A R E P O R T

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"S U M M M R T R A N I N G"

Undertaken at

UPPTCL 220/132 KV Transmission substation, Agra

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Contents

1. Definition of sub-station: -

"The assembly of apparatus used to change some characteristics (e. g. Voltage a. c. to d. c. freq. p. f. etc.) of electrical supply is called sub-station"

2. Introduction: -

The Present day electrical power system is a. c. i.e. Electric power is generated, transmitted and distributed in the form of Alternating current. The electric power is produce at the power station, which are located at favorable places, generally quit away from consumer. It is delivered to the consumer through a large network of transmission and distribution. At many place in the line of power system, it may desirable and necessary to change some characteristics (e. g. Voltage, ac to dc, frequency power factor etc.) of electric supply. This is accomplished by suitable apparatus called sub-station for example, generation voltage (11KV or 6.6KV) at the power is stepped up to high voltage (say 220KV to 132KV) for transmission of electric power. Similarly near the consumer's localities, the voltage may have to be stepped down to utilization level. This job is again accomplished by suitable apparatus called sub-station.

2.1 About the substation: -

Consists of 21 districts divided into 5 zones – Agra, Aligarh, Jhansi, Kanpur, Banda for better management. Total capacity was 2369 MVA in 2003-2004 which is increased to 6689 MVA in 2012-2013. In 2003-04 Input Energy was 8447 MUs which increased to 17571 MUs by 2012-13, there by increase of 108%

3.Site selection & Layout 220 KV substation: -

220KV substation forms an important link between Transmission network and Distribution network. It has a vital influence of reliability of service. Apart from ensuring efficient transmission and distribution of power, the substation configuration should be such that it enables easy maintenance of equipment and minimum interruption in power supply. Substation is constructed as near as possible to the load center. The voltage level of power transmission is decided on the quantum power to be transmitted to the load center.

Selection of site: -

Main points to be considered while selecting the site for substation are as follows:

i) The site chosen should be near to the load center as possible.
ii) It should be easily approachable by road or rail for transportation of equipment.
iii) Land should be fairly leveled to minimize development cost
iv) Source of water should be as near to the site as possible. This is because water is required for various construction activities (especially civil work), earthing and for drinking purposes etc.
v) The land should be have sufficient ground area to accommodate substation equipment, buildings, staff quarters, space for storage of material, such as store yards and store sheds etc. with roads and space for future expansion.
vi) The substation site should be as near to the town /city but should be clear of public places, aerodromes, and Military/Police installations.
vii) The land should not have water logging problem.

4.Equipment in a 220KV Sub-Station:-

The equipment required for a transformer Sub-Station depends upon the type of Sub-Station, Service requirement and the degree of protection desired. 220KV EHV Sub-Station has the following major equipment.

i) Bus-bar :- When a no. of lines operating at the same voltage have to be directly connected electrically, bus-bar are used, it is made up of copper or aluminum bars (generally of rectangular X-Section) and operate at constant voltage. The bus is a line in which the incoming feeders come into and get into the instruments for further step up or step down. The first bus is used for putting the incoming feeders in LA single line. There may be double line in the bus so that if any fault occurs in the one the other can still have the current and the supply will not stop. The two lines in the bus are separated by a little distance by a Conductor having a connector between them. This is so that one can work at a time and the other works only if the first is having any fault.

ii) Insulators :- The insulator serves two purpose. They support the conductor (or bus bar) and confine the current to the conductor. The most commonly used material for the manufactures of insulators is porcelain. There are several type of insulator (i.e. pine type, suspension type etc.) and there used in Sub-Station will depend upon the service requirement.

iii) Isolating Switches :- In Sub-Station, it is often desired to disconnect a part of the system for general maintenance and repairs. This is accomplished by an isolating switch or isolator. An isolator is essentially a knife Switch and is design to often open a circuit under no

load, in other words, isolator Switches are operate only when the line is which they are connected carry no load. For example, consider that the isolator are connected on both side of a cut breaker, if the isolators are to be opened, the C.B. must be opened first.

iv) Circuit breaker: - A circuit breaker is an equipment, which can open or close a circuit under normal as well as fault condition. These circuit breaker breaks for a fault which can damage other instrument in the station. It is so designed that it can be operated manually (or by remote control) under normal conditions and automatically under fault condition. There are mainly two types of circuit breakers used for any substations. They are (a) SF6 circuit breakers; (b) spring circuit breakers. For the latter operation a relay wt. is used with a C.B. generally bulk oil C.B. are used for voltage upto 66KV while for high voltage low oil & SF6 C.B. are used. For still higher voltage, air blast vacuum or SF6 cut breaker are used. The use of SF6 circuit breaker is mainly in the substations which are having high input KV input, say above 220kv and more. The gas is put inside the circuit breaker by force i.e. under high pressure. When if the gas gets decreases there is a motor connected to the circuit breaker. The motor starts operating if the gas went lower than 20.8 bar. There is a meter connected to the breaker so that it can be manually seen if the gas goes low. The circuit breaker uses the SF6 gas to reduce the torque produce in it due to any fault in the line. The circuit breaker has a direct link with the instruments in the station, when any fault occur alarm bell rings.

v) Protective relay: - A protective relay is a device that detects the fault and initiates the operation of the C.B. to isolate the defective element from the rest of the system". The relay detects the

abnormal condition in the electrical circuit by constantly measuring the electrical quantities, which are different under normal and fault condition. The electrical quantities which may change under fault condition are voltage, current, frequency and phase angle. Having detect the fault, the relay operate to close the trip circuit of C.B.

vi) Instrument Transformer: - The line in Sub-Station operate at high voltage and carry current of thousands of amperes. The measuring instrument and protective devices are designed for low voltage (generally 110V) and current (about 5A). Therefore, they will not work satisfactory if mounted directly on the power lines. This difficulty is overcome by installing Instrument transformer, on the power lines. There are two types of instrument transformer.

a) Current Transformer :- A current transformer is essentially a step-down transformer which steps-down the current in a known ratio, the primary of this transformer consist of one or more turn of thick wire connected in series with the line, the secondary consist of thick wire connected in series with line having large number of turn of fine wire and provides for measuring instrument, and relay a current which is a constant faction of the current in the line. Current transformers are basically used to take the readings of the currents entering the substation. This transformer steps down the current from 800 amps to1amp. This is done because we have no instrument for measuring of such a large current. The main use of his transformer is (a) distance protection; (b) backup protection; (c) measurement.

b) Voltage Transformer: - It is essentially a step – down transformer and step down the voltage in known ratio. The primary of these transformer consist of a large number of turn of fine wire

connected across the line. The secondary way consist of a few turns and provides for measuring instruments and relay a voltage which is known fraction of the line voltage.

vii) Metering and Indicating Instrument: - There are several metering and indicating Instrument (e.g. Ammeters, Voltmeters, energy meter etc.) installed in a Substation to maintain which over the circuit quantities. The instrument transformer are invariably used with them for satisfactory operation.

viii) Miscellaneous equipment: - In addition to above, there may be following equipment in a Substation: i) Fuses ii) Carrier-current equipment iii) Sub-Station auxiliary supplies

xi)Transformer: - There are three transformers in the incoming feeders so that the three lines are step down at the same time. In case of a 220KV or more KV line station auto transformers are used. While Abhishek Dave | CTAE, UDAIPUR (aloneabhi_21@yahoo.com) 8 in case of lower KV line such as less than 132KV line double winding transformers are used.

Auto transformer: -

Transformer is static equipment which converts electrical energy from one voltage to another. As the system voltage goes up, the techniques to be used for the Design, Construction, Installation, Operation and Maintenance also become more and more critical. If proper care is exercised in the installation, maintenance and condition monitoring of the transformer, it can give the user trouble free service throughout the expected life of equipment which of the order of 25-35

years. Hence, it is very essential that the personnel associated with the installation, operation or maintenance of the transformer is through with the instructions provided by the manufacture.

An auto transformer 220kv/132kv, in 220KV Substation, Sikandra, Agra.

Basic principles: -

The transformer is based on two principles: firstly, that an electric current can produce a magnetic field (electromagnetism) and secondly

that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil.

x) Lightening arrestors with earth switch lightening arrestors after the current transformer are used so as to protect it from lightening i.e. from high voltage entering into it. This lightening arrestor has an earth switch, which can directly earth the lightening. The arrestor works at 30° to 45° angel of the lightening making a cone. The earth switch can be operated manually, by pulling the switch towards ground. This also helps in breaking the line entering the station. By doing so maintenance and repair of any instrument can b performed.

xi) Line isolator: - The line isolators are used to isolate the high voltage flow through the line into the bus. This isolator prevents the instruments to get damaged. It also allows the only needed voltage and rest is earthed by itself.

xii) Potential transformers with bus isolators: - There are two potential transformers used in the bus connected both side of the bus. The potential transformer uses a bus isolator to protect itself. The main use of this transformer is to measure the voltage through the bus. This is done so as to get the detail information of the voltage passing through the bus to the instrument. There are two main parts in it (a) measurement; (b) protection.

xiii) Lightening arrestors: - Firstly we can see lightening arresters. These lightening arrestors can resist or ground the lightening if falls on the incoming feeders. The lightening arrestors can work in a

angle of 30 degrees around them. They are mostly used for protection of the instruments used in the substation. As the cost of the instrument in the station are very high to protect them from high voltage from lightening these lightening arrestors are used. It is a device used on electrical power systems to protect the insulation on the system from the damaging effect of lightning. Metal oxide varistors (MOVs) have been used for power system protection since the mid 1970s. The typical lightning arrester also known as surge arrester has a high voltage terminal and a ground terminal. When a lightning surge or switching surge travels down the power system to the arrester, the current from the surge is diverted around the protected insulation in most cases to earth.

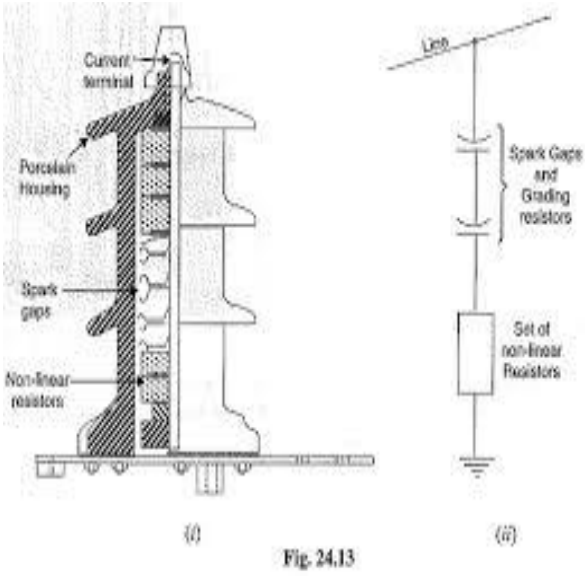
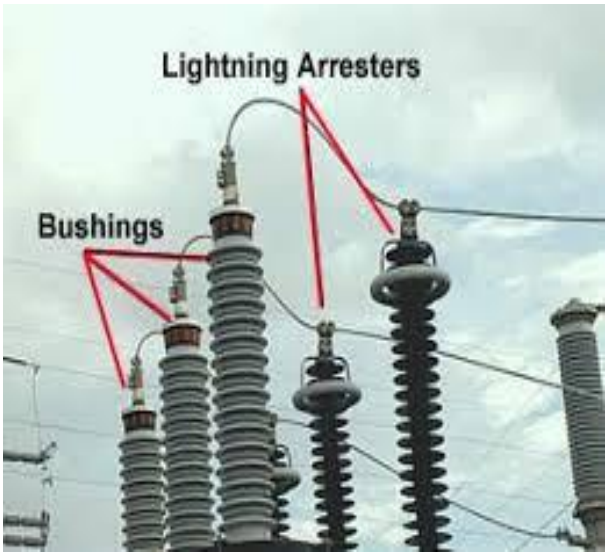


Fig. 24.13



xiv) Capacitor bank attached to the bus: - The capacitor banks are used across the bus so that the voltage does not gets down till the require place.

xv) Wave trap: - Wave trap is an instrument using for tripping of the wave. The function of this trap is that it traps the unwanted waves.

Its function is of trapping wave. Its shape is like a drum. It is connected to the main incoming feeder so that it can trap the waves which may be dangerous to the instruments here in the substation. Low pass filter when power frequency currents are passed to switch yard and high frequency signals are blocked. Line Isolator with E.B. – To isolate the line from Sub Station and earth, it under shut down.

xvi) L.A. - To discharge the switching and lightening voltage surges to earth. Coupling capacitor with line matching units – These are high pass Filters (carrier frequency 50KHZ to 500 KHZ) pass carrier. Frequency to carrier panels and power frequency parameters to switch yard.

xvii) THE FIRE PROTECTION: -The fire protection device should be kept in store yard for safety of equipment during storage.

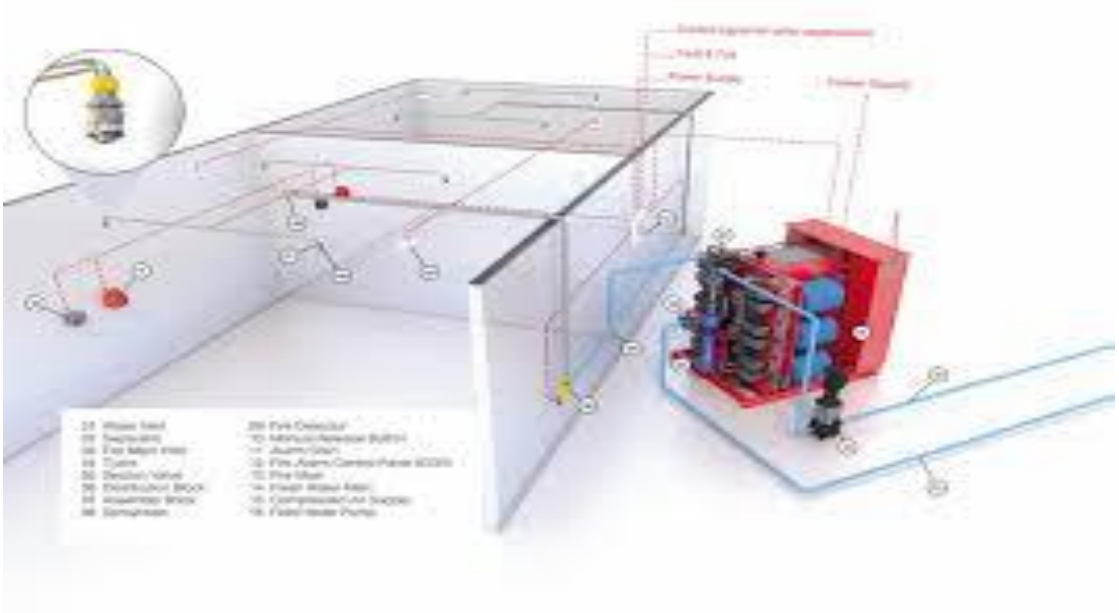


Fig. Fire protection system

Single line diagram (SLD)

A Single Line Diagram (SLD) of an Electrical System is the Line Diagram of the concerned Electrical System which includes all the required ELECTRICAL EQUIPMENT connection sequence wise from the point of entrance of Power up to the end of the scope of the mentioned Work.

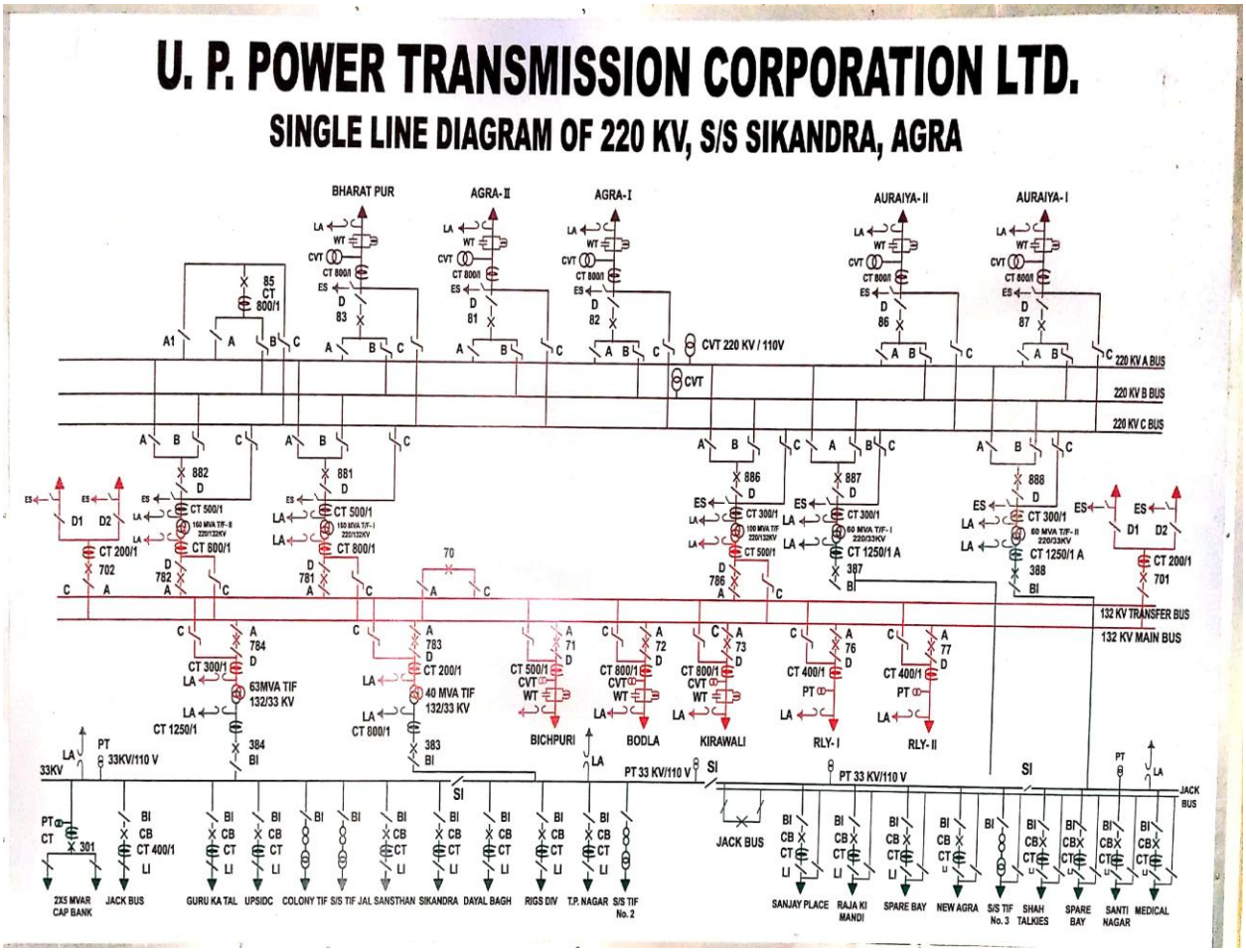


Fig. Single Line Diagram of 220KV S/S Sikandra, Agra

As these feeders enter the station they are to pass through various instruments. The instruments have their usual functioning. They are as follows in the single line diagram.

1.Lightening arrestors

2.C V T

3.Wave trap

4.Current transformer

5.Isolators with earth switch

6.Circuit breaker

7.Line isolator

8.BUS

9.Potential transformer with a bus isolator

10.Isolator

11.Current transformer

12.Circuit breaker

13.Lightening arrestors

14.Transformer

15.Lightening arrestors with earth switch

16.Circuit breaker

17.Current transformer

18.Isolator

19.Bus

20.Potential transformer with a bus isolator

21.A capacitor bank attached to the bus.

The line diagram of the substation:

This substation has the capacity of 220kv and can step down to 132kv using five input lines through the incoming feeders. The input feeders are namely:

1.Bharatpur

2.Agra-II

3.Agra-I

4.Auraiya-II

5.Auraiya-I

these feeders come into the substation with 220kv. The substation of 220kv/132kv has outgoing feeders, namely: Guru ka tal, Sikandra, Dayalbag, Sanjay palace, Raja ki mandi, New Agra, Sah Talkies, T. P. Nagar etc. These out going feeders are of 132kv line.

Brief descriptions of the instruments in the line diagram are: -

1. Lightening arrestors: Here that are used in the incoming feeders so that to prevent the high voltage entering the main station. This high voltage is very dangerous to the instruments used in the substation. Even the instruments are very costly, so to prevent any damage lightening arrestors are

used. The lightening arrestors do not let the lightening to fall on the station. If some lightening occurs the arrestors pull the lightening and ground it to the earth. In any substation the main important is of protection which is firstly done by these lightening arrestors. The lightening arrestors are grounded to the earth so that it can pull the lightening to the ground. The lightening arrestor works with an angle of 30° to 45° making a cone.

2. C V T: A capacitor voltage transformer (CVT) is a transformer used in power systems to step-down extra high voltage signals and provide low voltage signals either for measurement or to operate a protective relay. In its most basic form the device consists of three parts: two capacitors across which the voltage signal is split, an inductive element used to tune the device to the supply frequency and a transformer used to isolate and further step-down the voltage for the instrumentation or protective relay. The device has at least four terminals, a high-

voltage terminal for connection to the high voltage signal, a ground terminal and at least one set of secondary terminals for connection to the instrumentation or protective relay. CVTs are typically single-phase devices used for measuring voltages in excess of one hundred kilovolts where the use of voltage transformers would be uneconomical. In practice the first capacitor, C1, is often replaced by a stack of capacitors connected in series. This results in a large voltage drop across the stack of capacitors that replaced the first capacitor and a comparatively small voltage drop across the second capacitor, C2, and hence the secondary terminals.

CVT 220 kV rating

Type: WP-245 V

Operating voltage: 220/ 3 kV

Voltage factor: 1.5 V for 30 sec.

Test voltage: 460 kV

Test impedance 1050 kv peak

Ellec cap: 4400±10% PF of 50 Hz

± 5%

Nominal intermediate voltage 20/ 3 kv

Spark over voltage: 36 kv

Voltage divider ratio 220000/ 3 /20000/ 3

Total thermal burden: 1000 VA

Temperature categ: 10 to 55°C

Total weight: 900 Kg.

3. Wave trap: Wave trap is an instrument using for tripping of the wave. The function of this trap is that it traps the unwanted waves. Its function is of trapping wave. Its shape is like a drum. It is connected to the main incoming feeder so that it can trap the waves which may be dangerous to the instruments here in the substation.

4. Current transformer: Current transformers are basically used to take the readings of the currents entering the substation. This transformer steps down the current from 800 amps to 1 amp. This is done because we have no instrument for measuring of such a large current. The main use of this transformer is (a) distance protection; (b) backup protection; (c) measurement.

Current transformer rating……..

	Core 1		core 2		core 3	
Ratio (A/A)	800/1	400/1	800/1	400/1	800/1	400/1
Sec. Conn:	1S1-1S2		2S1-2S3		3S1-3S3	
Accuracy class:	0.2		5P 10		PS	

Burden (VA): 30 15 NA

Highest system

Voltage: 145 kV insulation burn 275 kV/ 65014 Vp

5. Lightening arrestors with earth switch: - Lightening arrestors after the current transformer are used so as to protect it from lightening i.e. from high voltage entering into it. This lightening arrestor has an earth switch, which can directly earth the lightening. The arrestor works at 30° to 45° angel of the lightening making a cone. The earth switch can be operated manually, by pulling the switch towards ground. This also helps in breaking the line entering the station. By doing so maintenance and repair of any instrument can be performed.

6. Circuit breaker: The circuit breakers are used to break the circuit if any fault occurs in any of the instrument. These circuit breaker breaks for a fault

which can damage other instrument in the station. For any unwanted fault over the station we need to break the line current. This is only done automatically by the circuit breaker. There are mainly two types of circuit breakers used for any substations. They are (a) SF6 circuit breakers; (b) spring circuit breakers. The use of SF6 circuit breaker is mainly in the substations which are having high input kv input, say above 220kv and more. The gas is put inside the circuit breaker by force ie under high pressure. When if the gas gets decreases there is a motor connected to the circuit breaker. The motor starts operating if the gas went lower than 20.8 bar. There is a meter connected to the breaker so that it can be manually seen if the gas goes low. The circuit breaker uses the SF6 gas to reduce the torque produce in it due to any fault in the line. The circuit breaker has a direct link with the instruments in the station, when any fault occur alarm bell rings. The spring type of circuit breakers is used for small kv stations. The spring here

reduces the torque produced so that the breaker can function again. The spring type is used for step down side of 132kv to 33kv also in 33kv to 11kv and so on. They are only used in low distribution side.

7. Line isolator: The line isolators are used to isolate the high voltage from flow through the line into the bus. This isolator prevents the instruments to get damaged. It also allows the only needed voltage and rest is earthed by itself.

8. BUS: The bus is a line in which the incoming feeders come into and get into the instruments for further step up or step down. The first bus is used for putting the incoming feeders in la single line. There may be double line in the bus so that if any fault occurs in the one the other can still have the current and the supply will not stop. The two lines in the bus are separated by a little distance by a conductor having a connector between them. This is so that one can work at a time and the other works only if the first is having any fault.

9. Potential transformers with bus isolators: There are two potential transformers used in the bus connected both side of the bus. The potential transformer uses a bus isolator to protect itself. The main use of this transformer is to measure the voltage through the bus. This is done so as to get the detail information of the voltage passing through the bus to the instrument. There are two main parts in it (a) measurement; (b) protection.

10. Isolators: The use of this isolator is to protect the transformer and the other instrument in the line. The isolator isolates the extra voltage to the ground and thus any extra voltage cannot enter the line. Thus an isolator is used after the bus also for protection.

11. Current transformer: Current transformers are used after the bus for measurement of the current going out through the feeder and also for protection of the instruments.

12. Circuit breaker: The circuit breakers are used to break the circuit if any fault occurs in the circuit of the any feeders.

13. Lightening arrestors: The use of lightening arrestors after the bus is to protect the instrument in the station so that lightening would not affect the instruments in the station.

14. Transformer: There are three transformers in the incoming feeders so that the three lines are step down at the same time. In case of a 220kv or more kv line station auto transformers are used. While in case of lower kv line such as less than 132kv line double winding transformers are used.

15. Lightening arrestors with earth switch: The lightening arrestors are used with earth switch so that lightening would not pass through the instruments in the station.

16. Circuit breaker: The circuit breakers are used to break the circuit for any fault.

17. Current transformer: Current transformers are used to measure the current passing through the transformer. Its main use is of protection and measurement.

18. Isolator: These are used to ground the extra voltage to the ground.

19. Bus: This bus is to carry the output stepped down voltage to the required place.

20. Potential transformer with a bus isolator: Two PT are always connected across the bus so that the voltage across the bus could be measured.

21. Capacitor bank attached to the bus: The capacitor banks are used across the bus so that the voltage does not gets down till the require place.

Storage of equipments for the substation:

All the substation equipments/materials received on site should be stored properly, either in the outdoor yard or in the stores shade depending on the storage requirement of that particular equipment. The material received should be properly counted and checked for any damages/breakages etc. The storage procedure for main equipment is as follows:

I. EHV C.T.s and P.T.s Normally, 220KV are packed in iron structures for extra supports with cross beams to avoid lateral movement while those of. 132KV C.Ts. and P.Ts are packed and transported in wooden crates vertically 132 KV C.Ts. and P.Ts. should be stored vertically and those of 220 KV and 400 KV should be stored in horizontal position. C.Ts and P.Ts. packed in wooden crates should not

be stored for longer period as the packing would may deteriorate. The wooden packages should be stored on a cement platform or on M.S. Channels to avoid faster deterioration of the wooden crates. C.Ts and P.Ts packed in iron cases stored in horizontal position should be placed on stable ground. No C.Ts and P.Ts. should be unpacked in horizontal position.

II. L.A. s. and B.P.I. These are packed in sturdy wooden case as the porcelain portion is very fragile. Care should be taken while unpacking, handling and storage due to this reason.

III) Batteries, Acid, Battery charger C & R panel, A.C.D.Bs copper piping, clamp connectors, hardwares etc. should be stored indoor.

IV. Circuit breakers: The mechanism boxes of 33 KV – V.C.Bs should be stored on raised ground and properly covered with tarpaulins or should be stored in door. The interrupter

chambers should be stored on raised ground to avoid rain water in storage area.

V. E.H.V. C.B. Now-a-days SF6 circuit breaker are used at EHV rottages. The control and operating cabinets are covered in polythene bags and are packed in wooden and iron crates. These should be stored on raised ground and should be covered with tarpaulins. The arcing chambers and support insulators are packed in iron crates and transported horizontally. The +ve pressure of SF6 gas is maintained in these arcing chambers to avoid the ingress of moisture. It should be ensured that this pressure is maintained during the storage. Other accessories like pr. Switches, density monitor, Air Piping, control cables, wiring materials, SF6 gas pipes; SF6 cylinder should be stored in store shed.

VI. Power transformers: The main Tank - The transformer is transported on trailor to substation site and as far as possible directly unloaded on the plinth. Transformer tanks up to 25 MVA capacity

are generally oil filled, and those of higher capacity are transported with N2 gas filled in them +ve pressure of N2 is maintained in transformer tank to avoid the ingress of moisture. This pressure should be maintained during storage; if necessary by filling N2 Bushings - generally transported in wooden cases in horizontal position and should be stored in that position. There being more of Fragile material, care should be taken while handling them. Rediators – These should be stored with ends duly blanked with gaskets and end plates to avoid ingross of moisture, dust, and any foreign materials inside. The care should be taken to protect the fins of radiators while unloading and storage to avoid further oil leakages. The radiators should be stored on raised ground keeping the fins intact. Oil Piping. The Oil piping should also be blanked at the ends with gasket and blanking plates to avoid ingross of moisture, dust, and foreign All other accessories like temperature meters, oil flow indicators, PRVs, buchholtz relay; oil surge relays; gasket ‘ O ‘ rings

etc. should be properly packed and stored indoor in store shed. Oil is received in sealed oil barrels. The oil barrels should be stored in horizontal position with the lids on either side in horizontal position to maintain oil pressure on them from inside and subsequently avoiding moisture and water ingress into oil. The transformers are received on site with loose accessories hence the materials should be checked as per bills of materials.

1.8CONTROL AND RELAY PART: -These are used to control the operation of breakers, isolator through protective relays installed on these panels various protection scheme for transformer, lines etc. are provided on these pannel.AC & DC DB'S – These are used for extending A.C. & D.C. supplies whenever required through various circuits. There are two main Buses in this arrangement connected by each diameter.

i) Through either of line breakers the line side Main Bus can be charged normally (Bus-I).

ii) The line breaker, tie breaker and IInd Bus breaker if closed in series will charge the IInd Main Bus.

iii) Outage on anyone Bus can be availed without interruption on any Bus. The second Bus can feed all the loads.

iv) Breaker from any bay can be taken out for maintenance without interrupting the supply.

v) For efficient working two diameters are required having source in each diameter preferably connected diagonally opposite to two different buses.

vi) If both the sources are connected to same Bus (i.e. from one side only one tie breaker can be attended at a time).

vii) If all the four breakers connected to Bus are out the transformer can be charged through the breaker from remote substation source.

viii) Changing over as in case of 2 Bus or 3 Bus systems is not necessary as supply is not interrupted, in any case as said above.

ix) All the breakers in the diameters are in energized position including tie breakers to keep the system in tact in case of any fault.

x) On line or transformer fault the tie breaker with respective line or transformer breaker will trip.

xi) On Bus fault on any Bus only the two breakers (of two diameters) connected Bus will Trip.

xii) The Teed-point remains unprotected in any of line or transformer or bus faults hence the Teed point protection is given by differential relay. In case of this protection the breakers (2 Nos.) connected to Teed point (tie breaker + Bus breaker) will Trip.