LECTURE NOTES ON

TESTING MAINTAINANCE OF ELECTRICAL MACHINE

(THEORY – 4)

SEMESTER-6th

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CHAPTER-01 INSTALLATION, COMMISSIONING & TESTING OF MACHINE.

Inspection of arrival of machine and inspection procedure before its installation:-

→ Inspection of Arrival of Machine:-

→ Inspection is the examination of certain machines may be motor or generator or their parts to inspect for their damage or missing.

→ The main aim of the inspection is to check that the machine received is in good condition.

→ This inspection work should be carried out by some competent persons who have got the thorough knowledge regarding the inspection of particular machine. i.e what to inspect and how to inspect.

→ Inspection on arrival of electrical machine following procedure

- The wooden crates containing motors should be unloaded by using cranes. sliding the motor down, an inclined plank using pipes or bars should be avoided.
- Handling of electrical machine (motor)

Motors should be handled very carefully to increase life and service of the motors.

→ The following precautions should be followed during handling:-

(a) Always using lifting hook to lift the motor except in very small frame where no lifting hook is provided.

(b) Do not use any other part of the motor for lifting purposes.

(c) Do not use shaft projection for dragging the motor.

(d) Do not roll or drag the motor on floor.

- Unpacking And checking the motor:

On arrival of motor at site, the packing cases should be checked against the dispatch particulars.

→ Any loss of packages in the transit should be intimated to the manufacture or supplier and insurance company.

Inspect all parts:-

→ After unpacking and checking the machine should be brushed down to removed all small piece of wood wool, packing paper dust etc.

→ Sometimes a machine is undefined with during transit, terminals lid and covers being left loose.

→ Everything should be well-tightened up before proceeding with the installation

→ Also check that the motor name-plate details agree with supply order.

• ~~Storage~~ o

procedure for storing a machine at site :-

→ The machine should be stored in clean, dry, store house having uniform temp.

→ Heaters should be provided to avoid dampness.

→ The air in the store room should not have humidity more than 68%. The temp should not below +15°C.

→ Direct sunlight, rain water, dust, gases, water, smoke should not be present in the store room.

→ Machine should not be kept on wood floor.

-Methods of heat application :-

→ Several alternative methods are available for application of heat.

→ The heat depends upon the size of motor, drying-facility available condition of motor etc.

Precautions while Drying out :-

1. Chamber should have thermal insulation to prevent heat loss.
2. The machine body should be covered with canvas to prevent heat loss.
3. Temperature of ~~off~~ air shall be controlled by turning off the heater from time to time.
4. Local Temperature should not exceed 75°C. There should be proper circulation of air in the chamber.
5. The temperature should be raised gradually. Not faster than 10°C per hour.
6. Heating should be continious and steady temperature shall be maintained continously during the entire drying period.

Methods of drying out an electrical machine :-

→ (a) By using Chamber and resistor heaters :-

→ The machine to be dried is placed in a drying chamber. The drying chamber should be of volume about 4 times the volume of motor.

→ The air is circulated by means of fans & air circulating system.

→ The air temperature is periodically measured by the thermometer.

→ The floor of store should not be subjected to vibrations. In case of vibration, the machine should be placed on rubber blocks.

→ There should be 'NO SMOKING' sign in the store room.

Procedure for inspection of an Electrical motor before its installation :-

→ The inspection of the motor should be carried out as follows :-

1. External inspection of motors for conditions.
2. Inspection of terminals by opening the terminals lid.
3. Blowing of the motor with clean, dry air to remove dust.
4. Checking of the rotor for easy rotation when turned by hand.
5. Rectification of defects observed during inspection.
6. particular attention should be given towards antifriction bearings of the motor.
7. Insulation resistance are tested between winding and frame tested by means of a megger.

Step in Drying-out of a motor or a Generator

1. preliminary preparation of the machine, source of heat measurement etc.
2. Arrange the set up.
3. Apply heat by one of the suitable means gradually.
4. Take periodic readings of the lock-time etc value.
5. Measure periodically of the insulation resistance
6. Intermediate stage
7. Rising stage.

→ The moisture expelled from the machine by out of the drying chamber with outlet air.

b. By radiating lamp (Infrared lamps)

→ This is a most convenient and simple method used for medium and small motors.

→ The lamps are located in the chamber opposite to the motor winding. (The motor is removed)

→ The heating should be continuous & carefully controlled so that it does not rise too high thus scorching & damaging the insulation.

→ In order to ascertain how drying out is proceeding megger reading should be taken every 12 hours.

c. By circulating short-circuit current:-

→ This is most convenient method of drying any electrical machine such as generator, slip ring motor, synchronous motor, field winding etc.

→ The machine is connected low voltage source.

→ The input voltage, current, power, the temperature of winding temperature of body temperature of air are periodically measured.

→ The increase in temperature should be very gradually upto the value of not exceeding 70°C. The cooling down is also gradual.

→ After drying coat air drying varnish should be applied by brush on the winding surface only.

→ The motor should be watched constantly during drying period.

GENERALISED PROCEDURE OF INSTALLATION OF ELECTRICAL MACHINE :-

→ Installation procedure of an electric motor involves a series of activities like ① Grouting ② Levelling & alignment ③ Fitting of other parts - ④ Location and layout :- ⑤ Final levelling & alignment.

→ The location of an electrical machine depends on the purpose of installation, definite type and size.

→ The location plan should permit to have required wide space all-around for continuing the erection work and should facilities regular inspection, repairing etc.

→ Once the location is finalised, the work of laying out the foundation plan is to be undertaken. Laying out means marking of the foundation plan.

→ It may be done with the help of chalk on a concrete floor and by a strings with number of pegs.

→ Excavation of soil may be started only when the layout is completed as per requirement.

(b) Positioning of Machines :-

→ positioning of the machine at the location is an important job, which deserves care, skill and an efficient team work.

→ An equipment may have the weight of a few tons. But it is to be loaded or unloaded, to be moved vertically or horizontally to bring at the site and to placed it on the foundation as well.

→ Different types of lifting devices like pulley blocks, chain hoists, over head crain etc be required.

(d) Grouting:-

→ Grouting is a procedure of concreting the machine with the foundation by a concrete mixture of plastic consistency or cement mortar.

→ Generally a quick setting element is used to perfon grouting.

→ The top of the foundation block is made roughened, melt, moisture with water and wooden poonstion are placed all around the machine.

→ The height of such wooden ~~partions are placed all around the machine~~ boards are kept much highen than the top gap between the top of the foundation and bottom of the machine.

→ Quick setting cement is then poured within the boundary with care to eliminate any air gap within it.

→ Once started the pouring should be completed continuously the machine must be left undisturbed for a few days to provide it time to set.

(e) Labelling & alignment:-

→ After having the machine on the foundation the important jobs to level and allign it with other acessories.

→ The lebelling penformed with labelling wige shoe etc.

→ The horizontal and slide vertical movement of the heavy mall is done by pipes rollers etc.

→ The pinch bars, spirit level indicator are generally used to level the machine.

(f) Fitting of other parts accessories, piping etc :—

→ When the machine is finally created; the other accessories may be joined accordingly.

(g) Final ~~Levelling~~ Levelling and alignment :—

→ After grounting has set in properly accurate levelling can be carried out such levelling involves minor adjustment.

ELECTRICAL WIRING FOR MOTOR

→ Every manufacturer or firm sends out a terminal diagram with his motors and this generally shows how the internal winding are arranged and how the terminals are lettered.

→ Size of Cable :-

→ All cable should be large enough size to carry the current which is stamped on the motor name plate.

→ The size of cable used should be capable of carrying full load current corresponding to the rating of the motor.

→ Methods for installation of Wiring for Two or More motors :-

→ When wiring is to be done for electric motors.

1. A separate circuit may be run to each motor from fuse distribution board. This method is generally adopted for a group of motors of small size.

2. The fuses are to be used in each branch circuits of ample capacity.

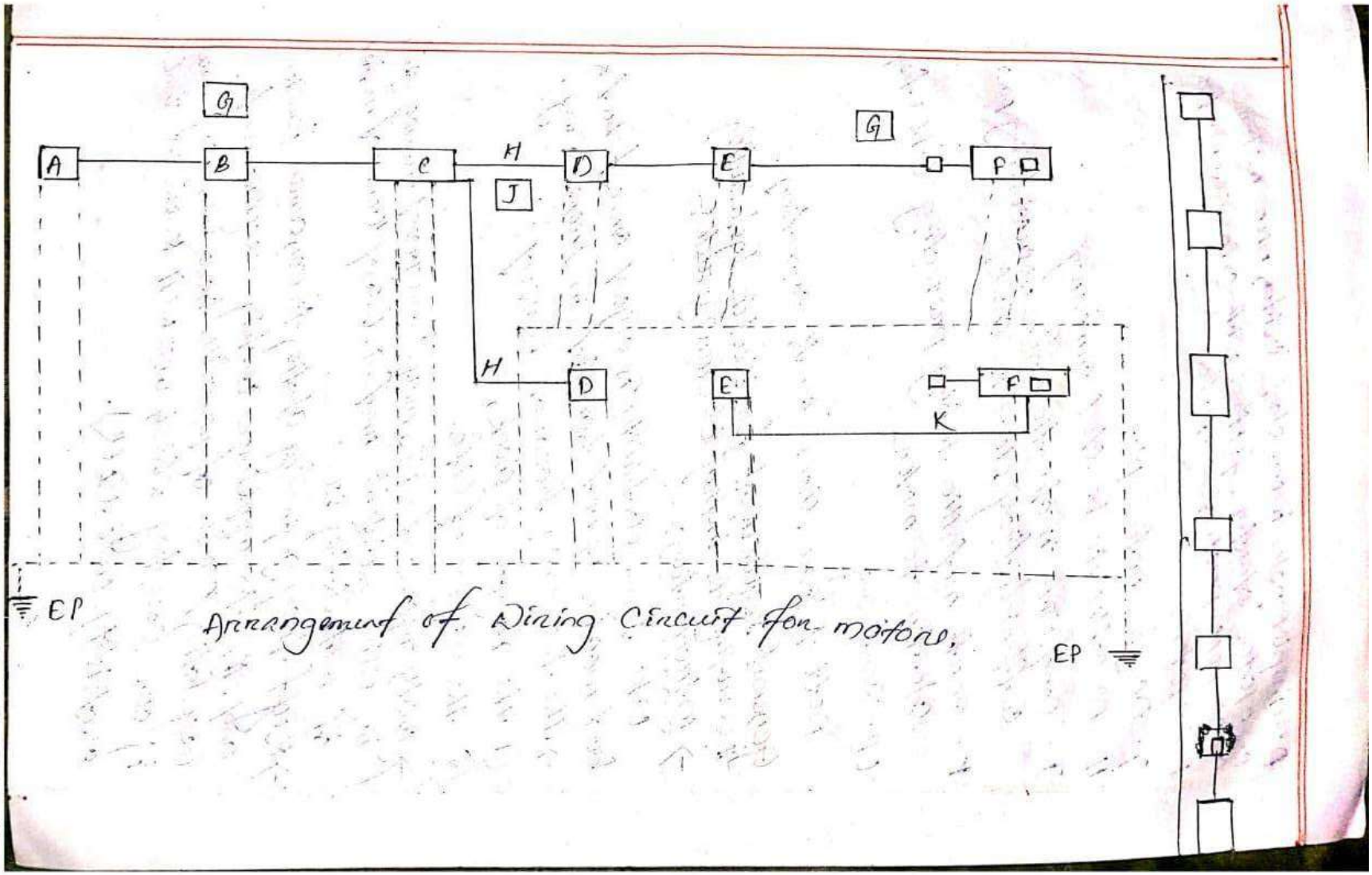
3. The frame of every motor shall be earthed by two separate and distinct connections through earth electrodes.

The earth connection should be visible for periodical inspection.

A = Supply company's metering panel

B = Iron clad main switch with over load release

C = Power panel



Arrangement of Wiring Circuit for motors.

D = Triple pole iron-clad switch near motor
E = Motor starter fitted with over current & no-volt protective device
F = Motor
G = Danger notice plate
H = All cables to be steel armoured
J = Card with instructions for resuscitating persons suffering from electric shock
K = Earth metallic tubing protecting cables from starter to motor
EP = Earthing
Dotted line shows earth connection.

General Requirement for Electric Installation according to Indian Electricity rule :-

→ Introduction :-
Like fire, electricity is a good servant but a bad master if not handled in proper way.
→ The two main hazards involved :-
(1) The danger of shock
(2) The danger of life.
→ Both types of risk may be reduced to negligible by using suitable material and correct method of installation etc.
→ Right from generating station to consumer premises and they to appliance certain requirements, regulation & code of practice have been laid down in our country which are well know as Indian electricity Rule. (IER).

c. Concrete foundation :-

→ The part of a structure which provides a base or support for the machinery is called a foundation.

→ Objects of foundation :-

- It carries and supports the weight of machinery in order to prevents any settlement of crushing.
- It maintains the alignment of machine.
- It gives a level and firm surface for the machine.
- It absorbs the vibration produced by the unbalanced forces created by reciprocating and rotary mass of the machining elements.

→ The depth of concrete foundation will depend on :

(i) the weight of machine
(ii) Amount of vibrations involved
(iii) Character of the subsoil

Planning the foundations :-

→ The static load and dynamic load of running machine is transmitted to the ground via the machine foundation.

→ The best material for the foundation is concrete.

→ Empirical formula : $(W_F) = k_f W_M$

where k_f is the factor commonly taken 2, 3 for the machine with dynamic load

W_M : is the weight of machine.

→ The height of the foundation = $\frac{\text{Weight of the foundation } (W_F)}{\text{Area of the base of foundation} \times \text{Specific wt. of material}}$

→ The abstract of new important IER are given below
30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 45, 46, 47, 48, 49, 50 etc

NECESSITY OF :- STARTER FOR BOTH D.C & AC MACHINE OR MOTOR

→ STARTER :-

→ When a motor is at rest back emf is zero armature resistance is very small. Therefore it is dangerious to start the motor of ratings above 5 H.P directly from the line.

→ The starting current is very high and this heavy current may damage the armature and also cause a flash over across commutator.

→ In series with armature at the time of starting which is gradually cut out as the motor gains speed and develops back emf which regulates the speed. So, the starters are used for limiting the starting current to safe value.

→ Low voltage is reaching to the motor terminals

→ So apart from reducing the starting current at start, suitable arrangement are made for protecting the motor from overloading by disconnecting it automatically from supply.

→ Hence starter is an electrically operated switch, designed for accelerating a motor from rest to normal speed in pre-determined direction of rotation.

→ Types of starter

(1) Two point starter
(2) Three point starter
(3) Four point starter.

→ Over load relay for necessity of motor :-

→ A relay is a device that opens or closes an auxillary ckt under some predetermined condition in the main circuit.

→ A relay is also an electro-magnetically operated switch. The main part of relay are armature contacts and coil.

→ When current flows through the coil, the armature is attracted and operates the contacts.

TESTING BEFORE GIVEN SUPPLY & TESTING REPORT :-

→ Testing before given supply are :-
① Electrical check ② Mechanical check.

① Electrical check :-

→ Insulation resistance test between installation and earth.

→ Insulation resistance between conductor.

→ Testing of earth continuity.

→ Earth resistance Test

- Test of polarity whether phase flows through the switches or not.

- starting device should be properly installed to save the motor from being damaged.

- The protective device should be of proper rating.

- Double earthing should be provided for protecting the motor in case of leakage.

(2) Mechanical check:-

→ The motor is well bolted down.
→ The motor should be checked for proper lubrication
→ The belt or other driving equipment should be tight.
→ All wires gearoff, terminals leads are in place.
→ The bearing should be free form moisture content and metallic particles.
→ All starter, switches control are in 'OFF' position.
→ All wiring should be right and correctly connected after conducting all the checks the motor should be run no-load for finding possible faults such as :- noise, vibration, overheating etc.

TESTING REPORT:-

MOTOR NO	KW	R.P.M	LOCATION	INSULATION RESISTANCE	RESISTANCE OF EARTH CIRCUIT	REMARK
					Signature of contractor	Contractor licence No:-

~~Testing~~

→ Before the electrical machine is put into service its installation should be passed by the electrical inspector.

→ The testing report must be approved by govt. approve electrical contractor.

→ Then the report along with application is submitted to electricity board authority.

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(CHAPTER-2) INSTALLATION COMMISSIONING AND TESTING OF TRANSFORMER

Basic idea on dispatch of transformer :-

→ Transformer are generally dispatch by manufacturer of in one of the following methods depending upon size & local condition.

(1) Dried out field with coil medium of service (Small transformer)

(2) Filled oil covering the core & coil soldier (medium transformer)

(3) With out in the tank filled with nitrogen at pressure (large transformer)

→ The transformer may be placed in a strong wooden packing case for dispatch on rail. Can also be send with out any pack case depending upon the condition of the transformer.

Delivery of transformer at the site :-

→ Low power transformer are transported to the site completely assembly medium power transformer either completely assembly or with some of the part dismantled and packed in boxes.

→ High power transformer and all transformers above 110KV are transported in partly dismantled condition with there radiator high voltage bushing, oil conservators, volt pipe and air blast system packed seperately.

→ Low & medium power transformer are taken there side by on trucks & high power transformers are mostly wagon or road trailers.

Handling on arrival of side :-

→ The simplest of most convient way to on-load the transformer with the help of cranes. Where cranes are not available in such cases a trench is to be dage to a depth equal the hight of trailer platform & the transformer is slied in position on rails.

Inspection of side :-

→ On arrival of side the packing cases should be checked against the dispatch particular any loss of packages in the transient should be communicated to the manufacturer and insurance company.

→ The transformer should be unpacked & inspected for any size fetting, bussings etc.

→ Oil leakage should be checked along the valves tank weld gasketed flanks.

→ Gas pressure should also be checked.

→ Transformer absorve moisture when not in use it is there for necessary to checked dielectric strength of the oil & the insulation resistance of the winding before putting them use.

→ (1) Checking of oil :-

→ A lower than 30 kV dielectric strength for 4 millimeter gap would indicate presence of moisture

→ The oil should be filtered and dried in suitable plant.

→ (2) checking insulation resistance of winding :-
→ Insulation resistance of winding should be checked with a 1000 volt megger the voltage being applied for a period of one minute.
→ All the winding except the winding under test should be earthed during this test.

→ (3) storage :-
→ The transformer arrived at sites are likely not to be installed immediately don't need long storage, but the transformer which are not to be installed immediately need proper storage to avoid the ingress of moisture effect of resins or dust etc.

Civil work associated with transformer foundation :
→ Civil construction features regarding installation :
- for indoor installation the following factors should be considered :-
(1) Ventilation
(2) Noise level
(3) Space for free movement

foundation and drainage of oil
→ (1) foundation :-
It must be strong enough to bear the load transformer with out any vibration & must be made with proper floor level and plinth level.

(2) Drainage of oil :-

→ Indoor transformers having oil capacity of more than 9000 litres should be provided with sock pits.

→ Gravel should be spread all around. Proper slopes should be maintained & sock pit filled with sand gravel should be provided with manholes.

(3) Cabling :-

→ power cable and control cable should never be placed in the same conduit. DC control cable, AC protection ckt cable and AC power cables should be separated from each other.

(4) Cable box for transformers :-

→ If the transformer is fitted with cable boxes and is to be connected by paper insulated power cables, the cable ends should be sealed and the cable boxes should be filled with oil.

(5) Provision for fire protection :-

→ Carbon-tetra chloride (CCl_4) and foam type fire extinguishers and buckets filled with sand and water should be kept ready for this purpose.

(6) provision of supports of Bushings :-

→ LT cables should be supported on wooden support along with angle iron to avoid bending of cables coming out of the transformers otherwise the bushings will be cracked.

Location of switch gear:—

→ switch gears should be installed in a separated room and power and control cables should be run in separate conduit pipes.

steps to be taken before commisioning of a power transformer:-

(1) fitting of all accessories:—

→ Transformers are dispatched with some accessories removed and packed in separate packing to damage during transportation.

→ The accessories are fitted are: (1) Oil Conservator (2) Silica gel dehydrating breather (3) Buchholz relay (4) Explosion vent (5) Temperature indicators for oil & winding (6) Bushing (7) Magnetic oil guage (8) Tap changing (9) Cooling equipment.

(a) Oil Conservator:—

→ Oil Conservator is, sort of drum, mounted on the top of the transformer. A level indicator is fixed to it, which gives alarm at low level.

→ Conservator is connected through a pipe to the transformer tank containing oil. This oil expands and contracts depending upon the heat produced and so the oil level in the conservator rises and falls.

(b) Breather:-

→ The breather is a box containing Calcium chloride or Silica gel to absorb moisture of air entering the conservator as it is a well know facts that the insulation property of the transformer oil is lost through the air breather.

→ The transformer oil should not be allowed to come in contact with atmospheric air. A small amount of moisture causes a great decreases in the dielectric strength of transformer oil.

→ When oil level in the oil conservator changes, air moves in and out of the conservator. This action is know as breathing

→ Breather containing silica gel or some other drying agent such as calcium chloride. This ensure that only dry air enters the transformer.

→ Dry silicagel is of blue colour. It turns pale pink as it absorbs moisture. The wet silicagel can be regenerated by drying.

(C) Buchholz relay :-

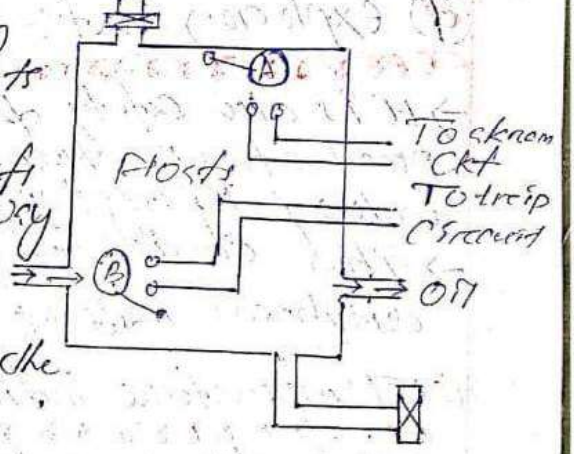
→ This relay is a gas acuated relay which is meant for the protection of oil immersed transformer from insulation failure.

→ The relay is situated in the pipe connected between the transformer and the conservator.

→ Construction and working :-

It consist of a case in which to spherical floats A and B are provided.

→ Each assembly of floats is arranged in such a way that when the transformer oil is completely filled and ready for service, the contacts of both the switches are open.



→ following precaution should be taken while installing the relay.

(1) It should be seen that piping and relay oil are free from any matter that may disturb relay operation.

(2) The distance of relay from conservator should not be less than 3 times the diameter of the pipe.

(3) The pipe should slope up from the tank to the conservator at an angle of 30-70°.

Advantages:-

→ It is the simplest form of transformer protection.
→ It is detects the fault at a stage much earlier than is possible with other form of protection.

Disadvantages:-

→ It can only be used with oil immersed transformers equipped with conservator tanks.
→ This device can detect faults only below oil level in the transformer.

(d) Explosion vent:-

→ It is also safety device of a transformer which protects the transformer tank form gases induced by any type of short ckt in the transformer.
→ This consist of vertical pipe closed by a diaphram made of thin bakelide sheet.

(e) Temperature Indicator:-

→ It is also a protecting device fitting to a transformer to indicate the temperature of transformer oil. for measuring the temperature of the oil.
→ Two indicating pointers black and red one provided. Black pointer indicates the temperature of the oil and its also drive red pointer.

(f) Bushing :

→ The bushing serve as supports and insulation of the bus bars and transformer terminals.
→ The bushing consist of porcelain shell, body, copper and brown locating washers used for fixing the position of bus bars and mounting flange with hole drilled for fixing bolt and it is also supplied with an earthing bolt.
→ The winding of a transformers is connected to the lines through the copper rods which are insulated from the tank cover. these are know as bushing.
→ Oil bushing is used for 33kV application and for current rating above 2000A.
→ Type of bushing ① H.V bushing ② L.V bushing
→ Important test on H.V Bushing
ⓐ Type tests ⓑ Routine tests

⇒ Maintence:-
(1) Oil strength of the bushing oil must be able to withstand 40kV at 4mm gap.
(2) The insulation resistance value between line terminals and flange should be more than 10,000 MΩ in case of healthy bushing.
(3) If the bushing have been stored for more than 5 years. the capacitance should be measured and compared with standard values.

j) Magnetic oil gauge:-

→ The magnetic oil level gauge supervises the level of oil in the conservator tank.
→ The oil level gauge is provided on the transformers are of the dial type with minimum and maximum level marking and a pointer which indicate the level of oil in the conservator.

k) Tap changing:-

→ The voltage control of transmission and distribution system is obtained by Tap-changing

→ The tap changes are either on-load or off load tap changers. Tap changer is fitted with the transformer for adjusting secondary voltage. The voltage control of the range ±16% can be achieved by tap-changing transformer

* procedure for filling the oil in transformer tank :-

→ The oil is filled in the tank after the following steps :-

(1) Drying out of transformer tank, core & coils
(2) filling of oil by means of oil filtering plant
(3) Before filling the oil, the transformer should (Hesk) be fitted with all accessories such as plug and valve gauge.

- oil sample should be taken and tested and then filled the tank. It should be ensured in oil filling operation that no air packets are left in the tank and no dust or moisture enters the tank. All the air vent is opened.

→ Equipment Required for oil filling :-

(1) High vaccum filtereting plant
(2) Oil storage tank with silicagel breather
(3) Vaccum gauge.
(4) Oil dielectric strength tester
(5) Oil sampling cones or bottles
(6) Vaccum tank
(7) Moisture content Meter.
(8) Thermometer
(9) Manometer
(10) Valves filling and hoses.

Changing the breather with fresh silicagel:-

→ Remove the wing nuts supporting the body.

→ Glass container should be squarely fitted on its gasket, then pour re-activated or fresh silica gel into the container upto a level 1/4 inch from the top.

→ fix the assembly to the top plate with inspection window facing outward from the transformer and secure it with the wing nuts.

→ Transformer oil should be poured into the oil cup until it overflows through the screw hole and fix it to the assembly with the nut.

→ Silica gel is re-activated by applying heat to it or by heating it in oven until its colour is restored to blue. While baking silicagel temperature should not exceed 150°C.

Characteristic of transformer oil:-

→ It should be have dielectric strength.

→ It should be free from moisture and water.

→ Acidity content should be low.

→ It should have high flash point (104°C)

→ The oil should be chemical stable

→ It should be ~~posses be~~ low viscocity.

Testing of transformer oil:-

(1) Break down test (BDV test)

(2) Crackle test

(3) Sight test

(4) Acidity test.

(1) Breakdown test :-
→ It is perform to check the dielectric strength transformer oil
→ The test performed in the oil testing set.
→ The sample of oil is drawn from near the top and bottom of the transformer and tested.
→ A lower than 30KV dielectric strength for a 4mm gap of electrodes could indicate the prevence of moisture in the oil.

(2) Crackle Test :-
→ It is perform to check prevence of moisture in the insulating oil, To perform this test a sample of oil is taken in a beaker and oil of 250ml.
→ One iron rood of 12.5 mm is made red hot and dipped in sample oil if there is any hissing sound coming through the oil in the beaker, it indicates the presence of moisture contents in the oil which will be ~~moisture contents in the oil which~~ consider no suitable for the use.

3) Sight Test :-
→ The test can be performed by taking water in a beaker and bent tube is filled with oil the level of oil should not less than 35mm by level of water in the beaker.
→ Close the end of the tube and fixed on the stand by dipping into water.
→ If the bubbles appeared at the jet it will indicate the prevence of moisture content in the oil.

(4) Acidity test :-
→ This test is done to measure the free organic and inorganic Compound present in the oil.

CHAPTER - 5 SUBSTATION

Introduction :-

A substation is an assembly of apparatus which is installed to control transmission and distribution of electric power.

→ The electric power generated at generating station is handled by several substation before it is delivered to the consumer.

** A substation performs the following operation :-

→ To perform voltage transformation operation i.e step up and stepdown

→ To perform switching operation.

→ To perform powerfactor correction operation.

Classification of Substation :-

→ According to design substation may be

1. Indoor substation.
2. Outdoor substation.

*1. Indoor Substation :-

→ Indoor distribution and transformer substation consist of a series of apparatus installed within the substation building

→ Such substations are generally used for voltage upto 11KV, but can also be erected for 33KV or 66KV with proper arrangement.

→ The main equipment of the given installation is arrangement in compartments.

→ The chambers space within which the equipment of any main bus-bar connection is mounted is called cell or compartment.

7. When the electric system is expanded, the earthing system should be expanded by using additional earth electrodes and earth wires separately.
8. pass the earth continuity conductor through the Galvanised pipe from being damaged.
9. The value of earth resistance should be not exceed 1Ω for better performance.
10. Avoiding the jointing from earth conductor.

Types of earthing:-

(a) Neutral Earthing
(b) Equipment Earthing

(a) Neutral Earthing:-

→ It is the connection of ground to the neutral point of star connected winding of generator transformers and other rotating machines.

(b) Equipment Earthing:-

→ Connecting non current carrying metal points of equipment such as Tower, motor body, transformer core, and tank etc. to the ground is called equipment earthing.

* points to be connected to Earth in Equipment earthing:-

(i) Metal frame of generator, motor and other metallic parts of equipment.
(ii) All metal parts of electrical installation such as: light fittings, iron clad main switches etc.

(b) At the time of accident contact between high voltage and low voltage transmission line.
(c) When the insulation of wires punctures.
(d) When lighting strokes falls on lines.

Purpose of Earthing :-

→ To save human life from danger on shock or death.
→ To protect large building from atmospheric lighting.
→ To protect all machine.
→ To maintain the line voltage constant.
→ To maintain potential of any part of a system at a definite value with respect to earth.

Preventive maintainance of earthing system :-

1. Earth resistivity should be checked half yearly during dry season and result should be compared with installation records.
2. In case of small substation water should be poured at regular internal.
3. Electrodes should be checked for any corrosion due to chemical or charcoal.
4. Tightened earth connection and should be properly welded with earth electrodes.
5. Examine and replace broken earth lead/s conductor with proper size.
6. In case earth electrodes if found corrosive replace immediately.

Installation :-

1. check nadines of foundation and their dimensions as per the drawings.
2. check the level of foundation surface.
3. Place the based frame / structure of the ckt breaker in position. place foundation nuts springs washers and tighten make connection of earthing riser to the structure.
4. Assemble operating mechanism in its position
5. Assemble support porcelain and interrupting heads
6. Join the links in the mechanism with the links of in the pole unit as explained in the manufacture instruction book.
7. Give auxillary supply to mechanism for motor for trip circuit and closing circuit.
8. Tighten all bolts and other accessories.
9. Measure insulation resistance.
10. Fill quenching medium after drying out operation check leakage and ensure leakage free assembly.
11. Make terminals connection and operate breaker from local control panel.
12. Operate the breaker from control room by operators instructions and they by operating the relevant relays.

Now the breaker is ready for putting into

Precommissioning Test of breaker :-
Those tests are performed in accordance with the agreed field quality plan and includes -

1. Leakage test
2. Time / contact travel characteristics
3. Time test
4. Insulation resistance test of main and auxillary circuit.
5. Cheking of earth connection.
6. Operation of breaker from local control cubicle
7. Operation of breaker from control room by manual command by relay command.

Earthing :-

→ Earthing means connecting the non-current carrying metal parts used in electrical installation to the general mass of earth by wire of negligible resistance.

→ This brings the body to zero potential and thus avoid the shock to the operator.

→ The earth potential is always taken as zero for all practical purposes.

→ The electrical appliances when connected to earth attained zero potential and are said to be earthed.

Earthing provides protection in the following cases

a) Insulation breakdown between primary and secondary winding of three phase transformer

→ In some arrangement two buses are provided to which the incoming or outgoing feeders are connected. one of these buses is called main bus & the other is called transfer or auxillary bus.
→ selector or transfer switches are used to connect the feeders to one bus.
→ The busbars in substation are generally rectangular shape but round tubes, round solid bars or square tubes may be used.
→ The busbar are usually made of aluminium worked with silver.
→ The main functional requirement of busbar system
→ TO carry - the normal current & overload current continuously with limited temperature rise.
→ TO withstand normal system voltage
→ TO withstand mechanical stresses due to wind short ckt without damage.
→ TO provide low resistance path for current flow.
→ procedure for joining to busbar section.
→ Clean the busbar joint with rough emery paper.
→ Apply an oxide grease on the prepare joint surface immediately. The grease is apply. to prevent the exposure of prepared surface to air and moisture.
→ Make joint as early as possible by bolting or clamping.

Connection of main Cable:-

→ The cable terminal box should be clean & moisture should be removed by blow lamp.

→ The cable coven is bolted properly no moisture or dirt should enter while filling the compound in the cable box.

→ The PVC hose is sleeved on the cable conductor which is protected by Varnish cambric tape.

→ The terminal log is shouldered to the cable conductor.

Installation of outdoor ckt-breaker:-

1. Reservion / storage
2. Civil work
3. pre commissioning checks.

1. storage / Reservion:-

→ The packing cases are inspected and stored in indoor / Concred stored in planned location.

2. Civil Works:-

→ The foundation plan is decided on the basic of requirement of the clearance & the base of equipment.

→ pockets are provided for grouting the foundation bolts cable are laid on trays located in the cable trenche. The installation work is started after completion of foundation.

→ Trenches and passages are provided for cables and other piping.
→ The floor should be correctly levelled and marked according to the drawing.

6. Erection :-
→ The equipment is installed according to the procedure mentioned in the instruction manual. Some types of lifting devices, special tools etc may be necessary.

2. The assembly is erected vertically.

2. The vertically is measured & checked by spirit label.

Relay :-
→ It is advisable not to adjust the relay mechanism.
→ Contacts on relay should be inspected for any sign of burning. If necessary emery paper should be used for cleaning.
→ All the terminals of the relay should be checked for tightness and the wiring should be checked.

Installation of Busbar :-
→ Conductor to which a no. of circuits are connected called Busbar.
→ There are having conductors & do transport electric current. Generally the busbar conduct

3. Location of SG :-

→ The following points should be kept in mind.

→ The location should be free from moisture dust reptiles etc.

→ Fire proof doors, roof, ceiling for indoor SG

→ Ceiling of cable duct floor should be dry and labeled.

3. Sub division of SG :-

→ Installation of fire fighting operations.

4. Unpacking :-

→ The equipment is packed in Crates and is brought to site by railway & motor truck.

→ packing are lowered on the site by means of rope, hoist or Crane.

→ It is to be taken care that equipments are always maintained in upright position.

→ Further the items are carefully inspected visually. If any damage found, the matter should be informed to the manufacture & insurance Company immediately & the damaged equipment should be returned.

5. Foundation :-

→ The foundation is prepared according to the foundation plan. Holes are provided of foundation bost.

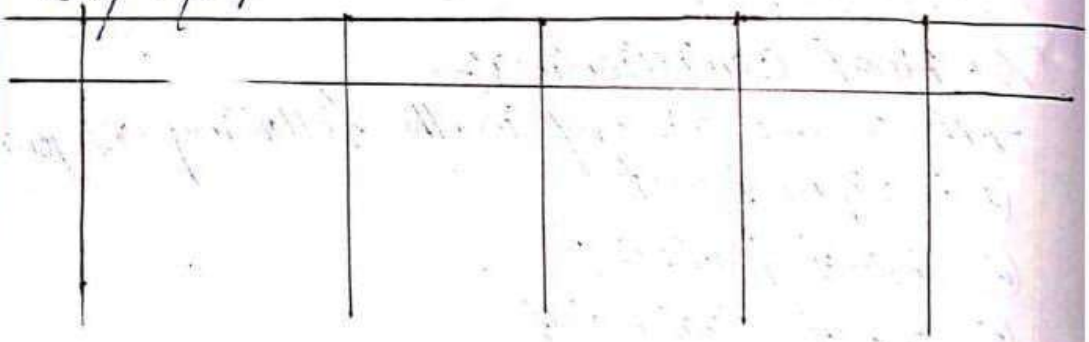
Types of S.G.:-

1. L-T SG
2. H-T SG

preliminary preparations:-

→ It include study of drawing, acceptance report checking certificates and test report of improvement completion of civil Engg. and arranging the tools lifting gears, organising labour, preparing sequence card for measurement the equipment.

→ prepare the schedule of installation of sequence card for erection of SG equipment



4. protection fitting :-

→ Buccholz relay, Explosion vent, pressure release valve, OTI (Oil temperature Indicator), WTI (Winding Temperature Indicator), Breather are fitted to transformer for protection purpose.

5. construction of mounting :-

→ The foundation plan of the complete substation indicates the building foundation, yard foundation, transformer foundation etc.

→ The foundation plan for an individual equipment is recommended by the manufacture.

→ particular attention should be paid to the design of transformer foundation.

→ The provision of cable trenches, earthing mat, drainage, auxillary supply should be taken into consideration.

6. final comissioning :-

→ These are divided in the following categories :-

(1) Equipment test
(2) Subsystem check
(3) Complete system test
(4) commissioning test
(5) performance characteristics test.

Installation of SG devices :-

→ SG are mechanical devices design to close or open the contact members in a electric circuit under normal or abnormal

Location of outdoor substation :-

→ (i) Selection of site for substation :-

→ For selecting the site for a substation the following factor are considered

→ Type of substation

→ Availability of suitable and sufficient land.

400KV substation - 50 acre land

220KV substation - 25 acre land

132KV substation - 10 acre land.

→ Communication facility

→ Atmospheric pollution

→ Availability of essential amenities to the staff.

→ Drainage facility.

(ii) Transport and receipt of transformer :-

→ The following modes of transport are used :-

(1) By ship

(2) By road

(3) By rail.

→ The power transformer short reactors, long busbars, long bushing, need special care an attention during transport.

→ The transport of these equipment should be planned before starting the detail design of such equipment.

→ The arrangement of road traitors, Cranes, special wagon should be made in advance. The necessary permit from railway authorities & road authorities should be obtained for transport.

(iii) Insulation resistance checking of winding :-

→ The insulation resistance is measured by a megger. A megger consist of a D.C generator and mega Ω metre.

→ The standard megger are of 1000V D.C, 2.5KV D.C and 5KV D.C

→ The insulation resistance is the ratio of $\frac{V_{dc}}{I_{dc}}$

V_{dc} - It is the applied voltage across two conductors separated by insulation under test.

I_{dc} - It is the current flowing through the insulation.

→ Megger test gives clear indication about health cleanliness and dryness.

→ In power transformer the insulation resistance is measured between each winding and earth tank.

→ Between H.V winding and L.V winding.

In case of other equipment the insulation resistance are measured between the terminal and earth frame.

(iv) Testing of transformer oil :-

→ (1) BDV test

(2) Crackle test

(3) Sight test

(4) Acidity test

→ An 11KV gang operated switch is installed for tapping 11KV supply to the transformer.
→ 11KV transformer fuse are provided between the G.O switch and 11KV bushing terminal.
→ Isolation of the supply can be done by operating the handle located on one of the pole of the structure at distance 1.25m from the ground.
→ The transformer steps down the voltage to 400V 3-φ, 4 wire. The 1-φ residential lighting load is connected between any one phase and neutral where as 3-φ supply is given to 3-φ load.
→ Where substation are the cheapest and smallest substation so majority of distribution substation are pole mounted type.
→ Foundation mounted substation:—
→ This substation are built in the open & all the equipment is assembled into one unit generally enclosed by a fence for a safety purpose.
→ Substation for primary and secondary transmission and secondary distribution [above 300KVA] are foundation mounted outdoor substation.
→ Site selected for setting these substation must have a good access for heavy transport.
→ Due to exposed busbar & other equipment, the clearance and spacing should be made keeping in mind.

→ A H.T. fuse is used for protection of H.T. side and an iron clad L.T. switch is used for protection of LT side.

→ Lightning arresters are installed over H.T. line to protect from surges.

→ Single pole or H-pole and four pole structures with suitable platform are used for placing transformers of capacity upto 15KVA, 100KVA and above 100KVA respectively.

Fig:

2. Fire protection :-

→ CCl_4 (Carbon tetra chloride) and foam type fire extinguishers and buckets filled with sand should be located in easily accessible position in substation.

3. precaution against dust and insects :-

→ Indoor substations should be made inaccessible to birds, reptiles, rats, insect and dust. All cable ducts and openings should be sealed as far as possible.

4. Effect of Atmospheric Condition :-

→ All steel and iron parts should be given anticorrosive coating for installation near chemical fumes or gases. epoxy or rubber chlorinated paint should be caused.

5. Earthing :-

→ Non-current carrying parts with conducting surface should be effectively earthed. The earth connection of all equipments should be made in duplicate

Pole mounted substation :-

→ Such sub-station are constructed for mounting distribution transformer capacity upto 300 KVA

→ The equipment is of outdoor type and is mounted on the supporting structure of H.T distribution line.

→ Triple pole mechanically operated switch is used for switching ON and OFF the H.T transmission line.

General requirement of layout of indoor :-

1. Building Construction :-

→ Adequate space should be provided for placing transformer H.T and L.T switchgear and cable trench for incoming and outgoing cables.

→ The building room should be spacious and have necessary clearance. Sufficient passage and doorways should be provided so that equipments can be moved in or out of repairs.

2. Ventilation :-

→ There must be free circulation of air on all sides of transformer. entry of water and birds through the inlet and outlet for ventilation should be prevented by appropriate protection.

3. Earthing :-

→ The equipment installed in the substation should be solidly earthed. Transformer neutral should be earthed.

4. Cable Trench :-

→ Cable Trench are provided for laying of cables. There should be protected against entry of water by blocking the openings and filled with gravells or sand and covered with slap.

Considerations for safe operation of substation

1. Fencing and gate for transformer enclosen :-

Metal fencing with channel iron support is provided to enclose the transformer. A small gate is provided with locking arrangement for safety. The fencing should be earthed to different point.

Design and planning of Indoor substation:-

→ The following points should be considered for planning and design:-

(a) The type of supply required [3-φ, 3 wire on 3φ, 4 wire]

(b) Atmosphere condition such as air temperature and moisture

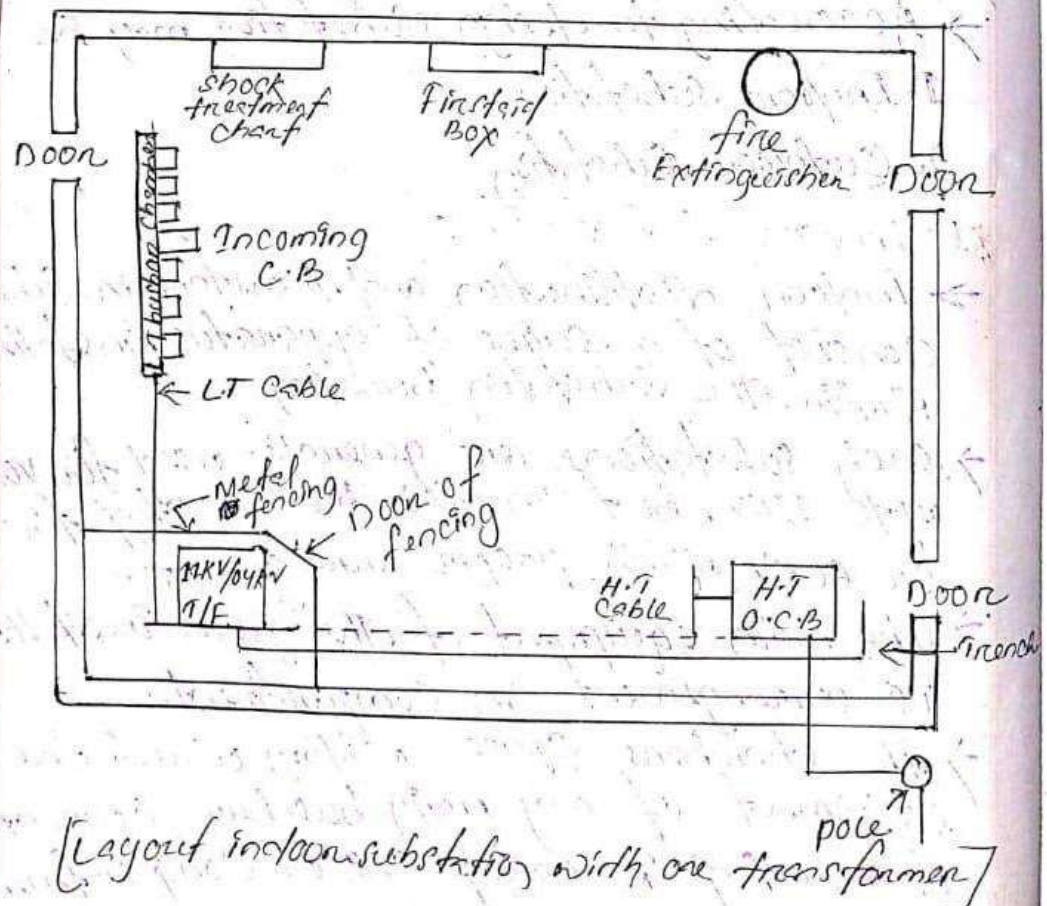
(c) Atomspheric pollution.

(d) Relibility of substation equipment so that there is minimum power interruption.

(e) possibility for modification or feature extension.

(f) Noise and vibration reduction

(g) Radio and telecommunication interference



[Layout indoor substation with one transformer]

(iii) Earth terminal of three pin lighting and power plug socket.
(iv) Steel tower, tubular poles, rail poles used on over head transmission line.
(v) metal casing of apparatus.

→ Earthing connections.
(i) Rod earthing
(ii) Strip earthing
(iii) pipe earthing
(iv) plate earthing

- Types of ckt breaker, starter, A.C motor, D.C motor, Relay.

CHAPTER 4

MAINTENANCE

Introduction:-

Maintenance is the process for maintaining any equipment or machinery in a proper and efficient condition.

→ It involves:-

(i) The fault diagnosis

(ii) Routine servicing

(iii) Repaire of electrical components of a machine log sheets on which the frequency of fault, type of repair are retain and maintainance schedule [daily, weekly, monthly or yearly] are tobeketed.

→ Each equipment in the plat or in big factory is provided with a history card.

→ The details about inspection, operation and remark are retained in there cards.

OBJECTIVE OR FUNDAMENTAL OF MAINTAINANCE:-

→ To maximize functional reliability of production facilities.

→ To maximize the useful life of equipment.

→ To minimize total production cost.

→ To keep the equipments in operating condition so that it continues to meet the rated specification.

→ To improve operational safety.

Classification of maintainence:-

① Corrective or breakdown maintenance

② preventive maintenance

③ contracted maintenance

4. CONDUCTOR & EARTH WIRE:-

→ Clearance of phase wire and earth wire to ground should be checked in according to IER (Indian Electricity Rule)

→ In case of slag it should be connected properly after disconnecting the line from the supply.

5. CONDUCTOR FITTINGS & JOINTS:

→ To check:-

(a) Closeness of binding on insulator and at joints.

(b) Slip of conductor from the insulator sheet.

(c) Burnt jumper and loose fittings

6. GANG OPERATED SWITCH OR FUSE:-

(a) To check defective switch

(b) Burning or overheating of contacts.

(c) Damaged arcing contact.

(d) Missing or broken earth wire.

7. BIRD NEST:-

→ Bird nest coming on the overhead line should be removed. Also remove the bird nest from cross arms.

(8) Earth electrodes should be watered from time to time

(9) Earth resistance should be check from time to time.

Under ground Cable :—

→ Terminals boxes should be carefully inspected if there is any damage or leakage of insulating oil.

→ Of all types of cable inspection & insulation resistance test should be made frequently.

→ check of excessive cable temperature.

→ check if any accumulation of water in cable ducts.

→ check any dripping of water, oil, other liquid on cables.

→ A check should be made for any excessive mechanical stress which may be caused during laying of cable.

→ Check any indication of insulation swelling corrosion of lead sheath.

SF_6 Circuit breaker :-

Serial No.	Activity	Periodicity	Activity
1.	checking of SF_6 pressure from densimonitor	Weekly	Remote monitoring system available for 4 bays.
2.	checking of grading capacitor PIR & Cft. supply	Yearly/during shut down period	Applicable to the EHV breakers above 220KV systems.
3.	SF_6 gas leakage test with leak detector	Yearly	
4.	SF_6 gas pressure checking with respect to diffrn temperature and climatic condition	Seasonal checking like winter check & summer check	Comparision of the semi with other breaker systems brings idea regarding gas.
5.	Dew point measurement of SF_6 gas.	2/3 yearly	Diffrnt guide lines are to be followed depending upon the manufacture

Over head transmission line :-

→ All overhead lines should be inspected regularly each month inspector at ground level, when the line is live.

→ SUPPORTS (TOWER)

(a) Metal Supports :-
The condition of the concrete foundation should be examined for possible damage.

(b) Wooden poles :-
The poles should be checked for correct alignment and also the underground person of the pole should be checked to verify there is any damage.

(c) PCC :-

→ Plane cement Concrete if should be checked for cracks.

2. CROSS ARMS :-

→ It should be checked whether the metallic cross arms are fitted on and wooden cross arms may be decaying owing to rot.

3. INSULATORS & FITTINGS :-

→ To check
(a) Broken & chip porcelain
(b) Tilted insulators
(c) Accumulation of dust, coal on insulation
(d) Resting of fittings
(e) Burnt and fumed spots on the glaze of insulator
(f) damaged insulation should be replaced.
(g) Dirty insulator should be clean after disconnecting the line from the supply.

Battery maintainance schedule:-

Serial No	Periodicity	Maintainance activity
1.	Daily	(a) Inspect the battery and room for general cleaning. (b) check the height of electrolyte. (c) keep the record of the topping done. (d) check the voltage of the pilot cell. (e) Record & check the specific gravity & temperature of the electrolyte of the pilot cells. (f) Record & check the temperature.
2.	Weekly	(a) Inspect the battery very carefully. (b) (i) Remove dust on dirt if accumulated (ii) keep the battery clean & dry. (b) check the cells for crack and electrolyte leakage if so take remedial measures. (c) Record and check the specific gravity voltage and temperature of the pilot cells. (d) check for the plate buckling collection of sediments at the bottom of the cells etc. (e) Give quick freshing charge after every heavy discharge.
3.	Fortnightly	(a) Carry out inspection schedule as laid down above. (b) Topping of all the cells be done with distilled water.

4.	Quarterly	(a) Check the specific gravity and temperature of each cell. (b) Check the voltage of the battery and each cell. (c) Check the level of electrolyte of each cell. (d) All the bolts and nuts should be checked for tightness petrolleum jelly or vaseline should be applied. (e) Check float and trickle charges. (f) Test the battery load & small continuous load.
5.	Yearly	(a) In addition to the inspection schedule given above check for the following condition :- (i) Condition of individual cell. (ii) Resistance that is terminal as well as cell to cell (iii) Inspection of battery rack. (iv) Level of the sediments if collected at the bottom of the cell. (v) point of each the racks, walls. the room with rust resistance paint if needed.

3.	Monthly/ Quaterly	(a) Winding :- Check the winding for proper insulation moisture content should also be checked. (b) Brushes :- Check the brushes for their proper fittings and free play in brushholder. Worn out brushes should be replaced. (c) Commutator :- The commutator surface should be checked for scratches and roughness. - It should be smoothned with the help of sandpaper, Emery paper (d) Ball or roller bearings :- The leakage of grease or oil from the bearing should be observed. If leakage is noticed, clean it. (e) Gear Box :- Oil in the gear box should be checked. If the oil is not found in good condition drain it
4.	Half yearly/ yearly	(a) Winding :- Check the winding for insulation resistance, cracks of insulation if needed dryout winding, clean it, varnish it and bake it (b) Airgap :- Uniformity of air gap should be observed. (c) Mechanical parts :- The inside & outside of frames and belts should be checked. The motor should be observed for missalignment.

Maintenance schedule of electric motors :-

Sr.No	Periodicity	Maintenance activity
1.	Daily	(a) Inspect and tighten earthing of power connection (b) check bearing (look out for over heating (c) check lubrication system (d) check for excessive vibration (e) Inspect fuses and relay setting.
2.	Weekly	(a) Care should be taken that cowdung water, acid, fumes may not enter the motor. (b) Check the bearing housing. If dry, then oil them, Creeping of oil along the shaft towards winding should be avoided. (c) check the ~~spacing~~ spanking & condition of commutator & process. The surface of the commutator should be smoothned with the help of sand paper. (d) check loose connection of brushes (e) check uniformity of air gap in the motor. (f) clean the dust in the winding with dry clean blow it with blower. (g) check any concived noise heard from motor due to metal contact or defect in varnish insulation. (h) check the belt for suitable slackness and good surface condition. The gears should be checked for worn & tear.

→ clean multi range ammeter, a double range AC voltmeter, D.C voltmeter and multirange DC ammeter are also used for maintenance work.
→ Other essential items that is required, stopwatch tachometer, small magnifying glass blower, electrical soldering iron, right measuring meter may be used for maintenance work.

Preventive maintenance schedule for power transformer

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Serial No	periodicity	maintenance activity
1.	Hourly	(a) ambient temperature (b) Winding temperature (c) oil temperature (d) Load pattern study (reading of voltage, current, power
2.	Daily	(a) oil level in transformer conservator (b) Oil level in bushing (c) cooling system (fan control & pump control system) (d) Silica gel breather (e) Relief diaphragm.
3.	monthly	(a) operation/checking of cooling system (auto start/stop of fans & equipment) (b) Details checking of oil leakage. (c) Oil in breather
4.	Quarterly (3 months)	(a) examine cracks and direct deposits on bushing (b) checking of OTI (oil temperature indicator) WTI setting (c) Electrical protection checking [Differential, REF (Restricted earth fault) Overload relay

		ⓓ check dielectric strength and water content of oil in transformer ⓔ mechanical protection checking (Buccholz relay, pressure release valve (PRV))
5.	Half Yearly	ⓐ preventive maintenance of fan motors, pump motors, OLTC drive motors (OLTC - on load tap changer) ⓑ checking of earthing (main tank earthing, neutral earthing) ⓒ checking of marshal box (cable box) ⓓ control wire checking ⓔ Auxiliary electrical item like - switches, contactor, relays etc.
6.	Yearly	ⓐ Testing of oil of main tank (top & bottom) sample BDV (Break down voltage), water content, tan delta, DGA (Dissolve gas analysis) ⓑ conditioning monitoring of insulators ⓒ Testing of all protective device [electrical relay & mechanical relay] ⓓ Cleaning of transformer, reactors, conservator tank, transformer body. ⓔ Tightness checking (conductor clamps, equipment nut bolts) ⓕ Routine test (Ratio test, magnetic balance test, vector group test, winding resistance, impedance test etc.) ⓖ Interlock trip & alarm checking ⓗ Testing of associated equipments (line lightning arrestors, line (CT, PT)

(ii) Inspection :-

→ The maintenance work mainly depends upon the inspection.

→ The inspection must be done by senior or competent person who has got through knowledge of maintenance work.

→ The inspection can be external inspection and internal inspection.

Tools & Tackles :-

→ Proper tools and tackles are more essential to carry out maintenance work.

→ Proper tools reduce the amount of manual labour for handling heavy equipment and saves time.

Inventory :-

→ Inventory control of stores and spares.

→ It is very necessary for maintenance section to make the inventory of all the spares required and should be made readily available for use when required.

List of Instruments [commonly used] for maintenance :-

→ Voltmeter with switch

→ A small switch board fitted with various size of lampholder and socket outlet. These may be used for continuity and insulation test.

→ Infrared lamps used for heating.

→ An oven provided with a fan use for drying out machine and other apparatus.

→ Megger for measuring earth resistance.

→ Earth fault loop tester for impedance test for earthing circuit.

(4) Any well plan preventive maintance will have following aspect :-

(i) Inspection :- how to inspect & what to inspect.
(ii) frequency :- How often to inspect.
(iii) Schedules :- when to inspect.
(iv) Organization :- who to inspect
(v) Records :- what to record & / how to record

Preventive maintainance planning :-

→ It is an important feature of modern industry and it is most commonly used in the maintenance department.
→ The maintenance engineer should inspect the plant periodically under working condition & also when it is at rest with good planning & preparation.
→ The planning of maintainance should be categorized in the following way.

(a) Routine maintance
(b) periodically [weekly, fourtnightly, monthly, quarterly, or half yearly.]
(c) maintainance of fault as & when the fault occurs

Advantages of preventive maintainance :-

→ It prevents unscheduled interruption to various machines and equipment and premature failure
→ It reduces the breakdown and increses the efficiency of equipment and machinery.
→ Satisfactory maintainance of machine and other equipment and low cost.
→ It makes working condition better
→ Increse life of machine.

→ Less stand by equipment is required and better conservation of aspects.
→ provides greater safety and protection to workers.
→ It helps to play flexibility in operation due to accurate knowledge of machine condition.
→ It lowers wear and tear of machine and the equipment.

Breakdown maintainance :-
→ When industrial plant or electrical machine are running and stop incidently, it is know as Breakdown.

Cause of Breakdown :-
(1) faulty design construction
(2) Incorrect use of instruction
(3) Negligence
(4) Over load
(5) Wear & tear
(6) Accident
(7) electrical design fault

→ Breakdown maintenance is carried out as and when necessary.
→ The following points on factors are recommended incrementation to breakdown maintainance.

Engineering records :-
→ The proper entry of all defected faults into the history card of the equipment is of special importance.
→ This card will tell us the overall condition of

1) Corrective or breakdown maintenance :-

→ Corrective maintenance is done when equipment fails or doesn't work satisfactorily. In this type acting such as repair, replacement or restore will be carried out after the occurance of failure

2) Preventive maintenance :-

→ Preventive maintenance is carried to reduce the failure of equipment to minimum.

3. Contracted Maintenance :-

→ In contracted maintenance contract terms are agreed upon by the supplier of the equipment and users and may include both preventive and corrective maintence.

Preventive maintenance and planning :-

→ It is an important feature of modern industry and it is most commonly used in the maintence department

→ It is based on principle "prevention is better than cure" It is a set of activities that are perform on plant equipment, machinery & system before occurance of a failure in order to protect them and to prevent or eliminate any degrading in the following condition :-

→ Basically function of this section are :-

① periodic visual inspection of various equipment to locate condition leading to breakdown.

② Up keep of equipment and repair defects at their initial stage.

③ To attend major breakdown