Advances in UHV Transmission and Distribution
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Lecture – 26
Preventive maintenance of Substation

So good morning we were discussing about the various substations. Particularly gas insulated substation the air insulated in the hybrid type of substations.

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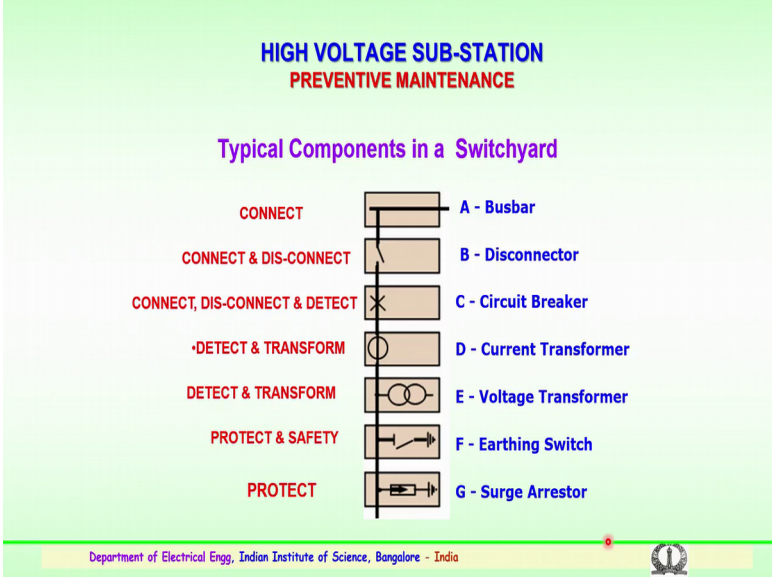

Which are recently being used for the EHV and UHV voltage levels. Now we will discuss about the important components of the switchyard in a substation. So, we have discussed earlier various components important components like the busbar, disconnector, the circuit breakers, current transformers, voltage transformers, the earthing switches and surge arrestors. These are the various components in any typical switchyard of a EHV or any high voltage HV EC or HV DC substation.

We will look into the various functions of the components which are being installed in any substations. So, the main important component being the busbar. So, this busbar main function of the busbar is to connect and deliver the loads or transmission the loads to the required centers. Then we have a disconnector switch the disconnector switch the main function of the disconnector switch is to connect and disconnect the circuit, disconnect the circuit for the maintenance or for any up gradation of the equipments in

the substation or any important changing over of the equipment or changing of the release and so on.

The third bring the circuit breaker circuit breaker is an important component as mentioned earlier. So, the important function of a circuit breaker is to connect the circuit of a normal operating conditions. Then disconnect in case of the over voltages or during the a fault conditions. And the main other function of the circuit breaker is also to detect the faults and operate accordingly.

Then we have 2 important in information components one is a current transformer and the other being the voltage or a potential transformer. So, these mainly detect the information and try to transform the information either in a current or a voltage to the control unit. Or in case of a scared other information is being fed to the control center. So, similarly we have a earthing switch earthing switch again this is being used mainly for the protection and also for the safety aspects, in case of any changing of the equipments in the substation the earthing switch is kept open and the equipment is being attended.

So, then the finally, we have discussed in the last class about the a lighting arrestor or a surge arrestor. The surge arrestor is an very important component. And it quenches the surges or a lightning or a switching surges and protects the major equipments like the transformer circuit breakers and other release and controls in the substation. So, these are the important components in any switchyard of a high voltage or UHV substation.

So, the preventive maintenance of these components is essential at a regular intervals so that the performance of these components or performance of this equipments over a long period of time has to be seen to be considered in the field.

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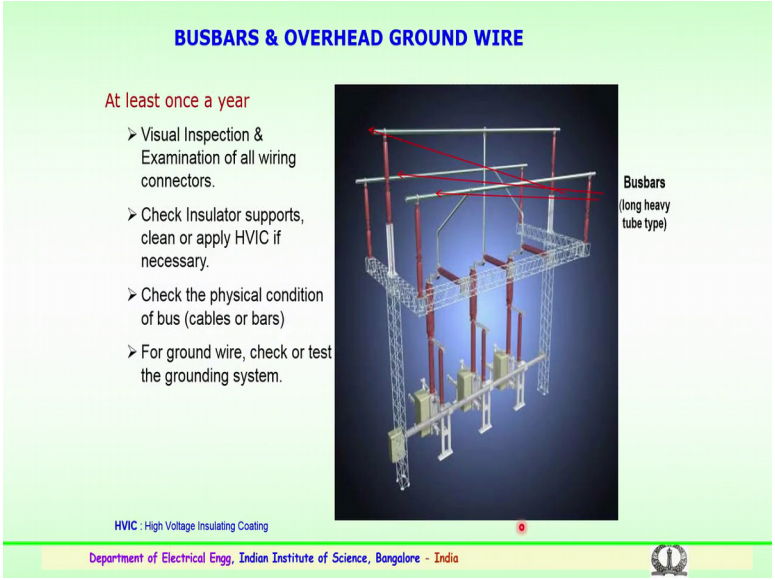

So, the busbars, the busbars are a long v tube tubular structures in any substation. So, these busbars or a overhead ground wires these are the busbars in any a substations.

So, these busbars at least once a year visible inspection is to be carried out regular intervals, in examining of all the wiring connections which are connected to the busbar the end connections of the busbar. To it has to be properly checked whether the following insulator support the insulators may be a (Refer Time: 04:43) or long rod type of insulators. So, these have to be verified and the contamination or the spread or the insulator surface have to be cleaned at a regular intervals. Or if necessary a suitable high voltage insulating coating if required has to be applied on these insulators in case of any necessity.

So, we have the physical condition of these cables or the busbars have to be attended at a regular time period, to check there physical conditions particularly as these are operating in the open environmental condition. The effect of corrosion or any other because of oxidation. So, a proper check is essential for the busbars. Similarly for the ground wires which are being connected a proper a check or the testing of the grounding system. So, we will be discussing about the grounding system in detail in a later lecture, but they very important is to see the ground wires are also being attended to.

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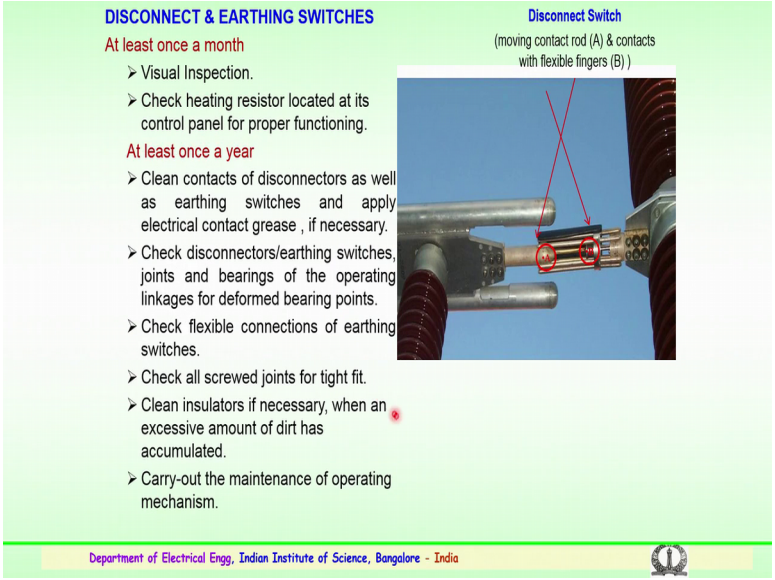

Then comes the disconnector or the earthing switch. So, this disconnector switch comprises of a moving contact with a flexible a fingers as shown. Again these disconnectors switches very with different voltage levels various types of connector switches are being employed at different voltage levels. So, these disconnecting switches have to be attended at least once a month a proper visible inspection has to be made and necessary check has to be maintained for the heating resistor particularly the near the contacts at it is control panel or whether there is a proper functioning or the contacts have being corroded or it needs inspection and also some remedial action to be done.

So, a regular maintenance apart from a regular maintenance of monthly once. At least once in a year the following have to be attended, that is the contacts of the disconnector switches and earthing switches have to be properly cleaned up and the electrical contact grease if necessary has to be applied for the smooth contact and to see the corrosion of formation near the contact or on the contact is happening.

Then the disconnector switches or to be checked a particularly at the joints near the joints where the bearings of the opening and closing of the units required. So, this will help to check the flexible connections of earthing switches also. Then all the important joints or particularly the joints for the unit have to be properly a tightened, and the insulators which are supporting these disconnector switches have also be have also to be cleaned at a regular intervals. And any excess amount of a pollutant or a contaminant has to be

which is been accumulated, has to be cleaned so that the surface discharges on these support insulator in our happens. So, the regular maintenance has to be carried out for the smooth functioning of the disconnector switches.

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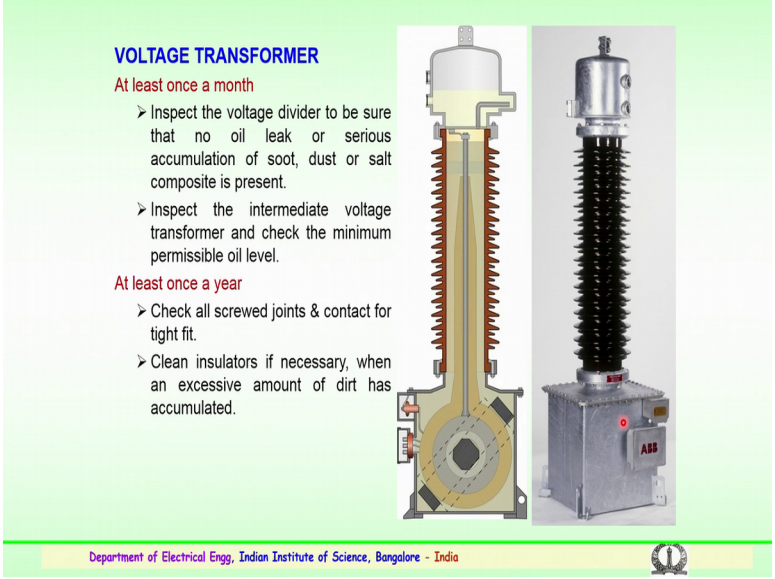

Then we have the 2 important components, the voltage transformer of the potential transformer and the current transformer. So, the voltage transformer at least once a month we have the inspection is essential, to see that the voltage divider to be sure that there is no oil leak, particularly which is a serious because this oil leak or a serious accumulation of soot dust or salt, composite could be present to it has to be removed so that is a reason for to see the maintenance has to be carried out at list a month.

So, inspect the intermediate voltage transformer and it has be checked for the minimum permissible oil level has to be maintained in the voltage and also the current transformer. And at least once in a year what you check all joints and the contact points for that there is no loosening of the contacts and the all the insulators which are again associated with this cities have to be properly cleaned, so that the dirt accumulation is a not being and then on the surface of the insulator which will again, during the a monsoon condition there is likely would of the discharges because of the surface contamination this has to be avoided.

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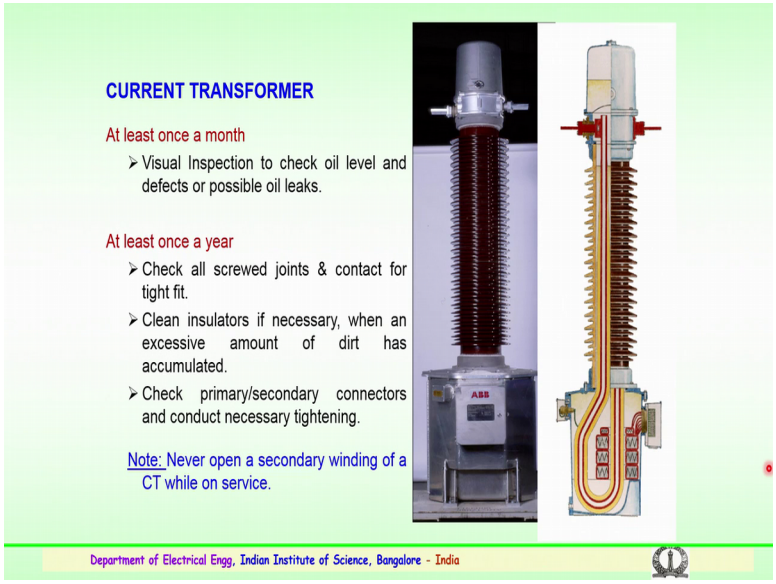

And the voltage or transformer and the current transformer both have to be at a regular intervals have to be monitored and properly calibrated, that is very important.

So, that the readings which these equipment or the information is the this current transformer or voltage transformer has going to be communicated have to be accurate, that is again one of the important aspects for the proper calibration has to be carried at least once in a year.

So, here current transformer visual inspection is important. To check oil level and also the defects of possible oil leaks in the current transformer. So, again here the insulating supports have to be properly checked for the dirt accumulation, and a necessary primary or secondary connections and the conducting parts have to be properly tightened, and nowhere and the loose contacts are to be seen.

The important point to be noted is that never open a secondary winding of a ct current transformer particularly while on service. So, this is a not advisable to see the current transformer secondary should not be open. That is one of the instruction to it should be carried out by the personal over attending to these maintenance job. So, both the equipments have to be calibrated nearly once that has to be done for proper information.

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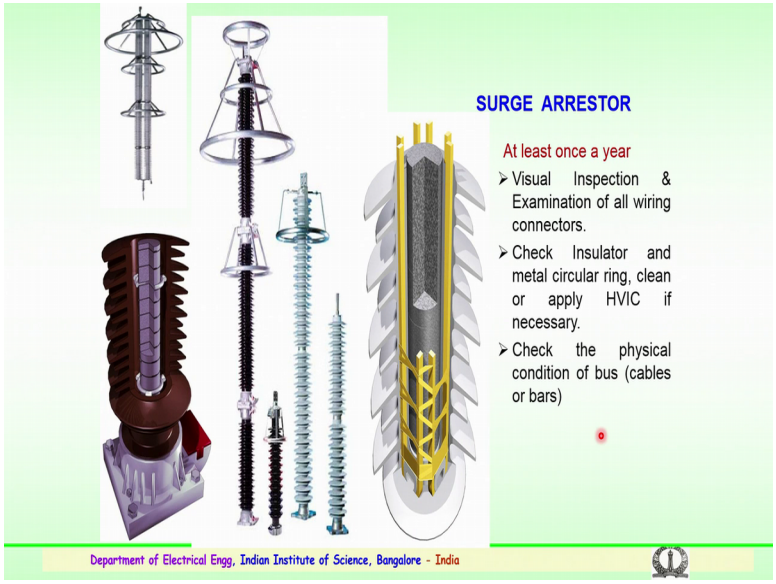

Then we have discuss lot about the surge arrestor or a lightning arrestor and the used for the transmission and distribution networks, mainly for protection of the transformers and other equipments. So, this surge arrestors has mentioned earlier consist of various a blocks of zinc oxide elements, which I have starts inside with the pressure relief or the surge counting device near the ground side and you have a surge counter and also leakage current monitor which gives the information about, the for performance of this lightning or a surge arrestor. So, this is a typical surge arrestor for various voltage levels, you can see the grounded portion here and this is a high voltage portion with the corona control rings.

So, near the grounded before the grounded connection, you have counter surge counter and also a leakage current monitor to give the information about the number of a lightning surges which you happened over a period of time. Here again the surge arrestors require a regular maintenance. So, visual inspection and examining of all the wiring connections which are being done to the arrestor. And again here the hollow insulator bushing which accommodates the surge arrestor elements have to be properly clean, including the corona control rings the metal rings, adjacent rings which are being used for the surge arrestor blow housing, have to be properly cleaned again using the high voltage insulating coating. If necessary and a physical check for the connections that is the busbar connection to the surge arrestor is essential at a regular intervals.

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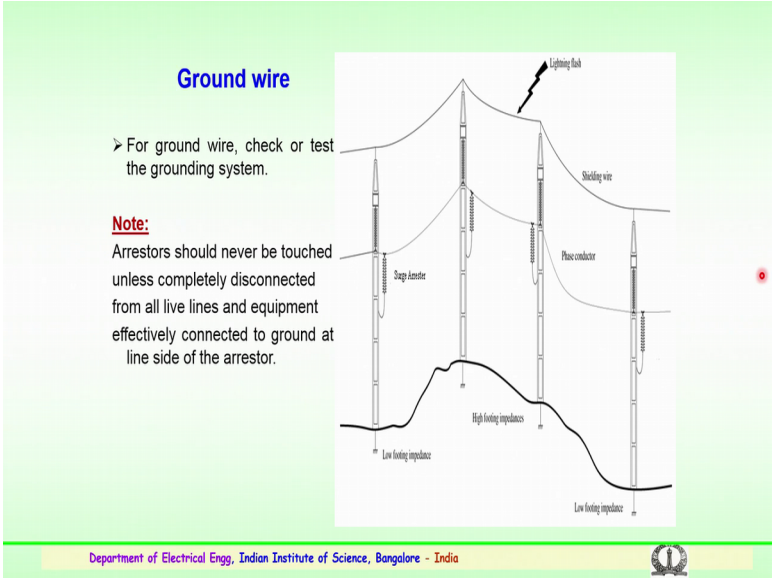

Ah and ground wire or the earthing wire place a very important role in the substation, where in case of the lightning surges or a lightning flashes which occur or the proper shielding has to be done so that this surges are diverted to the without the voltages or arisen potentially seen to the other equipments which are connected. So, very important the earth wire of the ground wire. This regular check on the grounding system is essential and the arrestors which are connected, it is shown here each phase of the transmissions conductors have been connected with a surge arrestors. So, these surge arrestors should never be touched unless completely disconnected, while maintaining the ground wire connections or refrying or checking the ground wire or shielding wires.

So, surge arrestors have to be properly disconnected from all the live lines and the equipment effectively which are connected to ground at the line side of the arrestor. So, very important everything has to be earth then the maintenance has to be carried out. This shows a typical a lightning or flash which is occurring to the grounding or a shielding wire, which is connected in the substation. And also you see the importance of the tower footing resistance the high footing impedance, we will be discussing about tower footing impendence's or the what is the minimum resistance which is required for the earthing or a grounding in any high voltage substations.

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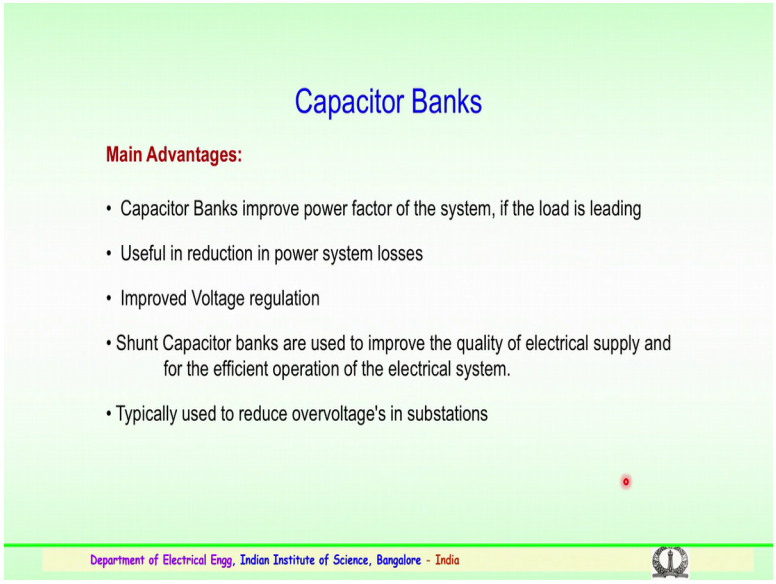

So, apart from this we have a capacitor units, several units' capacitor banks. And these are very important components in any substation very essential components. In a substation the capacitor banks will improve the power factor of the system, if the load is leading it is useful introduction particularly in the power system losses, and also these are used to see the voltage regulation is improved. So, capacitor banks that is a certain capacitor banks are normally used to improve the quality of electrical supply, and also for the efficient operation of the electrical system network. And capacitor banks are typically used to reduce the overvoltage's in the substation.

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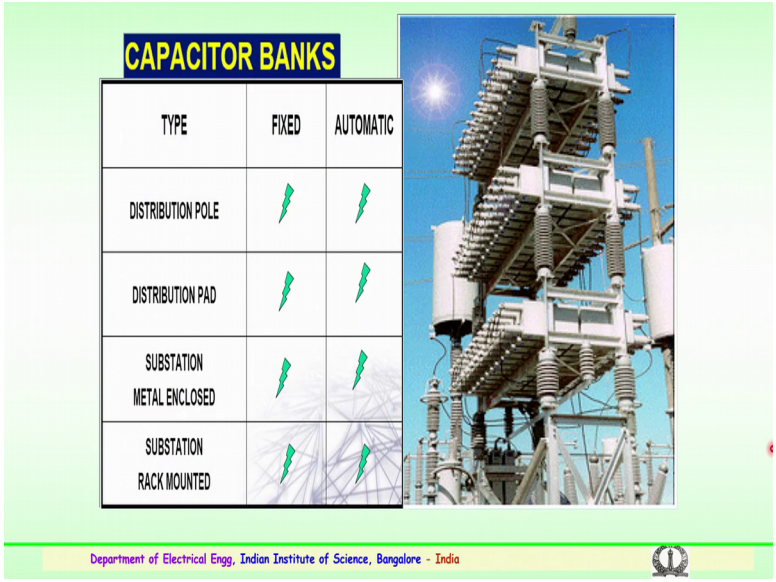

So, various types of capacitor banks are being used, some maybe fixed or automatic again and depends on different types and also the capacitor bank vary with type of voltage levels whether it is distribution or medium voltage or a high voltage or extra high voltage or ultra high voltage. There is a capacitor banks are suitably designed to be kept in the substation.

So, the types of capacitor bank distribution pole, this could again be a fixed or an automatic type. Distribution pad type which could also be a fixed or automatic substation, sometimes is a metal enclosed capacitor banks are installed whether in any required substation where it is again a fixed or an automatic substation. And some of the cases are also similar to these substation of rack mounted capacitor units, and this is one of the example which is used for the improvement of power factor and also reduction in the power system losses. So, one of the example is assembly of the rack mounted units of the capacitor bank.

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Similar examples are connected with the capacitor banks. So, several types again before the distributed pole mounted you have arrangement of the distribution system. This is metal enclosed type of a capacitor banks which are arranged in a typical substation, along with the capacitor bank you have the harmonic filters ah in a EHV or a UHV substation. So, these are various types which are capacitor banks which are being used for the proper correction of the power factor.

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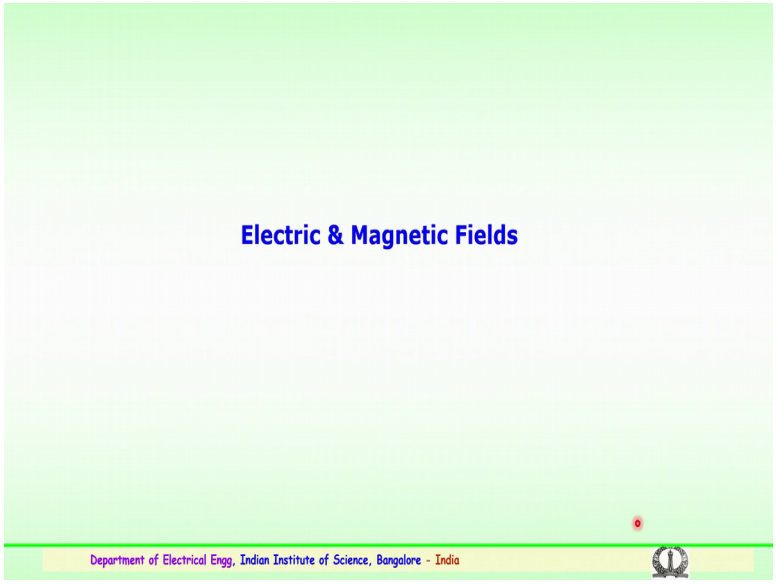

So, that was about the main equipment which are housed in any substation, very important. So, further to this in any substation, very important, because of the various components and the operation at very high voltage levels. So, the important aspect to be or considered is the electric and magnetic fields. So, electric and magnetic fields are play a vital importance in the proper design of the substation, and also helps to see the personal who are working in substation have to be considered, because of the clearances and the effect of the electric and magnetic fields pertaining to the health.

So, this is one of the concern as the voltage level in any typical substation goes above EHV or UHV level the electric and magnetic fields are very important. So, proper planning and proper estimation of this fields is necessary, and also the measurements is necessary to see the humans or not affected by the fields which are generated, because of the high voltage operations at the substations.

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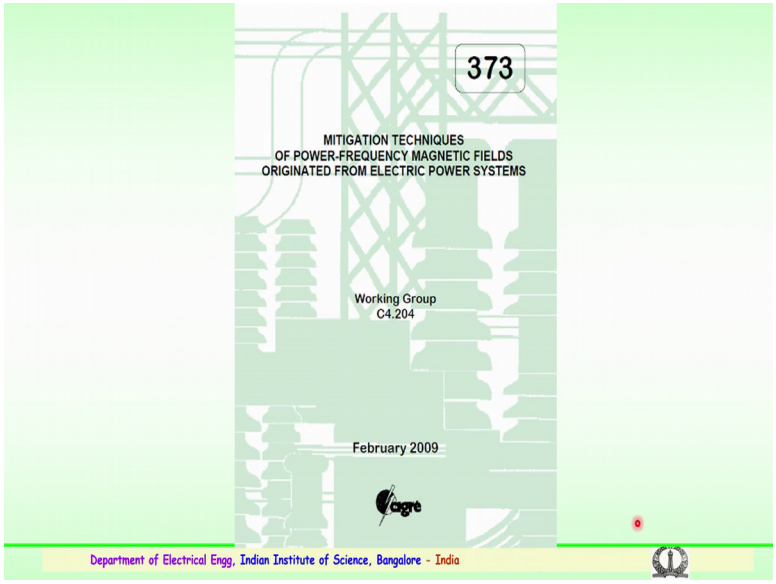

So, several mitigation techniques are also being standardized, for the power frequency magnetic fields which are normally originated by the electric power systems. So, there is AC grey working group again this is AC grey working group is the international council, for the large high voltage systems which work towards the standardization of the equipments and related to the electrical very high voltage aspects. So, this working group C4.204 has suggested some of the mitigation techniques particularly for the personal over working in the utilities and particular to the substations, and the specifications which are the regulations framed, the magnetic field and the electric fields have to be contained, so that there is no harm full effect to the humans over working in the substations.

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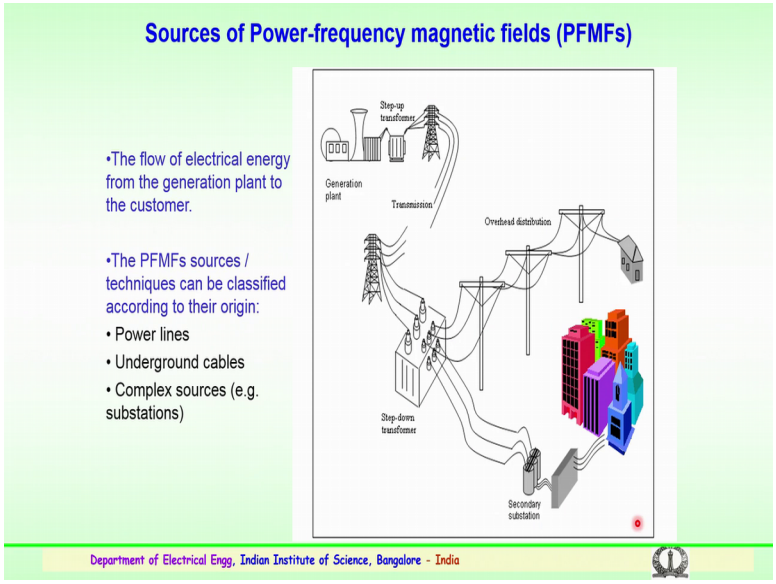

So, where do the sources of this electric and magnetic fields or seen? Particularly when the power frequency levels. So, we know that again going back we have a generating plants various type of generation we have step up transformer to transmit the voltage levels. At a very high voltage then we step down at the required levels, and the from the step in down we will through the substation we try to distributed to the local requirement it could be industries could be domestic purpose. Here during this process of the entire process the flow of energy as earlier mentioned and from the generating to the customer level. At the power frequency operating voltages could be of distribution or extra high voltage or ultra high voltage. The reason here the power frequency electric or a magnetic fields, and the sources from where it is being generated and ah, the techniques which are to be classified and how to mitigate is very, very important for the utility engineers and also for the personal over working in the electricity organizations.

So, here the power frequency magnetic field sources could be classified according to their origins. So, we are do the originate that is very important, it could be from the power lines which are transmitting from the generating to the load centers. It could be from the underground cables. Or it could be from the complex sources maybe from the substations, any of these substations.

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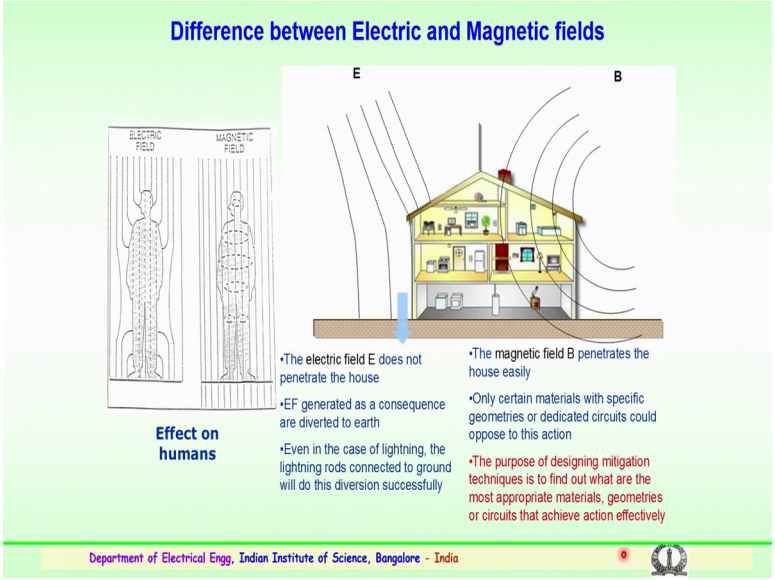

So, the sources could be any of these transmission or distribution or through the substation side, because of the equipment because of. So, when you compare the differences are between the electric and magnetic fields, very important aspect, how it could affect the humans particularly. You can very clearly see here indication diagram of human which is a shown here with the to the effect of electric field and to the magnetic field, it will be explained here in the following ways. So, this gives electric field lines in case you consider residential house, where you can see how the electric field lines in case if the transmission conductor is very near to the residential line residence residential area. How the electric field lines could affect the residence, and it is very clear that the electric field lines normally do not penetrate inside the house. But you can see this B being the magnetic fields magnetic fields of which are originating from the substation or through the transmission because of high power could a penetrate the residential house also.

So, very important factor. Similar explanation is being given here; the electric field does not penetrate the house that is to be noted. Electric fields generated as a consequences are normally diverted to the earth through the grounding arrangement. Even in case the lightning strikes the transmission line which is the going near the residential area. The suitable lightning rods which are available say, again if the house residential house of at all structure has a lightning rod this, normally is connected to the earthing ground where the surge which is a comes in the contract will be diverted to the ground.

So, the lightning rods connected to the ground will do the diversion successfully. So, no much of form with the electric fields because of the transmission or because of the lightning aspect. In case of magnetic fields you can see that magnetic field could penetrate the house if it is near the vicinity of the site where the effect of magnetic field is very high. Here only certain materials particularly which specific geometries or dedicated circuit could oppose this action. Else if the materials are not capable of particularly oppose in the magnetic field, then there is a likely chance of the magnetic field entering the or penetrating the residential apartments, in case if it is then vicinity of the magnetic field zone.

So, the purpose important aspect, the purpose of a designing the mitigation techniques for the magnetic field the is to see and find out what are the most appropriate materials which could be used, and the what are the type of a geometries to be employed to see that the effect of shielding for the magnetic fields could be effectively carried out, the very important aspect. So, magnetic fields are much more dangerous in compare to the electric fields. So, it has to be properly contained and it has to be suitably mitigated with the help of the available techniques.

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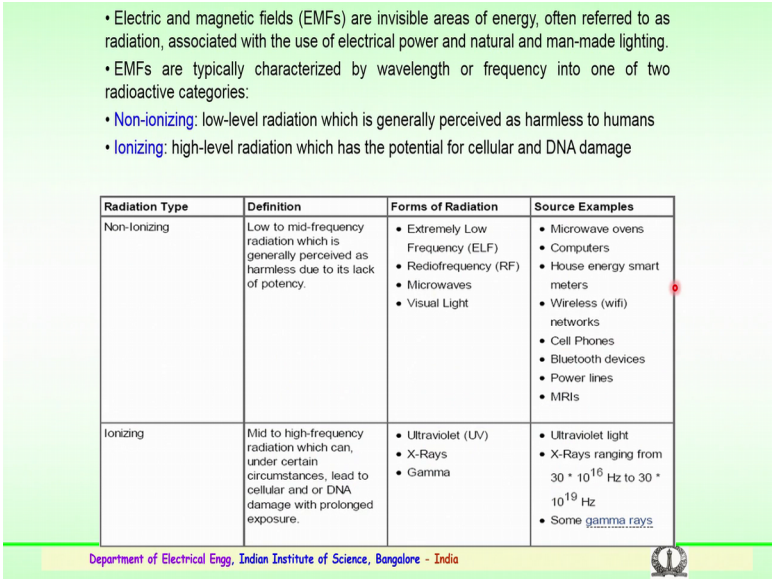

So, electrics and magnetic fields both are invisible areas of energy. These are often referred as the radiations, which is known as electric electro field magnetic field radiations. And these are all associated with the use of a electrical power at very high

current ridings and sometimes could be natural and also, maybe due to the manmade lightning aspects also.

So, EMF or electromagnetic fields are typically characterized by the wave lengths or the frequency, into one of the 2 radioactive categories which are internationally categorized. 2 important categorization where the electromagnetic fields are classified. One is the non ionizing a type. So, non ionizing type is a low level radiation which is generally perceived as harmless to the humans. So, the magnitude of the radiation which is emitting from this category, which is classified in this cat as a non ionizing level is not much harmful to the humans whereas, ionizing type, the second category, which is having a high level of radiation could be a factor which has to be considered, and where it could have the potential particularly for damaging the cellular and also the DNA that is very concerns. So, the ionizing type of a magnetic fields are the important consideration to see that it has to be contained.

So, these categories have been classified as follows which is that shown in this table. The radiation type, what is the non ionizing type, that is a low level radiations, then the ionizing type which is high level radiations. So, we see the definition for non ionizing is low to mid frequency radiation. Which is generally perceived as harmless due to it is lack of potency, it could not cause much of harmful to the humans as the magnitude of this radiations are very, very low.

The forms of radiation could be extremely low of frequency. It could be in the regional radiofrequency levels, or it is because of the microwaves or because of the general visual lighting which is ah, artificially which is a manmade arrangements. So, these all come under non ionizing magnetic fields. Again the sources could be from the microwave ovens. So, lot exposure of microwave oven is also not advisable the computers, again the computers could also be a source of low magnetic radiations. Then house energy smart meters the wireless Wi-Fi networks, the cell phones which are operating at a gigahertz or very high megahertz range. The Bluetooth devices gigahertz range, the power lines and MRIs, magnetic resonance imaging. So, so these could be the source of the non ionizing type of radiations which are generally not harmful to the humans.

To second category which is to be contained could be operating or could be do anywhere between mid to the high frequency radiation, this is cause could be because of the high

frequency radiation, which can under certain circumstances may lead to the cellular or DNA damage with particularly for a long exposure to this fields.

So, the magnetic fields which are following in this category the personal or not supposed to be exposed for a long period of time, and how to be taken prop proper percussions so that the penetration could be avoided. So, what are the sources normally forms of radiations could be in this category? Or ultraviolet race could be x rays or a gamma rays. So, these are some of the categories or forms of a radiations could be categorized in this. And the source examples from where the ionizing type of type of a electromagnetic radiations could occur could be from the ultraviolet exposure to the ultraviolet light, for a long period of time. The x rays which are typically range from 30 into 10 to the power of 16 hertz to 30 into 10 to the power of 19 hertz.

So, anywhere these frequency range where the x rays are being taken, if it is exposed for a long duration time he radiations could be higher. And also some gamma rays, this could again be because of the gamma rays. So, the personal should not be exposed for a long duration, and there are been internationally specified values for the non ionizing and ionizing type of magnetic fields. You could also see in the x ray personal over operating in the generally using the x ray machines in the hospitals. There could be indication which is being put on their prawn where it is says and indicates the exposure level, so that a suitable action has to be seen or is exposure, limit should not cross of the specified levels, there is a very important aspects. Particularly for people who are working in the x ray units and over expose to the ultraviolet radiations.

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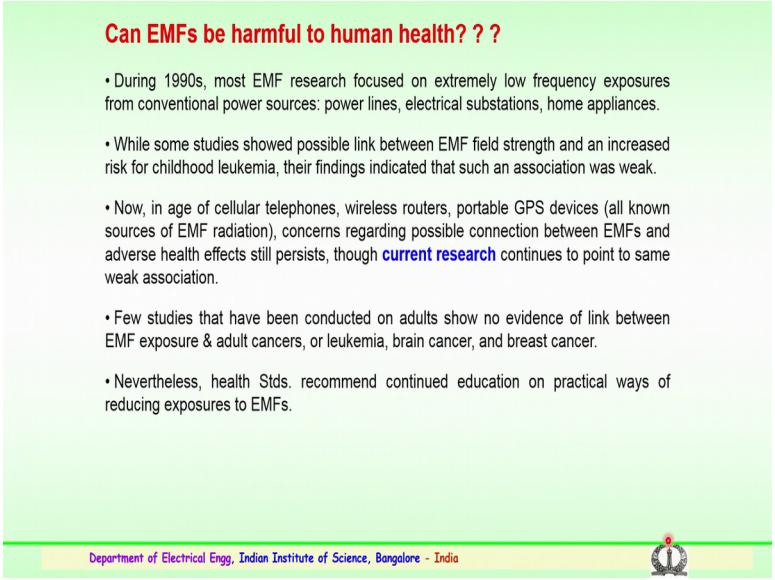

Could electromagnetic fields be harmful to the human health? This is a question. It is to be known that we have to understand whether this is of a concern or a serious concern, or it could be not a issue.

So, here during somewhere 1990s that is, decades, 2 decades back most of the electromagnetic field research particularly focussed on extremely low frequency exposures, from conventional power sources, power lines the electrical substations and also home appliances. So, when a people who had a concern. So, can electromagnetic we harmfully yes in some studies I have shown that a possible link could be established between the electromagnetic field strength and an increased risk of childhood leukaemia. But their findings indicated that such an association was very weak.

So, there is no proper support that the electromagnetic fields could be harmful. Now in the age of cellular telephone wireless networks routers portable GPS devices, all sources of electromagnetic field radiations. The concerns regarding possible connections between the electromagnetic fields and the adverse health effect still persists among the humans, though current research continues to point to same weak association, there is no concrete proof that the field which are generated by these sources could be harmful to the humans.

But few studies that have also been conducted to on adults, show no evidence of link between the electromagnetic field exposure. And the adult cancers or leukaemia, brain cancer or breast cancer. So, there are no solid proofs which support the exposure of

electromagnetic fields have let to this disease. So, nevertheless very important the health standards have to be followed. And international health standards have been recommended, and which are continually and also to be educated on practical ways of reducing the exposures, in particular to the electromagnetic fields. So, this is very important point to be noted, for the personal who are working in the areas where the electromagnetic sources have to be seen that long exposure to this fields have to be contained, this is very important aspect, right.

Thank you, we will stop here.