SUMMER – 2022 EXAMINATION

Subject Name: Electrical Substation Practices **Model Answer :** **22633:ESP**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1.		**Attempt any FIVE of the following:**	**10 Marks**
	a)	Classify substations based on constructional features. **Ans:** **Classification of Substations Based on Constructional Features:** 1. Indoor Substation. 2. Outdoor Substation. 3. Gas insulated Substation. 4. Underground Substation. 5. Pole mounted substation. 6. Plinth mounted Substation. 7. Compact/prefabricated substation.	½ Mark for each of any four points = 2 Marks
	b)	Write any four advantages of neutral grounding. **Ans:** **Advantages of Neutral Grounding:** 1. In this system the neutral point is not shifted and thus the voltages of the healthy phases remain nearly constant. 2. The high voltages due to arcing grounds are eliminated. 3. The earth fault relays can be installed to isolate the faulty portion for earthed neutral grounding system. 4. It provides greater safety to personnel and equipment. 5. It provides improved service reliability. 6. Operation and maintenance expenditures are reduced. 7. The neutral grounding stabilizes the neutral point. 8. Neutral grounding is useful in discharging over-voltages due to lightning to the earth. 9. The neutral grounded systems require relatively lower insulation levels as compared with ungrounded systems. 10. Discriminative type protective gear can be installed in a neutral grounded system. 11. Due to elimination / reduction of the arcing grounds, unnecessary tripping of circuit	½ Mark for each of any four advantages = 2 Marks

breakers is prevented.
12. Improved life of equipment, machines and installation is achieved.
13. The induced static charges do not produce any disturbance in the circuit / system as they are conducted to earth immediately.
14. Overall economy is achieved by providing more safety, reducing faults and accurate type of protection arrangements.

OR Equivalent Answer

c) State function of CT and PT in 33/11 kV substation.

Ans:

Function of CT and PT in 33/11 kV Substation:

Function of CT:

Current transformers are used for protection, measurement and control in 33/11 kV substation. — 1 Mark

Function of PT:

Potential transformers steps down the magnitude of line volatge for measurement, protection and control in 33/11 kV substation. — 1 Mark

d) Write any four needs of 132/33 kV substation.

Ans:

Needs of 132/33 kV Substation:

1. For decreasing the voltage level from 132 kV to 33 kV for secondary transmission.
2. To receive power from primary transmission system and supply it for secondary transmission.
3. Provides facility for switching when power is required to be turned "ON" or "OFF".
4. To satisfy / supply the new load growth.
5. To accommodate new generation i.e., there is a need of collector substation to tie solar / wind generators etc. and connect them to the power grid.
6. To maintain reliability requirements in case of fault etc. on the other substations / lines.
7. To provide overall support to the power flow system i.e., for better management of overall power flow system.
8. To connect communication signals to the circuits.
9. For regulating voltage to compensate for system voltage changes.
10. To measure electric power quantities flowing in the circuits.
11. Substations provide the necessary real-estate / infrastructure to install transformers and associated substation equipment required for power transmission and distribution.

½ Mark for each of any four needs = 2 Marks

OR Equivalent Answer

e) Suggest the suitable method of neutral grounding in 132/33 kV substation with its any two specific reasons.

Ans:

Suitable Method of Neutral Grounding in 132/33 kV Substation with Specific Reasons:

1. Generally, one neutral ground is provided at each voltage level for better safety, operation, protection and proper discrimination.
2. The neutral grounding is provided at source end and not at load end for more effective protection.
3. The neutrals of auxiliary supply generators (if used) are grounded through resistance grounding to limit the stator fault current.

4. The neutrals of synchronous motors and synchronous capacitors (if used) are grounded through reactance grounding to limit the earth fault current.
5. For all circuits / equipment / machines (e.g. star point of distribution transformer, current transformer, potential transformer etc.) which has the rated voltage in the range of 3.3kV to 33 kV resistance or reactance grounding is used because by adjusting the value of resistance / reactance the arcing grounds can be minimized.
6. Each major "Bus - Section" is provided with neutral grounding for safety and stability.
7. For all circuits / equipment / machines (e.g. star point of distribution transformer, current transformer, potential transformer etc.) which has the rated voltage of below 600 Volts and above 33 kV solid or effective grounding is used because effective grounding limits the voltages of healthy phases to line-to-neutral values in the event of ground faults.

1 Mark for each of any two points = 2 Marks

OR Equivalent Answer

f) Enlist any four advantages of Gas Insulated Substation (GIS).

Ans:

Advantages of Gas Insulated Substation:

1. It occupies very less space (1/10th) compared to ordinary substations. Hence gas insulated substations are most preferred where area for substation is small. (e.g.: In crowded cities).
2. It is very safe as the earthed metal enclosure makes for a safe working environment for the attending personnel.
3. Most reliable compared to air insulated substations, because the number of outages due to the faults are very less.
4. Initial high investment is required for installation but the cost can be comparable for the less maintenance, reliable and safe operation against conventional substations hence economical.
5. An extremely careful selection of materials, an expedient design and a high standard of manufacturing quality assures long service life with practically no maintenance requirements.
6. Low weight due to aluminum enclosure, leads to low cost foundations and buildings.
7. Can be assembled at the shop and modules can be commissioned in the plant easily.
8. As gas insulated substations are enclosed type of substations very Lesly impacted by pollution, outside disturbances etc.
9. The over voltages while closing and opening line, cables motors capacitors etc. are low hence less impacted by such ON and OFF operations.
10. As in gas insulated substations, SF6 gas is used in the circuit-breaker unit for arc quenching. This type of breaker can interrupt current without over-voltages and with minimum acing time. Contacts have long life and the breaker is maintenance free.
11. As gas pressure (4 kg/cm^2) is relatively low so not poses serious leakage problems.

½ Mark for each of any four advantages = 2 Marks

OR Equivalent Answer

g) Illustrate application of high speed Earthing Switch in Gas Insulated Substation (GIS).

Ans:

Illustration of Application of High-Speed Earthing Switch in Gas Insulated Substation (GIS):

1. The high speed ground switches can be furnished for single pole or group operated

applications to provide grounding for inspection, maintenance, repair or replacement of other substation equipment such as transformers, capacitor banks, circuit breakers, circuit switchers, etc.

2. High speed earthing switch have the additional capability of closing an energized conductor, creating a short circuit without receiving significant damage to the switch or the enclosure.
3. High speed earthing switches are used to ground various active elements of the substation, such as transmission lines, transformer banks and main bus etc.
4. In GIS facilities high speed earth switches are used to initiate protective relay functions. They are typically, not used to ground circuit breakers or voltage transformers.
5. High speed earthing switches are designed & tested to interrupt electrostatically induced capacitive currents & electromagnetically induced inductive currents occurring in de-energized transmission lines in parallel / close proximity to energized transmission lines.
6. High speed earthing switches can also remove DC trapped charges on a transmission line.

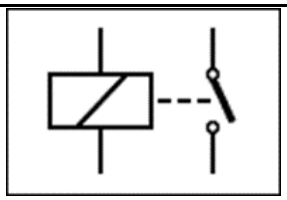
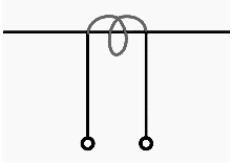
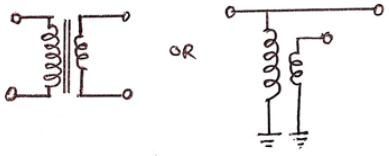
1 Mark for each of any two illustrations = 2 Marks

2. Attempt any THREE of the following: **12 Marks**

a) Draw symbols of Relay, Bus-bar, CT and PT used in single line diagram.

Ans:

Symbols of Relay, Bus-bar, CT and PT Used in Single Line Diagram:

Equipment	Symbol
Relay	
Bus-bar	
CT	
PT	

1 Mark for each = 4 Marks

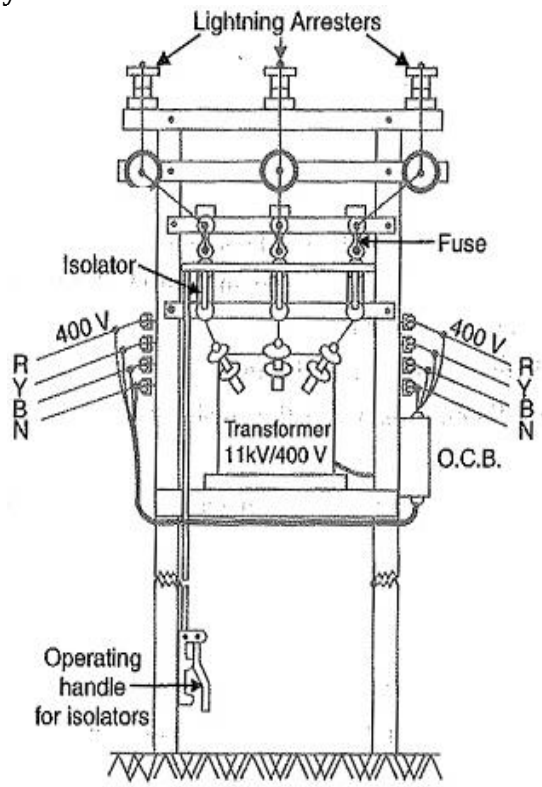
OR Equivalent Answer

b) Draw the layout of a pole mounted 11kV/400 V substation and enlist any eight equipment of it.

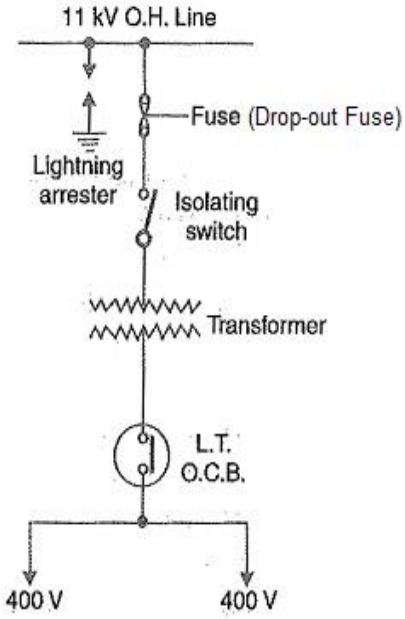
Ans:

Layout of a Pole Mounted 11kV/400 V Substation with Equipment:

Layout:



OR



2 Marks for sketch

Equipment:

1. Three phase distribution transformer.
2. DO fuses.
3. Lightning arrester.
4. Circuit breaker / Oil circuit breaker.
5. AB switch / Isolating switch.
6. Pin type insulators.
7. Current transformer.
8. Potential transformer.
9. 11kV overhead incoming conductors.
10. LV power cables.
11. Stay wire.
12. Earthing system.
13. DP structure.
14. Instrument transformers.
15. Metering and indication instruments.
16. Distribution panel board.
17. Capacitor bank.
18. Outgoing feeders (400 Volts).
19. Neutral grounding equipment.
20. Control cables / wires.

¼ Mark for each of any eight equipment = 2 Marks

c) List out any eight routine maintenance activities in 33 kV/11 kV substation.

Ans:

Routine Maintenance Activities in 33 kV/11 kV Substation:

1. The readings of the current, voltage, power, frequency, power factor, connected load, energy consumption and other related parameters through various meters etc. shall be checked and recorded in the log book / register. Necessary action is to be taken if the readings are not normal.
2. Inspection and rectification of terminations e.g. checking the lugs / terminals points of the electrical panels, switches, starters, indication lights, contactors, switchgear etc. and repair / replacement as per requirements.
3. Inspection and monitoring of the UPS, battery charger, battery bank and associated controls.
4. Cleaning of the interiors of the switchgears, panels by vacuum / air blower / wiping them to make neat and dry condition during shutdown.
5. Routine maintenance of switchyard includes cleaning of all outdoor equipment like CT, PT, isolators, post insulators etc. and checking of all conductor connections and tightening the same if required. The switchyard to be maintained clean by removing regularly the grass and other plants.
6. Monitoring and maintenance of transformers includes checking of oil level in conservator & if required top up of makeup oil, regular inspection for any leakage, checking of thermometer, recording of temperature, cleaning of breather assembly, removal of moisture by heating of silica gel if so required, inspection & checking of explosion vent etc.
7. Maintenance of lighting systems.
8. Upkeep of all the electrical equipment and keeping them in neat and clean condition.
9. Checking the inter-locking of the various equipment and trip circuits.
10. Maintenance of Earthing system as watering the earth pits for proper earth resistance, checking the joints & continuity of earth conductors visually and also measuring the earth resistance of each earth pits and to ensure that they are in the tolerance range.
11. Maintenance of switchgears, VCBs / ACBs as required. Checking of all the circuit breakers connected with the switchgear panels and their operating mechanism / contacts etc. and make them in perfect condition.
12. Maintenance of all the electrical equipment including relays, transformers, capacitor banks, motors etc. as per requirement of the OEM's manuals.
13. Inspection of cable trenches and cable ducts etc. concerned with the power, control and communication cabling of the systems.
14. Maintaining records of power failures with reasons.
15. Observing the yard and control room continuously and reporting any problem or faults to the higher authority which require major / minor improvements / repairs.
16. Maintaining system handing over and taking over charge sheets.
17. With prior intimation / permission to higher authority, changing the taps of transformers as and when required.
18. Maintain the proper co-ordination with all operators for efficient, reliable operation of 33kV / 11kV substation.
19. Follow permit system (Line Clearance) and maintain a permit book to facilitate system maintenance without accident / mishaps.
20. Routine Surveillance of 33kV / 33kV switch yard, indoor / outdoor equipment like

½ Mark for each of any eight activities = 4 Marks

control relay panels, station metering panel, switchyard control panel, AC & DC distribution boards, power transformers, SF6 / vacuum circuit breakers and their respective control panels, isolators, air compressors, CTs, PTs, LAs, distribution transformers etc.

21. Recording of all tripping of breakers and other events that occur in the order of sequence with the time of occurrence correctly and record them in Log Book.
22. Observing all safety precautions and ensure safety to men, material and the equipment during the contract period.
23. Attending to all emergencies which may arise during the contract period such as equipment failures, fire accidents, etc.
24. Attending to all telephone calls and issue receipt message promptly.
25. Preparing daily reports and periodic returns in the prescribed format in duplicate and submit to the concerned authority.
26. Routine maintenance includes all work required in cleaning all equipment from dirt, dust, cleaning the fixed and moving contacts of starters and replacement of burnt contacts.
27. Visual inspection, minor repairs, adjustments of equipment, lubrication of bearing etc. to ensure proper operation and safety.
28. Replacing small parts (replacement of carbon brushes etc.) that show deterioration.
29. Checking, testing & maintaining safety equipment, such as safety barriers, fire extinguishers & alarm systems.
30. Checking & measuring the Oil & winding temperature and ensure that temperature rise is within permissible limit.
31. Inspection and checking of main / auxiliary bus bars, overhead conductors, underground cables, cooling systems etc.

OR Equivalent Answer

d) Illustrate any eight reasons of major fire risks within 132 kV/33 kV substation.

Ans:

Reasons of Major Fire Risks within 132 kV/33 kV Substation:

1. Overloading of substation equipment e.g. transformers / cables / conductors etc. for long time, increases temperature & create the risk of fire.
2. The majority of fires are caused due to selection of incorrect rating of the switchgears or use of incorrect rating MCCB / fuses or incorrect setting of safety relays for substation equipment / system.
3. If there is damage / deterioration in insulation, in any substation equipment / system a short circuit may occur causing fire.
4. Loose connections / poor joints in cables, conductors, bus-bars etc. may cause overheating, sparking & lead to a fire risk in substation.
5. Failing to replace worn out / defective etc. equipment / cables associated with substation causes the electrical fire.
6. Storage of highly flammable liquids in the substation is the ultimate risk of fire.
7. Faulty / out dated electrical equipment, insulators, auxiliaries, supports etc. are a common cause of electric fire.
8. Fire may be caused if the substation is not maintained properly and regularly.
9. Use of poor quality of material, non ISI mark equipment, under rating equipment, under rating conductors etc. are the risk of fire.

½ Mark for each of any eight reasons = 4 Marks

10. If clearances are not maintained as per voltage level & as per IE rules then there is strong possibility of sparking, which is the risk of fire in the substation.
11. Incorrect insulation level / improper insulation of substation system / equipment is the risk of fire.
12. Use of equipment which are not as per the specifications is the risk of fire.
13. With so many people working with substation on a daily basis, human error can be a common factor in the causes of fires by using equipment / system incorrectly, not reporting faulty machinery etc.
14. Lack of basic fire safety training / unknown about the correct procedures to extinguish the electrical fire to concern staff is the risk of fire.
15. Faulty / inoperative / inaccessible / insufficient / non availability of proper fire fitting equipment in the substation is the risk of fire.
16. Fire risk is there if incompetent / unqualified / untrained / unskilled staff is working in substation, which are incapable to handle the fire risks.

OR Equivalent Answer

3 Attempt any THREE of the following: 12

3 a) State purpose of circuit breaker, isolator, and earthing switch. Explain their operational co-ordination in substation.

Ans:

i) Purpose of circuit breaker:

An electrical circuit breaker is a switching device which can be operated manually and automatically to interrupt or make the load current as well as the much larger fault current, which may occur on a circuit. 1 Mark

OR

A circuit breaker is an electrical safety device designed to protect an electrical circuit from damage caused by an over current or short circuit. Its basic function is to interrupt current flow to protect equipment and to prevent the risk of fire.

ii) Purpose of Isolator:

1 Mark

Isolators are used to disconnect the transformers, circuit breakers, and bus bars for repair and maintenance. They are operated under no current conditions (no load) only since they don't have rated making or breaking current capacity.

iii) Purpose of Earthing switch:

Main function of earth switch is to ground the isolated bus/conductor. Even after isolator operation there may be some residual charges on the bus which may harm the personnel going for maintenance. So before commencing maintenance we have to ground the isolated bus too to avoid any mishappenings. So earth switch provides extra safety to the working personnel. 1 Mark

iv) Operational coordination between circuit breaker, isolator & earthing switch:

i) During opening of circuit breaker the sequence of operation is as below-

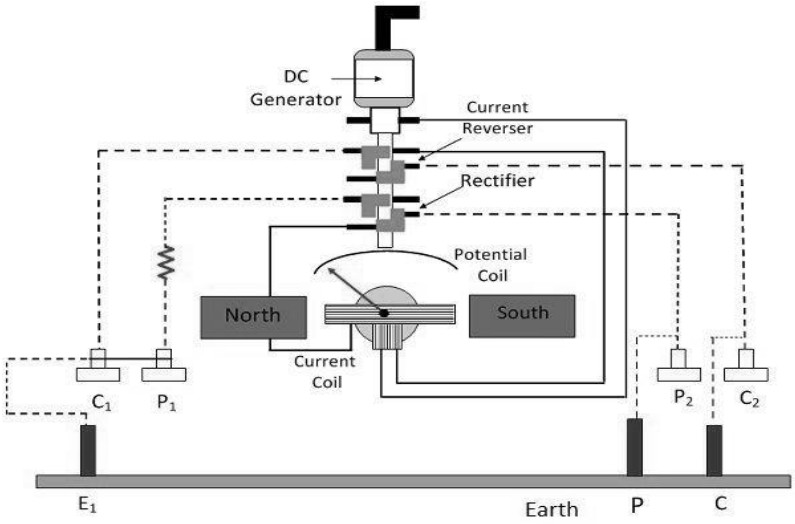
1. Open Circuit breaker

2. Open Isolator
3. Close earth switch

ii) During closing of circuit breaker the sequence of operation is as below- 1 Mark
1. Open earth switch
2. Close isolator
3. Close circuit breaker

3 b) Draw and explain working diagram of earth tester.

Ans:



2 Marks for diagram

Earth tester is an electrical measuring instrument used to measure the resistance between any two points of the earth. It is also called earth resistance tester.

Construction and Working of Earth Tester-

i) Earth Tester consists of a dc generator, a rotating current reverser, rectifier, and a PMMC instrument to measure resistance. The schematic diagram of the earth tester for measuring the resistance of earth soil is shown in above figure.

2 Marks for explanation

ii) The current reverser is used to convert dc to ac so that the earth resistance test can be done with alternating current. The ac supply from the current reverser is given to the earth electrode that is under test.

iii) The rectifier is used because the tester is equipped with a moving coil instrument to measure resistance. Thus the pressure and the current coil of the instrument need dc supply. The rectifier converts alternating current coming from the electrode to direct current and supplied to the current coil.

iv) The pressure or potential coil is connected across the generator and it measures voltage applied. The current coil is connected in series with the dc generator and it measures current through the electrode. Both current reverser and rectifier are connected with the help of two commutators mounted on the shaft of the generator. Two pairs of fixed brushes are provided with each commutator to transfer power from the rotating shaft to the stationary parts.

v) The earth tester is provided with four terminals C1, C2, P1, and P2. The terminals C1 and C2 are the current terminals while terminals P1 and P2 are known as potential terminals. The electrode under test i.e., earth electrode E is connected to the terminals C1 and P1 by shortening them. The two auxiliary electrodes P (potential electrode) and C (current electrode) are connected to the terminals P2 and C2 respectively.

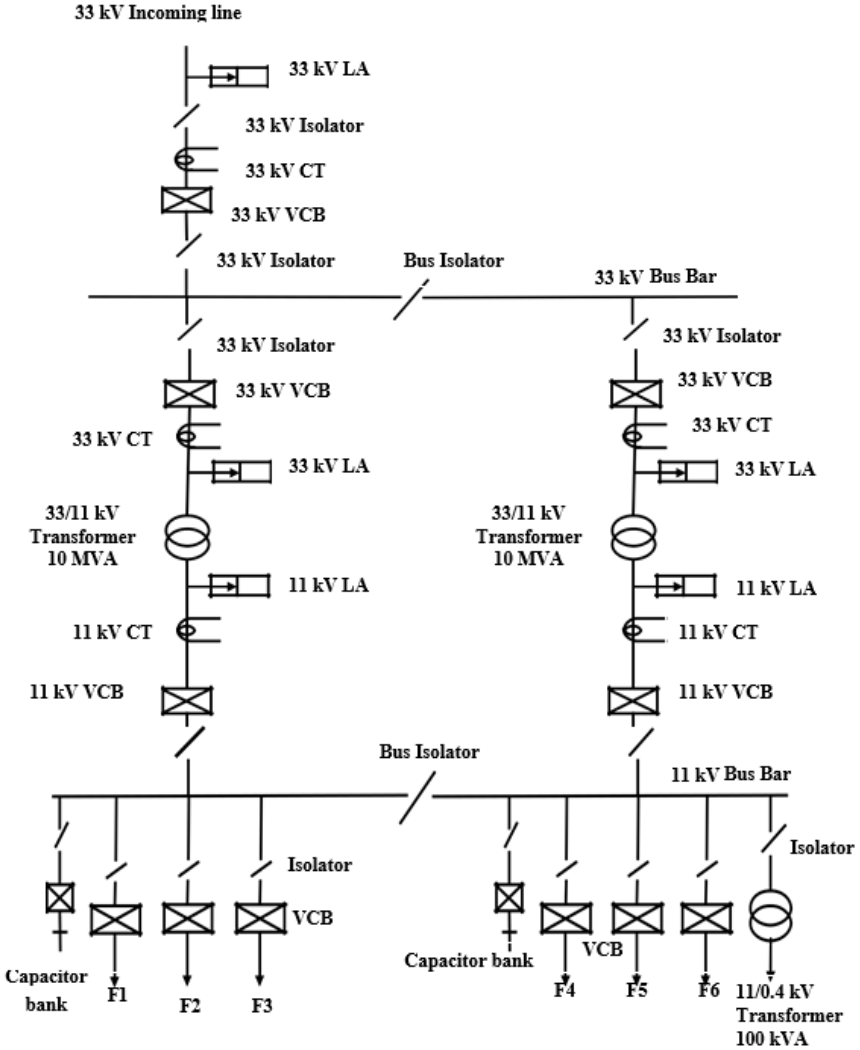
vi) The potential and current coils of the PMMC instrument are connected such that, the voltage drop between electrodes E and P is applied across the potential coil and current through the current coil depends upon the resistance of the earth.

When the generator is driven at its rated speed, the pointer of the moving coil instrument deflects and the earth tester indicates the resistance of the earth. The deflection of the pointer is given by the ratio of voltage across the potential coil and current of the current coil.

3 c) Draw schematic (single line) diagram of a 33 kV/11 kV substation and enlist any eight equipments of it.

Ans:

Single line diagram of 33 kV/11 kV substation:



2 Marks for Labeled diagram

Equipments in 33 kV/11 kV substation: (Any eight)

1. Bus-bar
2. Power transformer (33/11 kV)
3. Circuit breakers (33 kV and 11 kV)
4. Isolators(33 kV and 11 kV)
5. Earthing switches
6. Lightening Arrestors
7. Current Transformer
8. Potential Transformer
9. Capacitor bank
10. Insulators
11. Auxiliary supply transformer
12. Fire fighting system
13. Batteries for DC supply

½ Mark for each of any four equipment = 2 Marks

3 d) Define the terms Touch potential, Step potential, Mesh Potential and Transferred Potential in associated with substation.

Ans:

i) Touch Potential: The potential difference between any item of metalwork and the soil around it (creating a hand-to-feet voltage difference) during the time that fault current flows. 1 Mark

ii) Step Potential: Step potential in a particular direction is defined as the potential difference between two points a meter apart. 1 Mark

iii) Mesh Potential: The maximum touch voltage within a mesh of a ground grid is called Mesh Potential. 1 Mark

iv) Transferred Potential: The potential which is transferred into or out of the substation from or to a remote point external to the substation site is called transferred potential. 1 Mark

4 Attempt any THREE of the following: 12

4 a) State the function and rating of
i) AB switch
ii) CT
iii) PT
iv) DO for 11 kV substation.

Ans:

i) AB Switch:

1. Function of AB Switch-

The air break switches are mainly used for switching and isolation. It interrupts the small excitation current of a transmission line or the capacitive charging current. When a fault occurs or maintenance work needs to be carried out, with a systematic series of switching operations, it is used to isolate a certain section of the overhead line. ½ Mark

2. Rating of AB Switch-

System Voltage = 11 kV
Current carrying capacity = 400 A
Rated Short Time Current, for 1 sec. = 16 kA ½ Mark

ii) CT:

1. Function of CT-

Current transformers are used for metering and measurement purposes. It steps down the high line current to low value so that currents in higher voltage circuit can be measured with the help of standard low value ammeter. Also, CT output is provided to relays which continuously monitor the power lines and feeders. In case of any abnormal power flow, they send the signal to circuit breakers. ½ Mark

2. Rating of CT-

Rated system voltage kV(rms) = 11 kV
Highest System voltage kV(rms) = 12 kV ½ Mark
CT Ratio= 100/5 A or 50/5 A

iii) PT:

1. Function of PT-

Potential transformers are used for metering and measurement purposes. It steps down the high line voltage to low value so that higher voltages can be measured with the help of standard low value voltmeter. Also, PT output is provided to relays which continuously monitor the power lines and feeders. In case of any abnormal power flow, they send the signal to circuit breakers. ½ Mark

2. Rating of PT-

Rated system voltage kV(rms) = 11 kV
Highest System voltage kV(rms) = 12 kV
PT Ratio= 11 kV / 110 V ½ Mark

iv) DO Fuse(Drop out Fuse):

1. Function of DO –

Drop Out Fuses are protection devices that protect networks and equipment from current surges and overloads. An over current will melt the fuse element in the carrier disconnecting the line or equipment. They also provide network isolation points when manually operated with a hot stick. ½ Mark

2. Rating of DO-

Rated Voltage = 12 kV ½ Mark
Rated Current= 100/200 A

4 b) Enlist any eight routine tests to be carried out on 11 kV/ 400 V distribution transformers.

Ans:

Following are the routine tests that need to be carried out on 11 kV/ 400 V distribution transformers. (Any eight)

1. Winding resistance test of transformer

2. Polarity and Transformer ratio test
3. Transformer vector group test
4. Measurement of impedance voltage/short circuit impedance (principal tap) and load loss (Short circuit test)
5. Measurement of no load loss and current (Open circuit test)
6. Measurement of insulation resistance
7. Dielectric tests of transformer.
8. Tests on on-load tap-changer.
9. Oil pressure test on transformer to check against leakages past joints and gaskets
10. Impulse test
11. Temperature rise test

½ mark for each of any eight purposes = 4 Marks

4 c) Illustrate standard procedure to be carried out of Break Down Voltage (BDV) test on power transformer oil.

Answer:

Standard procedure to be carried out of Break Down Voltage (BDV) test on power transformer oil is as given below-

1. Collect the 300-400 ml oil sample of transformer oil from the bottom valve of the transformer in a glass or plastic vessel of the BDV testing kit.
2. Pour the oil sample in oil pot of the machine.
3. Keep the oil pot in open air for 5 Minutes so that air bubble if any gets out. Further, the vessel should be disturbed to get out of the air bubbles and for homogeneous distribution of impurities.
4. Now put the oil sample in the machine.
5. Increase the KV at the rate of 2 KV/Sec and observe the oil sample through a glass window.
6. Continuously observe the oil sample through an inspection window while increasing the voltage.
7. Note down the KV at which sparking is observed in the oil. The voltage at which sparking observed is the breakdown voltage of oil.
8. Repeat the step No. 4, 5, 6 and 7 for the same sample for six times and note down the breakdown KV in each case.
9. Take the average of BDV values observed in step 7 and 8.
10. If Breakdown value of oil is above 30 KV, transformer oil is good.

4 Marks for correct procedure

4 d) Explain operation of circuit breaker and disconnecting switch in Gas Insulated Substation (GIS).

Ans:

Operation of circuit breaker in GIS:

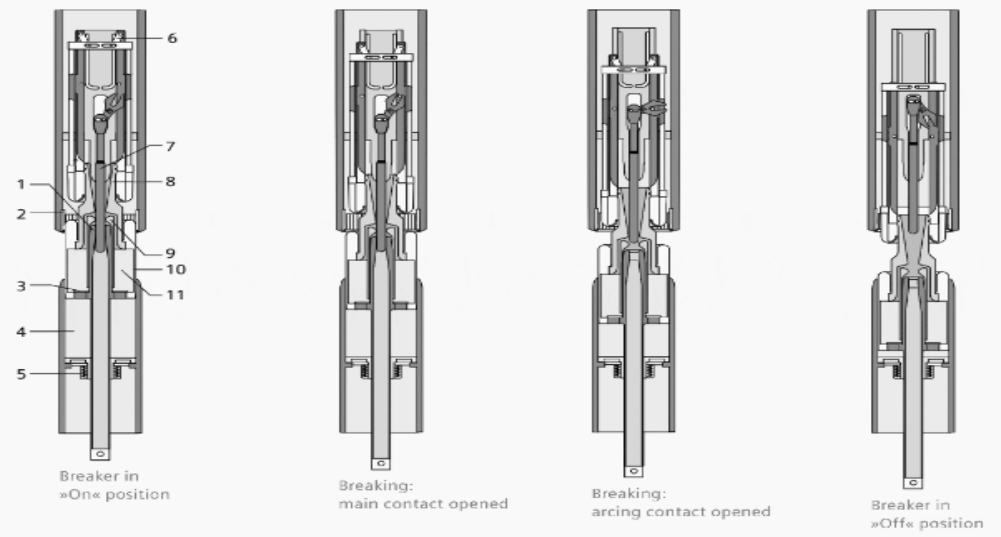
The circuit breaker is the most critical part of a gas insulated substation system. The circuit breaker in a gas insulated system is metal-clad and utilises SF6 gas, both for insulation and fault interruption.

The SF6 gas pressure in a circuit breaker is around 0.65 MPa.

At the core of the gas insulated switchgear is the interrupter unit which is housed in the circuit breaker module. It operates on a modern self compression principle. The current path consists of a base, a movable contact cylinder and a contact carrier in closed position.

2 Marks

The operating current flows through the main contact and through the contact cylinder. During the breaking of operating currents the main contacts opens first but the current still commutes through the arcing contact which remains closed at this stage of the switching process, this avoids erosion of the main contact. During the further course of opening the arcing contacts open and an electric arc is drawn between the arcing contacts at the same time the contact cylinder moves into the base and compresses the arc quenching SF6. This gas compression generates a gas flow through the contact cylinder and the nozzle to the arcing contact. This way the arc is extinguished.



Diagrams are optional (No marks)

Operation of disconnecting switch in GIS:

Disconnectors (or disconnect switches) are placed in series with the circuit breaker to provide additional protection and physical isolation. In a circuit, two disconnectors are generally used, one on the line side and the other on the feeder side. Disconnect switches are designed for the interruption of small currents, induced or capacitively coupled. Disconnecting switches can be motorized or driven manually. In GIS system, motorized isolators are preferred. A pair of fixed contacts and a moving contact form the active parts of disconnect switch. The fixed contacts are separated by an isolating gas gap. During the closing operation, this gap is bridged by the moving contact. The moving contact is attached to a suitable drive, which imparts the desired linear displacement to the moving contact at a pre-determined design speed. A firm contact is established between the two contacts with the help of spring-loaded fingers or the multi-lam contacts. The isolation gap is designed for the voltage class of the isolator and the safe dielectric strength of the gas.

2 Marks

An insulator is used to drive the moving contact and to isolate the drive from the high voltage components of the disconnector. The shape and size of the insulator are controlled by the electrical and mechanical requirements of the isolator. In three-phase ac systems, the individual phase isolators are ganged together to operate simultaneously. Leak-tight rotary seals are used in gas insulated isolators for transferring motion from external drive to the gas. Disconnectors in high voltage GIS operate at SF6 pressures of 0.38 MPa to 0.45 MPa. The operating speed of the disconnector moving contact ranges from 0.1 to 0.3 m/sec.

This is how disconnectors are operated inside SF6 filled switchgears (GIS).

4 e) Distinguish between Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).

Ans:

Sr. No.	Air Insulated Substation	Gas Insulated Substation
1.	Equipment deteriorates when exposed to ambient atmospheric conditions.	Equipment are housed in metal enclosed modules, hence there is no problem of deterioration.
2.	Requires a lot of real estate, which can be expensive to acquire in dense urban areas	The space occupied by SF6 installation is only about 10% of that of a conventional outdoor substation.
3.	Requires regular maintenance.	GIS requires less maintenance as compared to AIS as moisture, pollution, dust etc., have little influence on SF6 insulated sub-stations.
4.	Conventional Air insulated sub-stations require a few months for installation.	The principle of building-block construction (modular construction) reduces the installation time to a few weeks.
5.	System at high voltage and is open in the air, hence minimum standard clearance between the equipment as well as working personnel has to be maintained.	As the enclosures are at earth potential, there is no possibility of accidental contact by service personnel to live parts.
6.	i) Site development cost will be higher than GIS as AIS needs a lot of room for the long distances of atmospheric air. ii) Equipment cost is less as compared to GIS. iii) Installation cost is more than GIS.	i) Site development cost will be lesser because smaller space is required for installation of GIS . ii) Equipment cost is more due to grounded metal enclosure & high degree of factory assembly. iii) Installation cost is less than as compared to AIS as it is mostly assembled at the factory.
7.	Vacuum, air or oil is more generally used as arc quenching medium in circuit breakers. And it requires regular maintenance.	SF6 gas is used in the circuit-breaker unit for arc quenching. This type of breaker can interrupt current without over voltages and with minimum acing time. Contacts have long life and the breaker is maintenance free.
8.	Requirements of cleanliness are not so stringent.	Requirements of cleanliness are very stringent. Dust or moisture can

½ Mark for each of any eight points = 4 Marks

		cause internal flashovers.
9.	AIS can be installed indoor or outdoor.	Such sub-stations generally indoor. They need a separate building.
10.	AIS system will have shorter lifespan as compared to GIS.	GIS system will have longer life than its AIS counterpart.
11.	Difficult to install at high altitude and in seismic conditions.	Suitable for installation at high altitude and in seismic conditions.

5 Attempt any TWO of the following: 12

a) Write any six precautions to be taken while maintaining 11kV/400V distribution transformer.

Ans:

i. Ensure all safety arrangement while working on electrical installation.
ii. Ensure that all tools & tackles are in good & working condition.
iii. Check and thoroughly investigate the transformer whenever any alarm or protection is operated.
iv. Check the protection system periodically.
v. Ensure every employee is familiar with the instructions for restoration of persons suffering from electric shock.
vi. Trained the staff in operating the fire-fighting equipment.
vii. Always avoid un-balance loading on phase.
viii. Do earthing of all points before starting maintenance.
ix. Keep all spares away from dirt.
x. Work with full confidence.
xi. Ensure thorough and full cleaning of insulators, since partial cleaning is worse than no cleaning.
xii. Ensure perfect isolation of supply before commencement of maintenance work.
xiii. Put a caution board when on work.

1 Mark for any 6 precautions = 6 Marks

b) Suggest any six preventive maintenance activities for
i) Circuit Breaker
ii) Isolator in 33kV substation

Ans:

i) Preventive maintenance activities for Circuit Breaker:

Hourly:

1. Check Air and Gas pressure.

Daily:

1. Check Air and Gas pressure.
2. Check the operation of compressors /motors.
3. Check timing and sound.
4. Check gas density in each shift.

Monthly:

1. Air cleaning with blower.

½ Mark for any 6 activities = 3 Marks

2. Cleaning of circuit breaker body and bushings.
3. Auxiliary contacts cleaning.
4. Tightening of nuts and bolts.
5. Checking breaker Operation (Local/Remote operation).
6. Check anti-condensation protection.
7. Check of motor control
8. Checking and sealing of cable entry holes.
9. Use of anti-corrosion spray where required.

Quarterly:

1. Check for SF6 leaks.(Gas leakage test)
2. Oiling and greasing of all moving parts.
3. Functional check of trip circuit.
4. Checking the settings of air and gas pressure switches.

Half-yearly:

1. Checking ON/OFF Timings of Circuit breaker poles.
2. Complete servicing, lubricating and greasing of all moving parts.
3. Replacement of any defective part.
4. Recharge time of operating mechanism after specified sequence.
5. Checks on specific operations.
6. Inspection and operation of control circuit.
7. Measurement of Humidity if necessary.

Yearly:

1. Touch up painting wherever required.
2. Checking contact resistance of Breaker main contacts.
3. Checking of circuit breaker position level by using sprit level indicator.
4. Mechanism checking and lubrication to all moving parts.
5. IR values of Power and Control Circuits.
6. Operating circuits power consumption during operations.
7. Verification of correct rated operating sequence.
8. Checking and adjustment of Track alignment and Interlocking mechanism.

ii) Preventive maintenance activities for Isolator in 33kV Substation:

Daily:

Visual Inspection

Monthly:

1. Clean the porcelain insulators and inspection for cracks and chip off.
2. Check for tightness of nuts and bolts, drive tube locknuts, drive lever and phase coupling plan bolts etc.

½ Mark for any 6 activities = 3 Marks

Quarterly:

3. Open the dis-connector and earthling switch and inspect the contacts. (Wipe the contact surface with solvent).
4. Check for contact surface coating/wearing.
5. After maintenance and inspection, smear the contact surface lightly coated with contact lubricant (petroleum jelly).
6. Check for split pins in clevis replace the same if damaged.

7. Lubricate all clevis pins.
8. Check contact gap, if found inadequate replace contact spring.

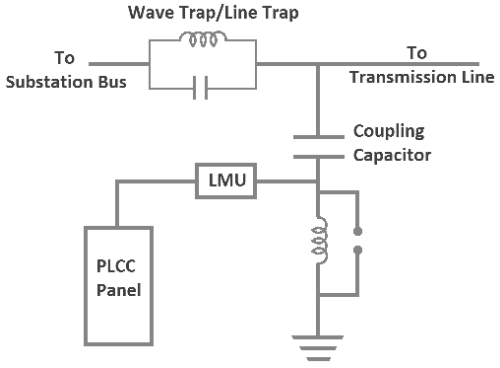
Half Yearly:

1. Maintenance of Drive Mechanism:
   i. Apply grease on the teeth of the spur gear and GEAR box / Lead screw and guide nut in case of lead screw type.
   ii. Oil auxiliary switch linkage and pivot on the guard aperture for manual operation.
   iii. Cleaning of auxiliary switch contact & greasing with silicon grease
   iv. Check that all the electrical components are firmly fixed and let the contactors operate freely.
   v. Check all electrical connections for tightness.
   vi. Check all mounting bolts for tightness.
   vii. Apply grease to mechanical interlock-cam groove, if the dis-connector is with earth switch.
2. Check interlocks.
3. Adjustment of limit switch if it is required.
4. Cleaning and lubrication of main contacts.
5. Check Alignment.
6. Main contact resistance measurement.
7. Tightness of nuts, bolts and pins etc.
8. Cleaning of support insulators and checking of insulator cracks, if any.
9. Checking and Alignment of earthing blades
10. Cleaning of contacts.
11. Checking of Contact resistance.
12. Operation of earthing switch.
13. Checking of aluminum/Copper flexible conductor.
14. Checking of earth connections of structures and marshaling box.
15. Visual check of auxiliary contacts.
16. Checking of healthiness of gaskets, else replace the gaskets.

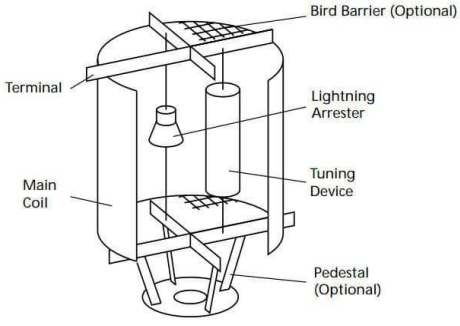
c) Explain with neat sketch functioning of
   i) Wave trap
   ii) PLCC

Ans:

i) Function of Wave trap:



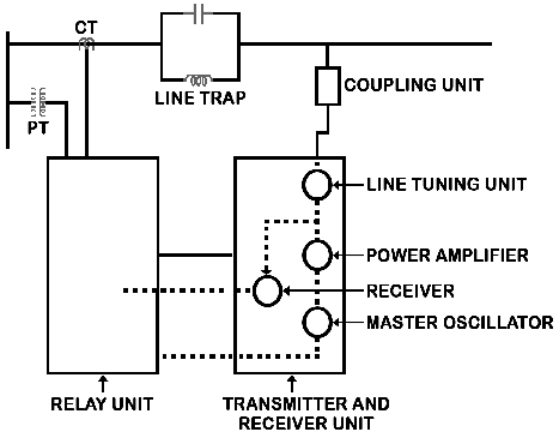
OR



1 Mark for sketch, 2 Marks for any 2 functions = 3 Marks

1. A wave trap is a Prevention device that is mounted on the transmission line to trap the high frequency communication signals sent on the line between two substations and prevented from entering the power system components in the substation.
2. These high frequency communication signals are diverted to the telecom/tele protection panel in the substation control room (through coupling capacitor and LMU).
3. This is relevant in Power Line Carrier Communication (PLCC) systems for communication among various substations without dependence on the telecom company network.

ii) Function of PLCC



1 Mark for sketch, 2 Marks for any 2 functions = 3 Marks

1. Power-line carrier communication (PLCC) is mainly used for telecommunication, and tele-monitoring between electrical substations through power lines at high voltages, such as 110 kV, 220 kV, 400 kV.
2. PLCC can be used for interconnecting private branch exchanges (PBXs).
3. Carrier protection scheme for transmission line.
4. Telemetering of electrical quantities such as kW, kVA, kVAR.

6 Attempt any TWO of the following: 12

a) Illustrate need of (i) Station Transformer (ii) Battery charging unit and (iii) Capacitor bank in a 33kV/11kV substation.

Ans:

(i) Need of Station Transformer:

1. Provide low voltage for AC power system inside substation such as lighting, air conditioners etc.
2. Provide power to DC power system such as protection relays, batteries, SCADA & telecom system.
3. Provide power for switchyard lighting in substation.
4. Provide auxiliary supply to motors in substation.

Two needs of equipment 1 Mark for each = 6 Marks

(ii) Need of Battery charging unit:

1. Provide DC auxillary supply to protection system in substation.
2. It ensures all the essential electrical systems in a substation continue to operate in the event of a power outage.

3. To supply power for control room lighting.
4. To provide supply to PLCC.

(iii) Need of Capacitor Bank:

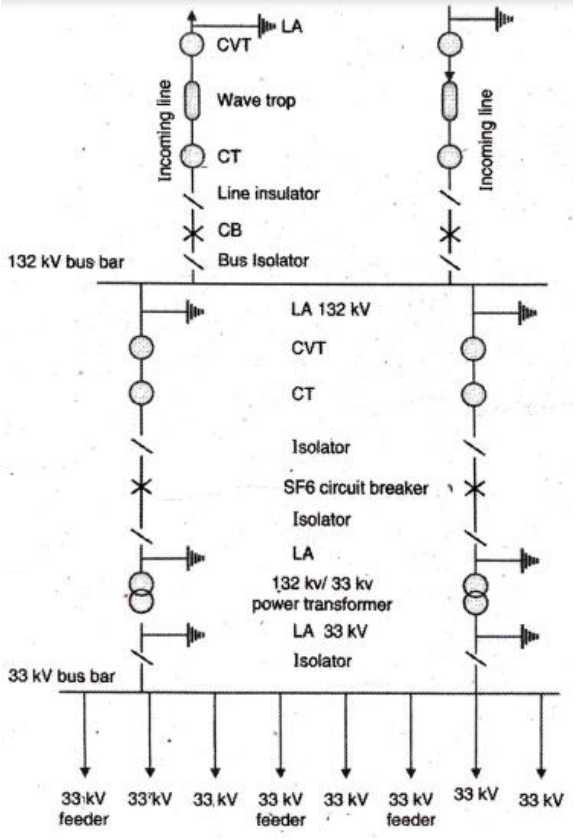
1. **For power factor correction** : Capacitors are source of reactive power . When connected in shunt they reduce the effect of high inductive loads in the system and improves the power factor. Low power factor may lead to higher losses.
2. **For Improved power transfer capability**: When connected in series they reduce the overall line reactance and thus improving the power transfer capability.
3. **For increasing voltage levels**: During high loading conditions they receiving end voltage may dip significantly. So shunt capacitor banks are used to increase the voltage levels.

b) Draw and explain single line diagram of 132kV/33kV substation indicating major equipment.

Ans:

Single line diagram of 132kV/33kV substation:

(Sample diagram is shown, any equivalent diagram is acceptable)



3 Marks for diagram

1. **132kV Incoming lines**:
   i) Two Incoming lines of 132kV voltage level.
   ii) Capacitive Voltage Transformer is connected to both the lines.
   iii) Major equipment like Lightning arrestor, Wave trap, Current Transformer, Circuit Breaker, Isolator on both side of breaker are connected in each bay.

3 Marks for explanation

2. **132kV Busbar**:

i) Two bus system is present.
ii) Major equipment like, Power Transformer, Current Transformer, Circuit Breaker, Isolator on both side of breaker are connected in each bay

3. 132/33kV Transformer:
i) 132/33kV Transformer is used to step down the voltage level.
ii) Isolators with Earthing are provided on both side of transformer.

4. 33kV Outgoing lines (Feeders):
i) Eight outgoing 33kV feeders are connected to 33kV Busbar which is common to all feeders.
ii) Supply will provide to all types of consumers through these feeders.

c) Illustrate visual, minor and major maintenance plan of Gas Insulated Substation (GIS).

Ans:

Visual, Minor and Major maintenance plan of Gas Insulated Substation (GIS):

Visual Inspection Plan:

On a frequent basis (few times a year), it is suggested to complete a visual inspection of all GIS devices. The equipment does not require de-energization. The objective of this inspection is to verify that there is no sign of unexpected wear or equipment disoperation. 2 Marks
Common operations completed during this inspection are:
- Examine compressor run times and adequate operation for pneumatic systems. In the case of spring operators conduct a visual inspection for any defects.
- Verify oil pressure and tightness.
- Note down switching equipment operations using the operation counters.
- Record and verify SF6 density using meters or installed probes.
- Verify adequate functioning of low voltages devices.

Minor maintenance Plan:

Minor verification can be completed every 5–10 years on GIS devices but the verification can also depend on a number of operations of switching elements. The objective is to verify the adequate operation of all switching elements. For this, the corresponding equipment has to be de-energized. Laboratory assessment of the gas may assist in identifying unusual 2 Marks
wear, insulator defects or other problems due to arcing or partial discharge and can be repaired before it degenerates to an unexpected major fault. This maintenance procedure does not demand opening gas chambers. Common operations completed during this inspection are:
- Verification of SF6 by-product and impurity content (SO2 and moisture, in situations when chambers are not equipped with absorbers)
- Verification of SF6 pressures (density)
- Find any SF6 leakages (in case of alarms since the last verification)
- Verification of SF6 gas purity
- Verify proper operation of pressure switches, in the case of hydraulic mechanism use
- Verification of SF6 density relay operations
- Verification of control and alarm functions

- Verify the correct alignment and operation of position indicators
- Note down and verify circuit breakers operating times (from auxiliary switches) Exercise the circuit breakers and switching elements.

Major maintenance Plan:

This verification can be completed every 15–20 years but it strongly depends on the number of operations of switching equipment. Typically, major verifications are more condition-based than time-based maintenance. Opening of some chambers may be needed during such verifications. In addition to the tasks completed during minor verifications, the common operations completed during major inspections are: 2 Marks

- Lubrication of different linkages and drives
- Replacement of gaskets and absorbers when chambers are opened
- Record and verification of travel curves for circuit breakers
- Opening and verification of the switching elements if they have reached the limits suggested by the GIS manufacturers
- Overhaul of the hydraulic mechanism with oil, filter, and switches replacement plus maintenance on the rams and drive mechanisms. Inspection of the circuit breaker interrupter mechanism including nozzles and contacts.

Overhaul of devices is required when it has reached its end-of-life. Typically, this is determined based on the suggestions and end user experience. Nevertheless, an overhaul operation asks for the expertise of the original equipment provider, while the other inspections can typically be completed by the user, provided that adequate training has been given by the GIS manufacturer. The conditions of the tools and devices used for maintenance, such as the gas-recovery cart, have also to be carefully verified.