected externally to the line and bus ducts. If the values are low, measure IR values after isolating it.</td>
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<td>9</td>
<td>Oil bag sealing arrangement where provided.</td>
<td>Check presence of oil outside the oil bag in the conservator.</td>
<td>- If oil is present check leakage in the oil bag by applying air pressure.</td>
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<td>F.</td>
<td>Half Yearly</td>
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<tr>
<td>1</td>
<td>Alarm, trip and protection circuits</td>
<td>Check operation of alarm / trip contacts of each protection by actual initiation and also check display and annunciation on the panel.</td>
<td>- In case of faulty operation, check contacts and wiring circuits.</td>
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<tr>
<td>2</td>
<td>Oil in bushings</td>
<td>Check BDV and moisture content of oil.</td>
<td>- If values are low, filter oil or replace with fresh oil.</td>
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<tr>
<td>3</td>
<td>Vibration level of tank walls for shunt reactors.</td>
<td>Measure vibration level.</td>
<td>- Compare with previous values.</td>
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<td>S. No.</td>
<td>Item to be inspected</td>
<td>Inspection Procedure</td>
<td>Action required if unsatisfactory condition indicated</td>
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<td>Yearly</td>
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<tr>
<td>1.</td>
<td>Oil in transformer shunt/ reactor</td>
<td>i) Complete testing of oil.</td>
<td>- Filter to restore quality or replace if the values have reached discarding limit.</td>
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<td></td>
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<td>ii) DGA of oil.</td>
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<tr>
<td>2.</td>
<td>Oil and winding temperature indicators.</td>
<td>i) Calibrate and also check differential between WTI and OTI by feeding current to the WTI pocket heating element.</td>
<td>- Adjust if found reading incorrectly.</td>
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<td>ii) Check oil in the pockets.</td>
<td>- Replenish, if required.</td>
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<tr>
<td>3.</td>
<td>Magnetic oil level gauge and prismatic level indicator</td>
<td>i) Check oil level in conservator by dip stick method.</td>
<td>- If oil level indication is not correct check the float.</td>
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<td></td>
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<td>ii) Clean the oil gauge glass.</td>
<td>- Replace glass if cracked.</td>
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<tr>
<td>4.</td>
<td>Buchhloz Relay Mechanical inspection</td>
<td>i) Close valve between buchholz and conservator and lower oil level.</td>
<td>- Buchholz contacts should operate when oil level comes below buchholz relay level.</td>
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<td>ii) Check the movement of floats for rise and fall.</td>
<td>- Make the movement smooth.</td>
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<td>iii) Check tightness of mercury switches.</td>
<td>- Tighten clamps if loose.</td>
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<td>iv) Check the operation of alarm and trip contacts by air injection.</td>
<td>- Check contacts if abnormality found.</td>
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<td></td>
<td>v) Clean cable entry terminal box.</td>
<td>- To be sealed to avoid ingress of moisture.</td>
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<tr>
<td>5.</td>
<td>Fan motors</td>
<td>Check IR value of motor winding, noise and vibration of fans.</td>
<td>Dry out if found low. Check balancing of fans.</td>
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<tr>
<td>6.</td>
<td>Tanks and accessories</td>
<td>Check painting and surface finish. Mechanical inspection of all accessories.</td>
<td>Touch up / re-paint, if required. Replace any component found damaged.</td>
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<td>S. No.</td>
<td>Item to be inspected</td>
<td>Inspection Procedure</td>
<td>Action required if unsatisfactory condition indicated</td>
<td>Applicable UATS, SSTS and distribution transformers when ticked ✓</td>
<td>Applicable transformers</td>
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<tr>
<td>1</td>
<td>Gasket joints</td>
<td>Check the tightness of bolts.</td>
<td>Tighten the bolts evenly to avoid uneven pressure.</td>
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<tr>
<td>2</td>
<td>Earth resistance</td>
<td>Check earthing resistance</td>
<td>Take suitable action, if earth resistance is high.</td>
<td></td>
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<tr>
<td>3</td>
<td>OLTC</td>
<td>i) Diverter switch servicing&lt;br&gt;ii) Check the contacts of diverter switch for burning or pitting marks.</td>
<td>- Draw out diverter, clean &amp; tighten contacts.&lt;br&gt;- Recondition/ replace, if required.</td>
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<td>4</td>
<td>Bushing top connectors and arcing horns</td>
<td>i) Check contact joints.&lt;br&gt;ii) Clean arcing horns and check gap.</td>
<td>- Retighten.&lt;br&gt;- Adjust arcing horn gap</td>
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<td>5</td>
<td>Air bag sealing arrangement where provided</td>
<td>i) Check healthiness of air bag.</td>
<td>- Clean, if required.</td>
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<td>6</td>
<td>Cable boxes, if provided</td>
<td>Check for sealing arrangement for filling holes. Examine compound for cracks.</td>
<td>- Replace gaskets, if leaking.&lt;br&gt;- Replace compound, if necessary.</td>
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<td>7</td>
<td>Lightening arrestors</td>
<td>i) Examine for cracks and dirt deposits.&lt;br&gt;ii) Measure IR value of each stack of las.</td>
<td>- Clean or replace.&lt;br&gt;- In case IR value is poor, replace.</td>
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<td>8</td>
<td>Off circuit tap switch</td>
<td>i) Move from minimum to maximum tap position &amp; return to minimum position.&lt;br&gt;ii) Check resistance measurement at each tap.</td>
<td>- Compare resistance values with previous results. If resistance is high, tap switch contacts to be attended to.</td>
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<td>9</td>
<td>Condenser bushing</td>
<td>Measure power factor/capacitance measurement.</td>
<td>- Dryout bushing if values are abnormal and replace oil if required.</td>
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<td>10</td>
<td>Electrical tests</td>
<td>Carry out&lt;br&gt;i) Resistance measurement at all taps for transformers with off circuit tap</td>
<td>- Compare with previous values. Incase of abnormality investigate causes.</td>
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<td>S. No.</td>
<td>Item to be inspected</td>
<td>Inspection Procedure</td>
<td>Action required if unsatisfactory condition indicated</td>
<td>Applicable UATS, SSTS and distribution transformers when ticked ✓</td>
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<td>1</td>
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<td>switch and at maximum, minimum and normal taps for transformers with OLTC ii) Magnetising current at 415 volts. iii) IR values after isolating the transformer. iv) Turn ratio.</td>
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<tr>
<td>17</td>
<td>Oil coolers</td>
<td>Clean oil coolers. Check for leaky tubes.</td>
<td>- Flush cooler tubes Repair leaky tubes. If more than 10% tubes leaking, replace the total tube nest.</td>
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<td>H</td>
<td>5 yearly for UATS and SSTS and Distribution Transformers &amp; 7-10 yearly for other Transformer/Shunt Reactors</td>
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<tr>
<td>1</td>
<td>Transformer core and windings</td>
<td>i) Wash by hosing down with clean dry oil.</td>
<td>- See following paras a &amp; b.</td>
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<td>I</td>
<td>20 Yearly</td>
<td>DP and Furan content measurement</td>
<td>See following para c.</td>
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Note:
(a) As there is continuous deterioration of oil and insulation in a transformer, it is preferable that the core and windings and the inside surfaces of tank be thoroughly cleaned for any deposits etc. at regular intervals. This can be done while the transformer is in position. Close all valves connecting the cooler circuit/ radiators to the tank. Drain oil from the tank while letting the dry air to go inside. Clean core and winding by hosing down clean dry oil through the inspection cover. Remove dirty oil from the tank and wipe off this oil from the tank bottom. Let there be a continuous entry of dry air into the tank while the cleaning activity is on so that
there is a minimum contact of the transformer core and windings with the atmospheric air. Similarly drain oil from cooling circuit and radiators and fill dry clean oil.

(b) Whenever transformer windings are to be taken out due to any reason such as to repair a damage, thorough washing due to sludge formation or for thorough inspection to locate a fault as a result of DGA or some other tests, after carrying out the necessary work for which the transformer was opened, do the following also:

(i) Tighten all coil clamping screws to remove looseness from the windings, if any.
(ii) Tighten all nuts and bolts whether metallic or made of insulating material on mechanical and electrical joints.
(iii) Tighten core yoke bolts, core-clamping screws etc.

(c) Under the normal operating condition transformer has an useful life of about 25-30 years. This may vary considerably depending upon the overloads it has carried and the temperature at which it has worked during its span of operation. Therefore for any future planning it may be worth while to know well in advance the remanent life of the transformer in service. This can be done by assessing extent of degradation of cellulosic paper through furan content in transformer oil or / and degree of polymerization (DP) of paper. It is proposed to carry out this study after a period of 20 years of service. After knowing the remanent life in a transformer, the action can be planned in conjunction with life assessment studies on generating unit.

As these are comparatively new studies, the data are still being built and one should go by the re-commendation of the Test Laboratory. However the following figures may serve as guidelines.

<table>
<thead>
<tr>
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<th>Degree of Polymerization</th>
<th>Furan content ppm (mg/kg)</th>
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<tbody>
<tr>
<td>New transformer</td>
<td>800-950</td>
<td>Negligible</td>
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<tr>
<td>Nearing end of life</td>
<td>150-200</td>
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</table>
4.4 PREVENTIVE MAINTENANCE OF HYDROMECHANICAL EQUIPMENT

4.4.1 Maintenance of Intake Gates

The maintenance work shall include:

- Cleaning up
- Adjustment
- Lubrication with recommended lubricants & methods
- Replacement of Defective parts
- Repair of damaged parts
- Recooating of damaged coat on ropes
- Recording details of all work carried out with date & time.

Inspection and checks

- Daily inspection should be carried out by gate operator to ensure:
  - Proper oiling and greasing wherever required
  - Tightening of loosened parts tightening contacts in electrical system
  - Check of ropes and hoisting arrangement.
  - Checking general condition of gates and gate grooves wheels etc.
- Periodic inspection (half yearly or annual)
  - Disassemble and check all components for any damage.
  - Rectify damages or replace worn out irreparable components.
  - All safety precautions eg taking proper shut down installing safety tags, red flags etc. are must, when any work is being on gates.
  - Before taking up work on gates, stop log gates must be lowered in the groove meant for the same and plug all leakages through these.

- Lubrication of gate parts:
  - Servogem EPI (IOC) or (equivalent of other brand)
    - Rope drum shaft for all hoisting unit (once a month)
    - Plumber blocks for all hoisting units fitted with bush bearing (once in two months)
    - Coupling for transmission shaft (once in two months)
    - Plumber blocks for manual operation (once in three months)
  - Servogem – 3 (IOC) or (equivalent of other brand)
    - Spherical roller bearings for gate wheels (once in 2 months)
  - Compound – D (Bharat camax) or (equivalent of other brand)
    - Lifting ropes (once in six months)
  - Servocoat 120 T (IOC) or (equivalent of other brand)
    - Gears & Pinions for all hoisting units (once in 2 months) (Meshing faces only)
    - Gears & Pinions for manual operation (once in 3 months)
    - Gears & Pinions for all travel mechanism (once in 2 months)
    - Gears & Pinions for position indicators (once in two months)
  - Servosystem (320 IOC) or (equivalent of other brand)
    - WOM reducer for all hoisting units (once in two months)
Problem in electrical circuit and checks

- No supply at control panel inspite of turning on main switch – check fuses.
- Incoming supply healthy but volt meter not showing – check fuses of voltmeter circuit
- Motor is running even after pressing stop push button
- Immediately put main switch off
- Check contacts of motor control contactor & push button contacts. If damaged replace these
- Reset O/L relay before starting again
- O/L relay tripped
  Check control fuse
  If fuse OK check control transformer
- Gate is creeping down & restoration has failed indicating lamp is glowing but alarm not ringing
- Check position to toggle switch (it should be in reset position)
- Indication of lamps are not glowing.
- Check by pressing lamp test push button replace bulbs, if found fused.

4.4.2 MAINTENANCE OF MAIN INLET VALVES

The turbine may have either a butterfly or spherical valve. This valve is used each time the unit is shut down. Valve seats, seals, operating links, bearings, bushings, power source and hydraulic links are the main primary maintenance concern.

The valve function should be verified periodically through test or normal frequent operation.

Butterfly valves (head upto 120 m)

- Butterfly valves generally consists of a disc or lattice mounted on a shaft that rotates in cylindrical body
- Usually, the disc and lattice profile is contoured in the flow direction to provide a smooth hydraulic flow and balance forces on the valve.
- The disc is oriented parallel to the flow to minimize any restriction when opened and at right angle to the flow to provide full closure
- Valve seals are on the circumference or in contact portion of the valve body
- These seals can be replaced or adjusted without removing the disc from the valve.
- Valves have flanged connections and spool pieces to facilitate dismantling. Sometime welded connection are preferred to save cost

Maintenance procedure

- Check operating system daily and ensure it is working smoothly
- Check for any leakage through connection daily
- Replace seals in annual maintenance
- Overhaul operating system annually
- Replace gaskets in flanged connection during overhaul
**Spherical valves (for heads more than 120 m)**

Spherical valves have a body shaped like hollow sphere with flanges or other connection for mounting in a piping system.

The rotor, shaped like ball, has a cylindrical hole through its centre at right angles to support shafts located on each side of valve. In open position with rotor opening parallel to the flow direction, the valve offers an unrestricted flow with minimum disturbance to the flow path. To close the valve, the valve rotor is turned to 90° from the axis of rotor opening.

Spherical valve has tendency to close for positions less than 50% opening which facilitates emergency closing.

Moveable seals reduce valve leakage when the valve is closed. Mostly valves have both upstream and downstream seal. The upstream seal is maintenance seal or emergency seal, the down stream seal is working seal.

When valve is closed under full pressure, the upstream maintenance seal allows replacement or maintenance of the working seal without dewatering the penstock. The upstream maintenance seals have positive mechanical locking to prevent accidental opening.

- Daily checks of operating system and remedial measure are must.
- Annual inspection and overhauling of mechanical seal after dewatering penstock is must.
- Annual inspection and overhauling of operating seal is also essential.
- Annual overhauling of operating mechanism to ensure smooth working throughout year is also done.
- Annual overhauling of the valve rotor and other parts are also taken up as required.

**Following Checks are also Essential**

- Checking and attending leakages from valve & dismantling joint.
- Checking and attending oil leakages from Servomotor
- Checking the operation of operating valves.
- Checking and attending the setting of Limit Switches & Operation of the same
- Checking and attending leakages of distributing valve
- Checking the correct working of the pressure gauges. Lubricate the parts if necessary.
- Checking and attending for leakages in the piping.
- Checking all the MIV System connections & Union for tightness
- Checking all the MIV servo linkage during operation, looking for backlash
- Cleaning of valve body, seal & solenoid valve
- Checking the actuating solenoids for operation of valve. Cleaning the contacts and rollers.
- Checking the operation of bypass valve
- Checking for cracks, pitting and cavitation etc. of MIV and Servomotor
- Inspection of Rubber Seals
- Checking trunions & bushes, bolts & nuts etc.
- Checking gland packings and lubrication
• Checking foundation bolts and nuts of valves & servomotor. Cleaning the bolts and nuts etc.
• Checking servomotor piston and its collars & its gland packing
• Checking hole of the servomotor cylinder
• Checking the pins and bushes of servomotor & its air valve
• Checking the diapharms in the opening & closing circuit. Checking the opening & closing times of the MIV.

4.4.3 MAINTENANCE OF DRAFT TUBE GATES

One, two or three bulk head gates are needed to close off the draft tube. These are usually cable suspended gravity gates and designed for balanced pressure closure. These are usually dropped to close or lifted to open through hoisting arrangement having rope drums.

The main problem with sealing is due to debris in bottom seal area. For withdrawal of gate/ equalizing pressure across the gates is done with byepass line valve located with in gate.

When machine are running these gates and hoist remains available for maintenance. These should always remain in perfect condition for use during emergencies of power station.

During annual maintenance of the unit these gates are required to be lowered so that dewatering of draft tube is possible. As such maintenance and overhaul of these gates are taken up before starting annual maintenance of machine.

Lubrication of operating mechanism, its electrical system and coating all ropes meant for lifting are of main concern for maintenance.

4.5 PROCEDURES FOR TYPICAL MAINTENANCE ACTIVITIES

Fig 1 to 4, 10, 12 to 14 have been taken from “Hydropower Stations: Generating Equipment and its installation” by AN Goncharov

4.5.1 Reassembly of Vertical Hydro Unit

Sequence and Checks

• Lower all guide vanes.
• Trial assembly of Turbine runner for checking clearance between runner & runner chamber (Kaplan) or static labyrinths & rotating labyrinths (Francis).
• After setting above clearances take out runner & shaft assy. to service by.
• Assemble runner, runner shaft and top cover and lower the complete assembly in pit. Again check clearances between runner and runner chamber. Also check free movement of guide vanes. Check top and bottom clearances of all guide vanes and set.
• Lower all the guide apparatus components in the pit and carry out installation & setting.
• Lower bottom bracket with brake, set elevation, centering and tighten with foundation.
• Lower rotor with brake track in pit.
• Carry out fitting & setting of Thrust bearing (and other guide bearings).
• Check rotor level, verticality of shaft and centering of shaft, correction of inclination of shaft to be done at this stage itself (Alignment of generator).
• Couple Exciter shaft and assemble excitors, PMG, Oil header (Kaplan) etc. carry out centering and setting.
• Couple Turbine and Generator shaft properly as per procedure with help of torque spanners. Ensure elongation of shaft bolts as per procedure.
• Checking unit alignment and taking corrective action by providing shims or scrapping.
• Carry out load sharing of thrust pads.
• After completing assembly of machine and rotating the machine at no load check balancing of rotor as per procedure. Balancing of the machine by adding calculated weight on rotor spider and at proper angle, is done.
• Check vibrations of machine at no load, part load and full load, rectify defects if any.

4.5.2 Checking Concentricity of Labyrinth Seals

The upper and lower labyrinth rings must be concentric with the shaft to within 10% of the gap on one side of the labyrinth seals. This is checked with a special device mounted on the shaft (Fig. 1)

4.5.3 Balancing of Runner

For balancing of runner a balancing device, ‘1’, a steel plate ‘2’, a sphere ‘3’ will be required (Fig. 2). The centre of gravity of runner must always be below centre of gravity of sphere so that during balancing runner remains in stable position. Following steps are taken to balance the runner.
Fig 2: Balancing of Runner [Goncharov]

Calculation of displacement of centre of gravity of runner (h)

- The runner is placed on the device having horizontal steel plate-2 and sphere in such a way that its centre of gravity lies well below the support point
- A small weight is then placed on the lower band. This causes the runner to resume a new equilibrium position. The runner is thus tilted. Equilibrium condition in this case is equal to the moments acting on runner:

\[ PR = Ga + G\mu \]  

\[ P = \text{weight applied in kg} \]
\[ R = \text{radius at which wt. is placed} \]
\[ a = \text{displacement of centre gravity of runner} = \frac{h \cdot b}{R} \]
\[ \mu = \text{coefficient of rolling friction (0.001 to 0.0015)} \]

Thus \[ h = \frac{(PR - G\mu)R}{G \cdot b} \]

- To find centre of gravity of runner a weight is placed on lower band such that it is sufficient for shifting the centre of gravity 1 to 2 mm. If magnitude ‘h’ is more it can be adjusted with the help of adjusting screws. The following optimum value of ‘h’ are recommended.

<table>
<thead>
<tr>
<th>Runner wt. (Tons)</th>
<th>50</th>
<th>100</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height h (mm)</td>
<td>40 to 60</td>
<td>40 to 60</td>
<td>40 to 60</td>
</tr>
</tbody>
</table>

Procedure of Balancing

- Now four levels are placed on the upper runner band
- Different weights placed on the lighter side of lower band until the face of upper band is horizontal. It is the balanced position of runner.
- The sensitivity of balancing device is also checked by minimum weight \( P_{\text{min}} \) whose value is determined as explained above. The runner is then balanced by adjusting earlier placed weight. The face of upper band should be horizontal.
- The horizontal position of runner should also be checked. The clearance between runner band and the stand must permit oscillation during balancing.
• Any possible imbalance of runner (due to inertia and friction between the supporting parts of balancing device) is determined after runner has been brought into equilibrium. This is done by placing weights at six to eight points of the band circumference which cause the runner to assume equal inclinations. The magnitude of the residual imbalance is equal to half of max and min weights needed for this. The weight for this imbalance should be placed where the maximum weight is placed.

• The balance weight should be reliably fixed on the runner in such a way that it is protected from the action of flow. Best location for this is on the top of runner beneath protective casing. The weight must be recalculated since the radius of location has been changed.

• Balancing must again be checked after weights have been fixed.

• Balancing is checked if minimum weight placed successively at two diametrically opposite points tilt the runner by equal angle.

4.5.4 Checking Concentricity of Kaplan Runner

![Image of checking concentricity of Kaplan runner]

Fig 3: Checking concentricity of peripheral edges of runner blades; 1) Plumb line; 2) boom; 3) cable; 4) frame; 5) rollers [Goncharov]

It is advisable to check the concentricity of the peripheral edges of the blades after their assembly in service bay. This is done with a special device (Fig. 3) mounted at the top of the servomotor piston rod. The check is performed by measuring the clearance between a plumb line and the peripheral edges of the blades.
4.5.5 Hydraulic Testing of Runner (Kaplan) in Service Bay

The correct assembly of the blade-actuating mechanism and the tightness of the flanged joints of the runner and of its blade seals are checked after assembly. The tightness of the runner is checked by hydraulic tests, while the correct assembly of the blade-actuating mechanism is verified by rotating the blades.

The runner is hydraulically tested before the hub extension is fitted. This makes it possible to check the tightness of the joint between hub body and hub bottom. Servomotor cylinder cover (2) is placed on hub (1) before the test. A temporary cover is used if the permanent cylinder cover is integral with the shaft flange. The openings in the cylinder over for the connection with the shaft are blanked off with plugs (3). The gap between piston rod and cylinder cover is closed with seal (4). Temporary connecting piece (5) with two unions is placed on the piston rod. One union is connected to the opening in the rod and oil is delivered through this opening into the servomotor cylinder beneath the piston. The second union is connected to the opening in the rod, delivering oil into the cylinder above the piston. The other ends of these unions are connected to pump (7) via hoses (6) (Fig. 4).

The hub is filled with oil through a plug in the bottom and pipe (8). The air escapes through valves fitted on top and bottom of the servomotor cylinder. Oil delivery to the hub is stopped when oil flows from these valves. Oil is then delivered through pipe (9) by pump (10). The oil pressure is thus raised to a level which usually corresponds to three times the height of the oil column from the runner hub to the oil supply head.

The runner must remain under the test pressure for 24 hours at a runner and oil temperature of not less than 10°C. During testing, the blades are successively set to their no-load, half-load, and full-load positions, and held in each position for 8 hours. No oil should leak through the fixed joints of the runner. The maximum permissible oil leakage per day through the seal of each blade is as follows:

<table>
<thead>
<tr>
<th>Runner diameter, m</th>
<th>3.0</th>
<th>5.0</th>
<th>7.2</th>
<th>9.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil leakage per day, l</td>
<td>0.10</td>
<td>0.15</td>
<td>0.18</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Fig 4: Testing of Runner [Goncharov]
The blades are set to the no-load position by the oil pressure acting on the bottom of the servomotor piston. Pressure on the top of this piston causes the blades to move into the full-load position. This pressure is created by a pump. The smoothness of blade actuation is tested at the same time, as are the blade travel and setting angle.

### 4.5.6 Centering and Alignment of Vertical Hydro Generator

- Alignment of rotor during installation is ensuring rubbing surface of thrust bearings and the shaft mirror disc face are perpendicular to rotor centre.
- The procedure for rotor centering is as follows.
  - First centering of turbine shaft is checked since its flange and centre line from reference bases centering of the generator rotor
  - The generator is then provisionally centered relative to turbine shaft.
  - Then perpendicularity of rubbing surfaces of thrust bearing and shaft flange face to the generator shaft centre line is checked.
  - Then final alignment generator and turbine is done.

#### I. Procedure for alignment of unit

- Set elevation of thrust bearing
- Carry out rotational check of gen. shaft
- Calculate maximum throw and direction
- Minimize throw by scrapping insulated surface of mirror disc.
- Couple generator shaft with turbine shaft
- Again check elevation & level of thrust bearing
- Carry out rotational checks
- Find out run out at LGB & coupling flange
- If throw is still more again carry out scrapping of insulated surface of mirror discs. Again check by rotation method and repeat till throw is within limit
- Check throw and its direction at TGB
- Minimize throw by providing shim between coupling flange
- Check throw at LGB, coupling flange and TGB, ensure these are within limit. This is necessary to establish unit axis.
- Check verticality of shaft with respect to duly leveled thrust bearing at correct elevation.

#### II. Coupling of Shafts

A. Before coupling of generator shaft and turbine it is to be checked that following requirements are met:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Deviation</th>
<th>Allowable Deviation in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Shift of Gen. shaft axis with turbine shaft axis</td>
<td>0.01 mm</td>
</tr>
<tr>
<td>2.</td>
<td>Non parallellity of mating surfaces of both flanges at shaft dia.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upto 600 mm</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>Upto 1000 mm</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>Upto 1500 mm</td>
<td>0.030</td>
</tr>
</tbody>
</table>
B. Coupling

- Force of tightening of all bolts should be identical
- Elongation of bolts, required to ensure proper tightening
- Soundness of flange connection is checked by feeler gauge of 0.03 mm thickness

III. Setting Elevation of Thrust Bearing

- Elevation of upper bracket should be such that the runner is at desired level
- Allowance for deflection of upper bracket due to weight of rotating parts and initial thrust should be taken into account.
- Mount thrust bearing on upper bracket
- Check perpendicularity of thrust collar with shaft
- Set elevation of bearing, by providing shims under flexible support

![Fig 5: Position of Dial Indicators](image)
IV. Rotational Checks

- Arrangement to turn rotor by 360° in steps of 45° smoothly
- In machines having high pressure lubrication of TH.B. It is possible to rotate machine manually.
- In other machine mechanical arrangement is made and rotation is done with the help of EOT crane. For lubrication of thrust pads in such case is ensured by using Molybdenum-di-Sulfide Grease (Molysulf Grease)
- Mount dial Gauges at UGB, LGB, Flange & TGB to find out run out (Fig 5)
- Throw and its direction is calculated by resultant method (Table 1 & Fig 6)

V. Shimming of Scrapping

Amount of Scrapping or Shim Thickness (Fig 7 & 8)

\[ t = \frac{Max. \text{ resultant throw } \times \text{ diameter}}{2 \times \text{ effective length}} \]

a. For correcting gen. shaft
   (i) \( T \) = amount of scrapping
   (ii) Max. throw at coupling flange for correcting gen. shaft
   (iii) Eff. Length = distance between insulated surface or mirror disc and coupling flange
   (iv) Diameter = Dia of thrust bearing mirror disc.

b. For correcting turbine shaft
   (i) Max throw at TGB
   (ii) Eff. Length = Between Flange and TGB (Dial Gauge Locations)
   (iii) Diameter = Dia. of coupling flange

Shimming or scrapping to be done at coupling shaft joint

VI. Checking Verticality of Shaft (Fig 9)

Four piano wires with dash posts are placed as shown in the figure. Precession stick micrometer is used to measure \( a_1, b_1, c_1, d_1 \) and \( a_2, b_2, c_2, d_2 \). The whole procedure of calculation of deviation is given with the figure itself. If the deviation is less than 0.05 mm/m of shaft length, then verticality is taken to be normal otherwise corrective measure has to be taken.
### Table – 1

**RESULTANT METHOD OF ALIGNMENT**  
*(ACTUAL EXAMPLE OF UNIT-I OF A POWER STATION)*  
*(VECTORIAL RESULTANT – AT FIG. 6)*

<table>
<thead>
<tr>
<th>Position of Dial Gauge</th>
<th>No. of Point at Shaft</th>
<th>Upstream Side Dial Gauge</th>
<th>Down Stream Side Dial Gauge</th>
<th>No. of Point at Shaft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LED Flange</td>
<td>TGB</td>
<td>c-a</td>
</tr>
<tr>
<td>0°</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>45°</td>
<td>1</td>
<td>+½</td>
<td>–32</td>
<td>–46</td>
</tr>
<tr>
<td>90°</td>
<td>2</td>
<td>0</td>
<td>–40</td>
<td>–85</td>
</tr>
<tr>
<td>135°</td>
<td>3</td>
<td>0</td>
<td>–40</td>
<td>–86</td>
</tr>
<tr>
<td>180°</td>
<td>4</td>
<td>0</td>
<td>–30</td>
<td>–65</td>
</tr>
<tr>
<td>225°</td>
<td>5</td>
<td>+1</td>
<td>–8</td>
<td>–22</td>
</tr>
<tr>
<td>270°</td>
<td>6</td>
<td>–½</td>
<td>+15</td>
<td>+26</td>
</tr>
<tr>
<td>315°</td>
<td>7</td>
<td>0</td>
<td>+6</td>
<td>+17</td>
</tr>
<tr>
<td>360°</td>
<td>8</td>
<td>–1</td>
<td>+4</td>
<td>+14</td>
</tr>
</tbody>
</table>

Note:  
(a) The readings of upstream side dial gauges are not acceptable as closing error is more.  
(b) Unit-II side readings are fine because:  
(i) Closing error is negligible  
(ii) Curve plotted along X-Y axis is nearer to sine curve  
(iii) These are confirmed in subsequent rotation also. Further calculations and correction is based on these.
Fig 6: Resultant Method of Throw Calculation

Fig 7: Calculation of Shims Between Flanges
Fig 8: Illustrative Example of Scrapping
4.5.7 Load Sharing of the Thrust Bearing

There must be uniform distribution of load between all thrust pads. Over loading of any pad may cause destruction of babbit material and failure of thrust bearing. The load is equalized after the generator shaft wobble has been eliminated or after the turbine and generator shaft has been connected and the unit has been aligned.

Uniform distribution of load is achieved by tightening supporting screws against the elastic plates beneath the shoes carrying rotor weight. This is done by striking the spanner with sledge hammer.

The load distribution is adjusted in this manner by first checking that all supporting screws are tightened equally. The position of locking device of each support screw is then marked with the vertical lines on it and on the thrust bearing housing or on the support stand.
A sledge hammer of approximately 8 kg weight is then used to strike hard once or twice the end of 600 to 700 mm long spanner placed on the head of supporting screw considered. The process is carried out on all shoes with the same force. The position of all pads are measured after each round with a slide caliper and distances between the lines on the locking devices and on thrust bearing housing are recorded. This tightening process is repeated several times until distances between the lines are increased equally by hammer blows on all supporting screws. Another round of tightening the screws is then performed with lighter sledge hammer. Adjustment is considered completed if the distance between the line have not changed in one round.

The load can be adjusted by using a dial indicator also as shown in Fig 10.

The support screws must be locked after completion of this activity

### 4.5.8 Dynamic Balancing of Low Speed Hydro Generator

- A sensitive dial gauge (0.002 mm) is fixed as shown in Fig. 11.
- A suitable bracket, which is firm and rigid, will be required to fix dial gauge.
- Four runs of machine at full speed will be required to find out magnitude of weight and position of correction
  - First run
    Run to rated speed and note total deflection of the pointer on dial (the reading is proportional to the unbalance force). Make two marks on rotor ‘A’ & ‘B’ at 0° and 180° respectively
  - Second run
    Put a calibration weight (Wc) at 0° and run upto full speed and note the dial gauge reading (the calibration weight must be sufficient to produce and appreciable difference in the reading compared to the first run reading).
  - Third run
    Remove weight from 0° position and put at 180° position and run upto full speed. Note reading of dial gauge.
**Fig 11: Checking Balancing of Generator**

- Draw to some scale a line ‘OA’ to represent reading of first run. Extend OA to ‘C’ such that OA = AC
- With centre ‘O’ and radius equal to second run reading to the earlier scale draw an arc.
- With centre ‘C’ and radius equal to third run reading to same scale draw an arc to cut earlier arc at point ‘B’. Join AB.

Balance weight ‘W’ = \( W_c \times \frac{OA}{AB} \)

The angle of this weight is to be put with reference to 0° position and is given by angle 0AB.

- Whether this angle is to be measured in the direction of rotation or opposite to the direction of rotation is done by trial. The position which gives minimum vibration is the required position. This is done by Fourth run. For fourth run calculated weight at calculated angle is put and machine run at full speed if dial gauge reading is almost zero, the weight and direction is corrected otherwise the weight is required to be put in the opposite direction.
4.5.9 Alignment of Horizontal Generating Set

Adjustment of Turbine Shaft

- The centre line of turbine bearing with respect to longitudinal axis of generator is checked by stretching a horizontal wire through spiral casing and along bearing centre line. Correct position of wire inside spiral casing is checked with inside micrometer.
- Bearing housings are centered with respect to longitudinal axis of generator by an end gauge which is inserted into the bores of bearing shell.
- Ensure clearances of guide vanes at both ends are uniform and are between 0.2 to 0.6 mm. Feeler gauge is used to check these. These can be adjusted by tightening bolts. When distributor is closed there should be no clearance in guide vanes.
- Measure clearance with feeler gauge between shaft and the lower bearing shell to ensure correct position of rotating parts of turbine.
- If there is no clearance, it indicates that the shaft is resting on both bearings.
- The horizontal position of shaft is checked by placing a level successively on both bearing journals. Then turn the level by 180° and place in the same position as before and check level. Arithmetic mean of two measurements should be taken, if two differ (more than one division). If difference is more investigate reasons and take remedial measure.
- The permissible inclination in shaft is 0.04 to 0.06 mm per m length of shaft.
- The permissible inclination in transverse direction is 0.1 mm / m of shaft length. This should also be checked with level.
- The radial clearance between runner and the cover plates which should not exceed 2.5 to 3.0 mm. these should be uniform.
- The gaps in labyrinth seals should be with in 0.5 to 0.6 mm.
- The axial gaps in labyrinth seals should also be measured and these should be within 0.2 to 0.3 mm. These are measured by pushing the rotating parts to extreme positions.
- All the clearances and gaps are measured again after turning the rotating parts through 180° and 360°. These should be with in permissible limit.
- 1 mm thick lead wire of 30 to 50 mm length is used to measure clearance between turbine shaft and the upper bearing shell. Length of this wire are placed across the shaft in two sections beneath the shell which is then tightened well. The thickness of flattened wire thus indicate the clearance on top of the shaft which should be 0.2% of shaft dia.
- The lateral clearance between the shaft and the lower shell are checked at a depth 10 to 12 mm below the plane in which bearing is split. These should be half of clearance between shaft and upper bearing shell.
- The adjusted shaft of turbine will be reference base for alignment of generator shaft.

Preliminary alignment of generator shaft

Alignment consists

(i) Removal of misalignment of turbine shaft and generator shafts (Fig 12)
(ii) Making generator shaft horizontal
(iii) Making centerlines of generator and turbine shaft coincide
(iv) Alignment is carried out relative to half couplings of turbine and generator shafts
(v) Wobbling at half coupling should not be more than 0.2 mm
Procedure for preliminary alignment:

- The turbine and generator shafts are forced to their outermost position after the generator is assembled and clearance between half coupling is ensured. This clearance should be 5 to 6 mm (or as designed).
- A straight edge is pressed against the turbine or generator shaft along generator axis in four diametrically opposite positions. Clearance if any is checked and equalized. For this shims are provided beneath foundation frame.
- By measuring clearances between faces of half coupling at four points, alignment of shafts at joint is checked.
- The position of generator is first checked in vertical plane than in horizontal.
- Misalignment is corrected by placing shims under foundation frame.
- After this foundation bolts are tightened and locked.

![Fig 12: Misalignment of turbine and generator shafts [Goncharov]](image)

Procedure for final alignment

- Check positions of half coupling.
- Measure clearances between half couplings in the initial position and after turning through 90°, 180°, 270° & 360°.
- The position of half coupling should be same of initial position and after rotation by 360°.
- For radial displacement of half couplings is measured by mounting a dial indicator on a bracket fixed at turbine half coupling (Fig 13).

![Fig 13: Aligning Horizontal Generator with Turbine [Goncharov]](image)
• Determine alignment and inclination of generator axis first in vertical, then in horizontal plane. Record measurement in following table.

<table>
<thead>
<tr>
<th>Site of measurements</th>
<th>Clearance b between half-coupling ends, mm</th>
<th>Distances a to generatrices of half-couplings, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positions of rotating parts of generating set</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0°</td>
<td>90°</td>
</tr>
<tr>
<td>Top a1;b1</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Bottom a3;b3</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Right a2;b2</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Left a4;b4</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Note: The “plus” sign indicates that measurements were carried out at this point.

• Compute displacements of generator rotor, for ensuring correct position
• Move generator rotor in correct position and check axis.
• Check position of stator
• All measurements of clearances and displacement should be recorded viewing from generator side.
• Magnitude ‘a’ are measured in one position and after turning rotating parts by 90°, 180°, 270° & 360°
• End clearance ‘b’ is measured at four points in order to eliminate the effects of axial displacement of the rotor. The mean clearance is then calculated for each position of generator rotor (Fig 13)
• The measurements are satisfactory if both \((a_1 + a_3)-(a_2+a_4)\) and \((b_1 + b_3)-(b_2+b_4)\) are with in 0.02 mm.
• All measurements are repeated till good set is achieved.
• Permissible deviations in alignment of horizontal hydro generating unit are given in following table.

<table>
<thead>
<tr>
<th>Rotational speed of generating set, rpm</th>
<th>Permissible skewness and eccentricity, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 500</td>
<td>0.15</td>
</tr>
<tr>
<td>Up to 750</td>
<td>0.10</td>
</tr>
<tr>
<td>Up to 1500</td>
<td>0.08</td>
</tr>
</tbody>
</table>

• If, after alignment radial and end clearances at diametrically opposite point are with in limit as shown in table, the alignment is taken as adequate other wise repeat alignment procedure and compute more accurately.
• Computing eccentricity of generator shaft with respect to turbine shaft (measurement ‘a’) and its direction and computing inclination and its direction (measurement ‘b’) is done as explained below: (Fig 14)
  (i) Displacement of generator shaft axis due to eccentricity relative to turbine shaft:
  Horizontal plane: \(h_x = \frac{(a_2-a_4)}{2}\)
  Vertical plane: \(h_y = \frac{(a_1-a_3)}{2}\)
The displacement of bearings due to inclination of shaft are given by difference between end clearances. They depend on the location of bearings and dia of coupling ‘Dc’.

(a) Front bearing in horizontal plan
\[ k_{x1} = \frac{(b_2-b_4)}{Dc} \frac{l_1}{Dc} \]
\[ k_{x2} = \frac{(b_2-b_4)}{Dc} \frac{l_2}{Dc} \]

(b) Front bearing in vertical plane
\[ K_{y1} = \frac{(b_1-b_3)}{Dc} \frac{l_1}{Dc} \]
\[ k_{y2} = \frac{(b_1-b_3)}{Dc} \frac{l_2}{Dc} \]

Correct position of the generator rotor can be obtained by moving its bearings by following distances:

(a) Front bearing – horizontal plane
\[ A_{x1} = \frac{(a_2-a_4)}{2} + \frac{(b_2-b_4)}{Dc} \frac{l_1}{Dc} \]
\[ A_{x2} = \frac{(a_2-a_4)}{2} + \frac{(b_2-b_4)}{Dc} \frac{l_1}{Dc} \]

(b) Front bearing – vertical plane
\[ A_{y1} = \frac{(a_1-a_3)}{2} + \frac{(b_1-b_3)}{Dc} \frac{l_1}{Dc} \]
\[ A_{y2} = \frac{(a_1-a_3)}{2} + \frac{(b_1-b_3)}{Dc} \frac{l_2}{Dc} \]

- The rotor must be moved up and to the right if the computed displacement is positive
- The rotor must be moved down and to left if the computed displacement is negative
- The air gaps of generator are checked after completing alignment. These should be equal all around the circumference
- The turbine and generator half coupling are connected after completing alignment of generator shaft

Fig 14: Determining Displacements of Generator Bearings [Goncharov]
SECTION – III

GENERAL GUIDELINES
SECTION-III

GENERAL GUIDE LINES

1.0 GUIDELINES FOR TAKING OVER O&M OF SHP

The O&M of the plant shall be taken over from agency executing the project after due diligence and checking on following conditions. A report shall be prepared and both handing over and taking over party shall sign it. Following are the guidelines:

1.1 Operating condition of E&M equipment shall be monitored for 72 hrs continuous running for full load condition and results, observations are noted. If any defect is found, it shall be noted and corrected. This shall include turbine, generator, auxiliaries, control metering and relay panels, HT and LT switchgear, main and auxiliary transformer and switchyard equipments.

1.2 All civil building and structures such as water carrier system, lake diversion weir, channel, pipe line, forebay, tailrace, draft tube, etc shall be monitored during load test and observations and defects noted. However all civil structures under water shall be inspected on draining, if possible. Leakages, cracks on wall, and operation of main gates shall be noted.

1.3 All the area of the plant shall be cleaned and all rooms checked for unwanted material stored in it. Such material shall be taken out of building and stored in closed out door yard.

1.4 All the spares of the E&M equipment shall be listed and their condition checked for use during replacement. These shall include gate, valve, turbine, generator transformers, breakers, panels, AVR and governor spares.

1.5 All the tools and instruments ordered for the plant shall be listed and their condition checked.

1.6 Documents: Following documents shall be insisted upon:

- All plant and equipment drawings with as executed status.
- All commissioning reports duly signed. This shall include generator, turbine, auxiliaries, transformers and breakers, DC station battery, battery charger
- Cable schedule and termination drawing, panel wiring drawing.
- Suppliers manuals including erection and trouble shooting manual.
- Relay test report and relay setting duly signed by manager/ resident engineer.

2.0 GUIDELINE FOR MANPOWER, SELECTION AND TRAINING

2.1 Man power required for the operating and maintenance of SHP shall be based on following factors:
• Type of plant such as ROR, dam based or canal based. The manpower for the ROR plant is more because of the spread of hydraulic structures, the water channel and its equipment.
• The number of shifts/ hours the plant is going to work e.g. one shift or three shift. A plant with 3 shift working will need more staff than a single shift.
• Location of the plant, a remotely located plant will need additional staff for the support services such as transport, maintenance of residences etc.

This may increase the strength of the remotely located ROR plant. However the manpower can be kept minimum by employing a multidisciplinary force such as an engineer with experience in civil and electromechanical work. Or technician with driving experience etc. The guiding factor is safety of equipment and manpower.

Other method is to employ local labor, during requirement of additional work such as rainy season where inspection of water channel is needed or during annual maintenance work. It will benefit the plant, if these persons are given proper on job training.

2.2 SELECTION

Manpower required for operation and maintenance shall be selected before commercial operation of the plant.

• The operation staff shall be selected well in advance preferably during the pre-commissioning and commissioning of the plant.
• The experience of the persons shall be in hydro generating plant, DG plant of a co-generation plant. An experience on large electrical substation with DG set may be accepted.
• Plant incharge having basic degree/ diploma in electrical with experience in civil and mechanical works is most suitable.
• Testing engineer is most important for any generating plant. He should be experienced engineer familiar with all equipment testing to take decision in case of any fault on electrical equipment such as generator, transformer and switchgear. This being a specialized job it may be difficult to get such persons and to hold them as such can be engaged by group of plants or among the IPPS in the area.
• For the technician an ITI certificate with hands on experience in electro-mechanical work such as DG plant, electrical installation, hydraulic equipment, electrical panel, PLC panels cabling work etc.
• Contractual work such as civil maintenance, welding and fabrication, etc may be awarded on annual basis to keep work force low.

2.3 TRAINING OF OPERATION STAFF

The operation staff shall be given training by Sr. Experienced personal and also on simulator, if available. The training shall be in the area of SHP operation, maintenance, safety and fire fighting. A training period of three month is necessary for small hydropower plant.

• On completion of training the trainee shall be assessed for his skills and capability on actual work in the plant where they will be working.
• On placing them on operation duty they shall be periodically assessed for their performance in actual operation such as start of units etc.

3.0 ESSENTIAL T&P, INSTRUMENTS ETC

(i) Ordinary tools, instruments
For effective maintenance it is necessary to list out all required ordinary T&P as also assess quantity and arrange the same otherwise it may become difficult even for a skilled and capable technicians to carryout the require maintenance job. Ordinary T&P includes different type & sizes of screw drivers, pliers, spanners hammers etc.

(ii) Special T&P
Such type of T&P is required during assembly or dismantling of machines. For example, rotor lifting device and endless slings, pole turning device, shaft lifting device, rotating device and slings for alignment, shaft extension pieces and so on. These are not required for day to day maintenance, as such these should be properly stored and secured. Necessary maintenance, if required, must be carried out on these devices in time. Slings should be stored duly coated with preservatives as recommended by the manufactures.

4.0 FIRE PROTECTION & FIRE FIGHTING

It is necessary to install necessary hydrant points fire extinguishers at different locations of the power station as per recommendations of district fire officer.

Periodic drill of use of different types of fire extinguishers is must so that staff on duty in the power plant could operate these in case of emergencies.

First aid boxes as per recommendation of Factory Rules must be kept in the PS and these should be inspected periodically by station incharge. Timely recoupment of consumed items must be ensured by shift incharge.

Shift incharge should also ensure timely refilling of fire extinguishers installed in the powerhouse. He must periodically check working of hydrant points.

Smoking inside power station should be prohibited. Throwing match sticks and other burning stuff may some time create fire in the power station.

Additional fire extinguishers must be kept during maintenance specially when activities like, welding, brazing etc. are going on.

Asbestos cloth must be used to cover electrical parts during such maintenance activities.

In power stations normally following types of fire extinguishers are used:

- Soda acid type
- Dry chemical type foam type (chemical foam)
- CO₂ cylinders
- Fire hydrants
5.0 SAFETY ASPECT OF RUNNING SHP

It is said that 90% of accidents are avoidable. Out of these 20% are due to faulty conditions and 20% due to faulty behavior and 60% due to both.

Accidents cause human suffering and loss of production to the organization. Safety measures are therefore, essential. Success of safety measures depends on safety mindedness of the management supervisions and workers. Some of the methods to improve safety consciousness are given below:

- Prompt investigations pin pointing cause of accident and remedial measures
- Use of personal protective equipment such as helmet, goggles, gloves safety belts etc.
- Arousing safety consciousness through the use of posters, films, journal, safety talks, safety competition etc.

General Safety Precautions in SHP

- All voltage level, even low shall be considered dangerous even though the voltage may not be high to cause shock.
- All electrical circuit to be treated live and no work should be carried out without proper shut down and ensuring that it is
  (i) De-energised  
  (ii) Insolated from all sources
  (iii) Effectively connected with ground

Fundamental on Safety

Prevention of accidents require whole hearted cooperation of all members of organization. A capable, mentally alert employee will avoid accident.

Unsafe acts which may cause accidents are as follows:

- Operation of an equipment without authority or warning.
- Operating without proper instructions
- Making safety device inactive
- Working nearby dangerous or live electrical equipment which could conveniently be deenergised
- Using defective T&P or equipment or its improper use.

Unsafe conditions which may cause accidents are as follows:

- Unground equipment
- Defective material or equipment
- Improper illumination
- Non standard design and construction

Accidents are, therefore, results of unsafe acts or unsafe conditions or combination of both.
Safety Precautions and Practices in Operating and Maintenance

- No unsafe operation will ever be permitted. Feedback regarding unsafe operation/condition should be taken into consideration with proper spirit and review should be made to avoid accidents.
- Interlocks should not be by-passed unless it is very essential. Written permissions should be obtained from the superintendent/incharge of the station. Extra precaution should be taken by all the parties during such cases.
- Equipment are designed for certain operating conditions, it should be operated within prescribed operations limits. Overstressing of the equipment should be for minimum possible time with minimum percentage of overloading. This will avoid damage to the equipment.
- Operation and Maintenance staff should be familiar with the station layout and operations limits of different equipment such as breakers, transformers, isolators CTs, PTs, etc. A person should be allowed to operate or take over the equipment only after he has acquired adequate knowledge of the equipment.
- Operation should be carried out as per Operations Instructions. This will help in carrying out operations safely and maintaining uniformity. In case of any modifications/change in the layout operating instructions should be reviewed.
- Booklets/manufacturer’s instructions for different equipment should be available and should be referred to before taking out equipment for maintenance.
- It is the responsibility of the supervisor to interpret correctly and explain safety rules and regulations to all the persons concerned and ensure that they thoroughly understand the same.
- Breach of safety rules should be suitably dealt with.
- Only authorized persons shall be allowed to carryout operation and maintenance.
- Supervisor shall guard against the use of defective safety appliances, tools, and materials.
- In case of any emergency, in which quick action is necessary, in order to safe guard personals or property, only authorized persons will take necessary action. Under no circumstances attempt shall be made to carryout operations which are not safe.
- All persons must use the standard protective equipment intended for the job.
- All protective equipment should be periodically tested.
- Metal ladders should not be used in switchyard.
- Adequate number of first aid and fire fighting equipment shall be maintained.
- First aid and artificial respiration chart shall be exhibited. Every person shall be familiar with the same.
- Every person shall be familiar and should know how to operate fire fighting equipment, so that fire can be extinguished promptly thus minimizing damage.
- In the event of the fire on electrical installation, the affected part shall be immediately switched off and isolated from all the sources.
- Use HRC fuses only with proper capacity.
- While opening isolator confirm that it is not carrying load current. Similarly isolator should not be closed on load.
- Underrated circuit breakers should not be used to clear the fault.
- No breaker should be operated beyond stipulated operating duty.
• While working on the breaker, its operating mechanism should be de-energized such as discharging spring, releasing air pressure etc.
• Transformer should be discharged and grounded from all sides (windings). Neutral grounding of the transformer should not be treated as grounding.
• Current transformer secondary should never to be left open circuited.
• After cutting out capacitor bank, it should be allowed to discharge through discharge PT for about 10 minutes. The bank should be grounded with hot stick before commencing the work.
• ASKAREL compound used in capacitor bank as a dielectric is very toxic and harmful. Hence, should be handled with great care.
• Apparatus, frame work and other non-current carrying metal parts associated with power system are to be effectively grounded.
• Lighting arresters shall be grounded independently.
• Isolating switches provided for Generators and synchronous condensers and other rotating machines should never be opened when connected to any voltage source even when the machine is carrying no load.
• The areas should be cordoned off indicating location of work on the particular equipment.
• Use of safety tags must be ensured while allowing shut down for maintenance on some part/ equipment.

6.0 GUIDELINES FOR DOCUMENTATION

Documentation

Documentation at all levels of work done is necessity for any references and analysis of data/information in future as and when required.

Roll of operation staff is very important in registering all valid information operating parameters such as temperature, vibrations pressure, generation, voltage current etc. in the operation log books and shift registers.

Every event should clearly mention frequency, voltage, MVAR, MW, MWH at the instant with other necessary data e.g. alarms, annunciations temperatures, forebay levels/reservoir levels, inflows etc. as may be necessary from case to case.

Any tripping event should be clearly noted with relevant details, such as relay operation details, disturbance recorders and event logger print outs. Restoration activities after every tripping should be reported with details of preventive action taken or to be taken based on certain conditions. This information should be presented in prescribed format, should be checked on daily basis by Engineer concerned who will check and authenticate the same for future use.

For maintenance also similar registers are maintained giving details of maintenance activities at different frequencies such as daily, monthly, annual etc. or break down maintenance.
Results of test and measurements carried out during maintenance should be tabulated in standard formats and this should include the commissioning and acceptable values are applicable for proper comparison and planning remedial action.

The log books and log sheets normally maintained in SHPs are given in annexed table:-

**Operating Condition Record Sheets**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description of Log</th>
<th>Purpose/used for</th>
<th>Location/authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Log Books</td>
<td>Very important station record of events. Helps during even analysis by others.</td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Control Room Shift Log Book</td>
<td>Record of events date and time wise and sequential in case of operation carried out. This will also record any instructions given or taken from. Left side of the page to record specific equipment operated and right side events such as tripping, set synchronizing, taking over shift with signature switchyard operations etc.</td>
<td>Control Room Shift Charge Engineer</td>
</tr>
<tr>
<td>b.</td>
<td>Turbine Room Shift Log Book</td>
<td>All turbine and its Aux. operation and events, same as 1.a above.</td>
<td>Turbine operator</td>
</tr>
<tr>
<td>a.</td>
<td>Control Room Meter Reading</td>
<td>Hourly readings of all panel metes, transformer auxiliaries, generator and transformer temperature, and general condition of equipment. Ambient temp.</td>
<td>Control room / assistant shift engineer / shift engineer.</td>
</tr>
<tr>
<td>c.</td>
<td>Turbine room log sheet</td>
<td>Hourly readings of bearing temperature, aux. in service, pumps running, cooling water pressure, compressor air pr, etc. turbine water head/pressure and other quantities as per manufacturer.</td>
<td>Turbine operator</td>
</tr>
<tr>
<td>3.</td>
<td>Defect cum Equipment Record Books</td>
<td>Equipment defects noticed by operation and action taken by maintenance dept.</td>
<td>Corrections to be recorded by maintenance engineer.</td>
</tr>
<tr>
<td>4.</td>
<td>Monthly Generation record register.</td>
<td>Keeps monthly total of unit generation, aux. consumption, running hours, shut down hours, outages, forced and</td>
<td>Control room shift charge engineer.</td>
</tr>
<tr>
<td>Type</td>
<td>Description of Log</td>
<td>Purpose/used for</td>
<td>Location/authority</td>
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<td>emergency outages, maximum equipment temperatures during month, water utilized, rainfall, lake contents etc., plant load factor, availability factor etc. the data is important in studying plant performance over years.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Daily report book</td>
<td>For sending daily short summary to main office of important events in plant. Shall give rainfall, lake condition, water utilized, water rate, generation, outages, tripping of lines etc., and any other operation related information. DC battery related voltage. Over loading of units etc.</td>
<td>Control room Resident engineer/ manager operation/ shift charge engineer.</td>
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<td>(duplicate)</td>
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<tr>
<td>6.</td>
<td>Station water</td>
<td>For mainly Hydro power plant, keeps records of daily/ monthly water discharge for generation, leakage, wind and evaporation losses for storage dams, meteorological and atmospheric data, at lake and at power house.</td>
<td>Control room. Resident engineer/ manager operations. Head works engineer.</td>
</tr>
<tr>
<td></td>
<td>consumption</td>
<td>monthly</td>
<td></td>
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<tr>
<td></td>
<td>report. Monthly</td>
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<td></td>
<td>(duplicate)</td>
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<tr>
<td>7.</td>
<td>Station occurrence</td>
<td>Record of all tripping, loss of time, and cause of tripping, relay action etc.</td>
<td>Shift charge engineer, manager operation.</td>
</tr>
<tr>
<td></td>
<td>record.</td>
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<tr>
<td>8.</td>
<td>Relay setting</td>
<td>Record of all relay equipment relay setting giving normal condition and during outage of transformer or line, record of all instructions for revision. This is an extremely important register shall be available for reference at all times.</td>
<td>Manager operation/ Resident engineer</td>
</tr>
<tr>
<td></td>
<td>register.</td>
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<tr>
<td>9.</td>
<td>Station operation</td>
<td>Manual giving all step by step operation procedure for outages etc. Giving all equipment data and equipment operating parameter. Guidelines for emergency operation, black start procedure, starting and stopping of units, lake discharge and other hydraulic data, all mechanical installation operating procedure and drawings, station interlocking drawings</td>
<td>Resident engineer, manager operations.</td>
</tr>
<tr>
<td></td>
<td>manual</td>
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<tr>
<td>10.</td>
<td>Station safety</td>
<td>Safety procedure for giving outages, and tagging procedure. Use of tools, cranes, compressor, pumps etc. instructions giving use of fire protections and fighting equipment. First Aid instructions.</td>
<td>Resident engineer manager operation, medical officer. Safety officer if appointed separately.</td>
</tr>
<tr>
<td></td>
<td>manual</td>
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<tr>
<td>11.</td>
<td>Disaster management</td>
<td>Gives details of instructions to be followed by shift staff during any disaster. It further gives details of how to act and tackle the disaster.</td>
<td>Resident engineer/ shift incharge</td>
</tr>
<tr>
<td></td>
<td>instruction</td>
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</tbody>
</table>

Some sample formats of log book and reports are also enclosed to provide a guide line to create formats for the power station under considerations:
# Daily Generation/Transmission Report for

**Generation (MU)**  

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Daily R/ Hours Hr: Min</th>
<th>OUTAGES HOURS (Hr: Min)</th>
<th>Available Hr: Min</th>
<th>Deemed Gen (MU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
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<tr>
<td>Unit 2</td>
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<td>Unit 3</td>
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<td>.......</td>
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<td><strong>Total</strong></td>
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</table>

**Transmission (MU)**  

<table>
<thead>
<tr>
<th>Monthly Cum1 (MU)</th>
<th>Yearly Cum1 (MU)</th>
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</table>

**Station Data**  

<table>
<thead>
<tr>
<th>AUX. CONSUMPTION</th>
<th>AVERAGE LOAD MW</th>
<th>MAXIMUM</th>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TOTAL, INFLOW, Cumecs</th>
<th>WATER UTILIZED, Cumecs</th>
<th>SPILLAGE, Cumecs</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX RESERVOIR LEVEL, M</td>
<td>MIN RESERVOIR LEVEL, M</td>
<td>MAX TRW LEVEL, M</td>
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<tr>
<td>MIN INTAKE LEVEL, M</td>
<td>SILT, (PPM)</td>
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</tbody>
</table>

**Weather**  

**Outage Details**  

<table>
<thead>
<tr>
<th>UNIT/LINE</th>
<th>OUTAGE TYPE PO/FOR/MISC</th>
<th>TRIPPING/OUTAGE TIME Hr: Min</th>
<th>RESTORED AT Hr: Min</th>
<th>TOTAL OUTAGE TIME Hr: Min</th>
<th>Energy Loss MU (If Any)</th>
<th>REASONS</th>
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**Transmission Details**  

**Reasons for Less Generation / Remarks:**

[SHIFT INCHARGE]
## HOURLY STATION DATA REPORT FOR

### (NAME OF POWER STATION)

<table>
<thead>
<tr>
<th>Time (kV)</th>
<th>BUS END</th>
<th>UNIT -1 GENERATION</th>
<th>UNIT -2 GENERATION</th>
<th>UNIT -3 GENERATION</th>
<th>...</th>
<th>TOTAL GENERATION</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>VOLTAGE Hz</td>
<td>FREQ. MVAR</td>
<td>MW</td>
<td>MVAR</td>
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### OPERATION PARAMETERS

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<td>°C Hrs. °C Hrs. °C Hrs. °C</td>
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<tr>
<td>STATOR WINDING</td>
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<td>TURBINE GUIDE BEARING</td>
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<td>UPPER GUIDE BEARING</td>
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<td>ANY ABNORMAL OPERATION</td>
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[SHIFT INCHARGE]

NAME & DESIGNATION

---

AHEC/MNRE/SHP Standards/ E&M Works – Guidelines for Operation and Maintenance of Small Hydropower Station 82
### (NAME OF POWER STATION)
### DAILY TRIPPING REPORT FOR __________ REPORT NO. (STATION)/TRIP/

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of Line/ Unit</th>
<th>Time Hr : Min</th>
<th>Details of tripping</th>
<th>Replay operated along with Alarm and Flags</th>
<th>Remarks</th>
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**COPY OF EVENT LOGGER/ DISTURBANCE RECORDER PRINTOUT ENCLOSED – YES/NO**

Specify reason if not attached __________________________

[Shift Incharge]
Name/ Designation
(NAME OF POWER STATION)
GENERATION REPORT

FOR THE MONTH OF ____________

<table>
<thead>
<tr>
<th>DATE</th>
<th>UNIT-1 MU</th>
<th>UNIT-2 MU</th>
<th>UNIT-3 MU</th>
<th>..........</th>
<th>TOTAL MU</th>
<th>DEEMED GENERATION (MU)</th>
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INCHARGE [OPERATIONS]
NAME / DESIGNATION
(NAME OF POWER STATION)
M/C AVAILABILITY REPORT FOR THE MONTH OF

<table>
<thead>
<tr>
<th>Unit</th>
<th>GENERATION (MU)</th>
<th>TOTAL TIME (Hrs: Min)</th>
<th>RUNNING TIME (Hrs: Min)</th>
<th>PLANNED OUTAGE (Hrs: Min)</th>
<th>FORCED OUTAGE DUE TO BREAK DOWN OF M/S (Hrs:Min)</th>
<th>MISCELLANEOUS OUTAGE DUE TO HIGH PPM (Hrs:Min)</th>
<th>LESS AVAIL. OF WATER</th>
<th>TRANSMISSION CONSTRAINTS ETC.</th>
<th>AVAILABILITY IN HRS (D+G+H+I)</th>
<th>% AVAILABILITY (J/C)*100</th>
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</table>

**PLANNED OUTAGE**: Outage planned in advance for annual maintenance, periodical/ routine maintenance/ checking, inspection. Any outage planned in advance because of abnormal operating parameters i.e. high temp, oil level failure of shaft seal etc. should come under forced outage and not in planned outage.

**FORCED OUTAGE**: Outage due to tripping caused by abnormal operating parameters like high temp. / oil level etc, stopping/ closure of units for inspection / investigation /rectification of abnormal operating parameters/ behavior condition.

**MISCELLANEOUS OUTAGE**: Outages due to reasons beyond control of generating stations or for which generating stations are not responsible like tripping of units due to failure of grid, line problems, etc. backing down due to grid constraints/ requirements, closure of units due to high ppm, less availability of water etc. outage for less than 15 minutes due to tripping and resynchronization should also come under miscellaneous outage.
**UNIT NO.___________________________**

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<tr>
<th>SI No</th>
<th>FORM TO</th>
<th>TOTAL</th>
<th>ENERGY</th>
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**PLANNED OUTAGE**

**FORCED OUTAGE**

**MISCELLANEOUS OUTAGE**

**INCHARGE [OPERATIONS]**

NAME/ DESIGNATION
# MONTHLY TRIPPING REPORT

FOR THE MONTH OF ________________

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Units/ Line</th>
<th>Type of Tripping</th>
<th>Tripping Report No. &amp; Date</th>
<th>Comments / Remarks (if any)</th>
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INCHARGE [OPERATIONS]

NAME / DESIGNATION
(NAME OF POWER STATION)
DEEMED GENERATION REPORT FOR THE MONTH OF

<table>
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<tr>
<th>Sl. No</th>
<th>Unit No.</th>
<th>DATE dd/mm/yy</th>
<th>CONSTRAINTS/ BACKING DOWN CODE</th>
<th>TIME FROM Hr:Min</th>
<th>TO Hr:Min</th>
<th>BACKING DOWN PERIOD (t) Hr</th>
<th>CAPACITY BACKED DOWN B, IN MW</th>
<th>ENERGY LOSS ELOSS (MU)</th>
<th>TOTAL GENERATION LOSS DURING THE DAY GLOSS (MU)</th>
<th>SPILLAGE ENERGY DURING THE DAY GSPILLAGE (MU)</th>
<th>DEEMED GENERATION GDEEMED (MU)</th>
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NAME/ DESIGNATION
### STATISTICAL ANALYSIS TRIPPINGS

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<th>CLARIFICATION FROM THE STATION</th>
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#### LEGEND

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Approved:
## Annual Maintenance Schedule

(POWER STATION)

ANNUAL MAINTENANCE SCHEDULE

(FOR THE YEAR )

UNIT/ EQUIPMENT FEEDER BAY/

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DETAILS OF EQUIPMENT</th>
<th>TYPE OF ACTIVITY</th>
<th>PERIOD</th>
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SIGNATURE

ISSUED BY POWER STATION
(POWER STATION)  
MONTHLY MAINTENANCE REPORT  
(FOR THE MONTH)

UNIT/EQUIPMENT/FEEDER BAY/

<table>
<thead>
<tr>
<th>SL NO</th>
<th>DETAILS OF EQUIPMENT</th>
<th>MAINTENANCE PLANNED</th>
<th>DATE OF COMPLETION AS PER SCHEDULE</th>
<th>STATUS AT THE END OF THE MONTH</th>
<th>REASON FOR DEVIATION IF ANY</th>
<th>ACTION PLAN IF ACTIVITY NOT COMPLETED IN TIME</th>
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SIGNATURE
ISSUED BY POWERSTATION

Engineer (O&M)

Head (O&M)
# Breakdown Status

## Unit/ Equipment/ Feeder Bay:

**Date & Time of Breakdown:**

**Date & Time of Restoration:**

<table>
<thead>
<tr>
<th>Breakdown Brief</th>
<th>Action Taken for Restoration</th>
<th>Preventive Action to Avoid Recurrence</th>
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**Signature / Date**

**Issued by Station**

Approved:

Issued:
## OUTAGE REPORT

**NAME OF POWER STATION**

<table>
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<tr>
<th>SL NO</th>
<th>NAME OF EQUIPMENT OF THE UNIT/FEEDE</th>
<th>STARTING DATE</th>
<th>TIME (Hrs:Min)</th>
<th>RESTORATION DATE</th>
<th>TIME (Hrs:Min)</th>
<th>TOTAL OUTAGES TIME (Hrs:Min)</th>
<th>REASONS</th>
<th>GENERATION LOSS IN MU</th>
<th>ACTION TAKEN FOR RESTORATION</th>
<th>PREVENTIVE ACTION TO AVOID RECURRENCE</th>
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**ACTION TAKEN BY STATION:**

[SHIFT INCHARGE]
NAME/ DESIGNATION