Advances in UHV Transmission and Distribution
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Lecture – 25
Insulation coordination, Components in a typical substation

So we have compared various substations; the air insulated, the gas insulated and the hybrid type of substations. The equipments or the main components which are housed in any substations are of prime importance and this maintenance of these components also is equally important. So, we will be seeing the main components which are housed in any air insulated or a gas insulated type of substation the general principle of the operation of these equipments which are installed.

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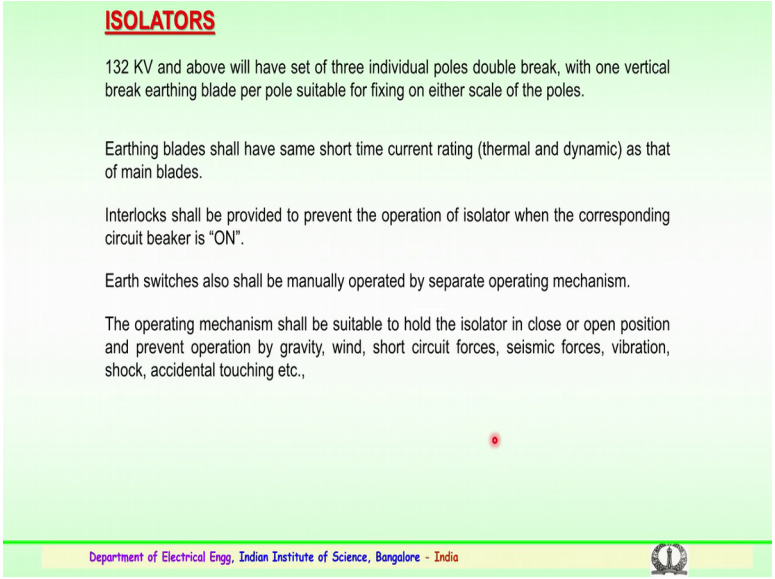

The first component being the isolators which are a very important component in any substation mainly helps in the proper maintenance and the isolating of the circuit during the maintenance aspect. So, 132 kV and above will have set of 3 individual poles which have a double breaking arrangement with one vertical break earthing blade per pole that is very important and this are suitable for fixing on either scale of the poles.

So, this isolators is similar to a circuit breaking arrangement have a earthing blades and have some short time current rating further operation and these are both thermal and could act as a dynamic short time current rating as that of the main blades interlocks are

also provided to prevent the operation of isolator particularly when the corresponding circuit breaker is on. So, the very important point without interlock interlocking facility is also been provided.

So, this earth switches shall also be manually operated by a separate a motor mechanism operating mechanism for a typical in which is being used in any substation for the isolation of the circuits connected with it. So, the operating mechanism shall be suitable and it could hold the isolator either in a closed or in a open position wherever the requirement is there and this will prevent the operation by gravity or by the wind or are those because we have short circuit of forces and could be because of the seismic forces there could be wind or vibration shock and the accidental touching etcetera. So, several of this aspects could influence the operating mechanism of isolator.

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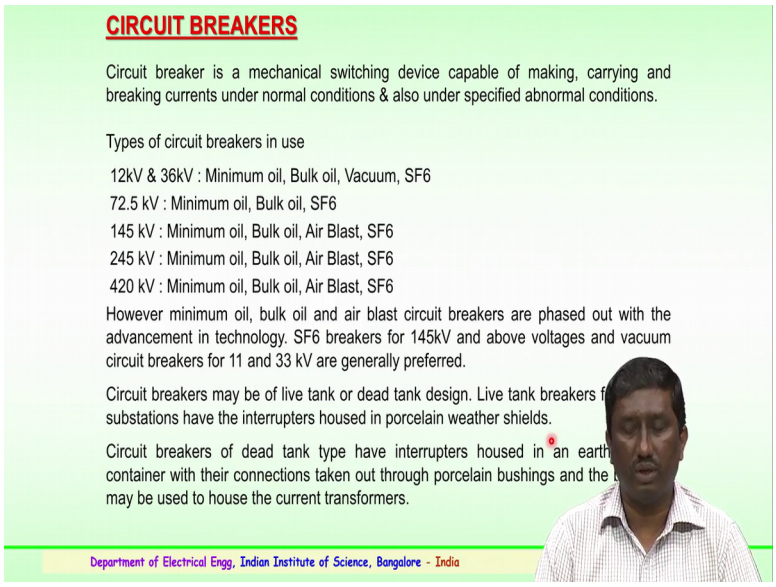

The circuit breaker is a very important switching device which is basically a mechanical switching device and capable of either making and carrying and breaking the currents under normal condition and also under specified abnormal conditions.

So, types of circuit breakers which are in use for various voltage levels a 12 kV and 36 kV generally used or minimum oil or a bulk oil type or vacuum circuit breakers or a SF6 circuit breakers sulfur hexafluoride insulation media. So, for more than 36 kV again a minimum bulk oil minimum oil bulk oil or SF6 are available for voltage levels of 145 kV

and above a minimum oil MCB or a minimum oil bulk oil or the air blast or the SF6 a insulating a breakers are generally use in a substation.

Similarly, for a 220 kV and above 420 and above either minimum oil or a bulk oil type a air blast or SF6 these 4 types of circuit breakers are generally apply used for a higher the voltages; however, both the minimum oil the bulk oil and the air blast are faced out with the advancement of technology. So, very the recent advancement because of the SF6 tech technology and having better insulating properties compared to the earlier oil type of or a minimum oil type of breakers. So, voltage levels above 145 kV and above employ SF6 breakers and vacuum circuit breakers are generally used for 11 and 33 kV or a lower voltage levels.

So, these circuit breakers maybe of live tank or a dead tank design, so live tank breakers are generally used for a outdoor substations which have an interrupters housed in a porcelain a weathering shields. So, the circuit breakers pertaining to the dead tank type have interrupters outs housed in a earthed metallic container with their connections which are normally brought out through the porcelain bushings and these bushings maybe used to house the current transformers. So, this is the use of the porcelain housings for the circuit breakers either if it is a dead tank or it is of the live tank arrangement.

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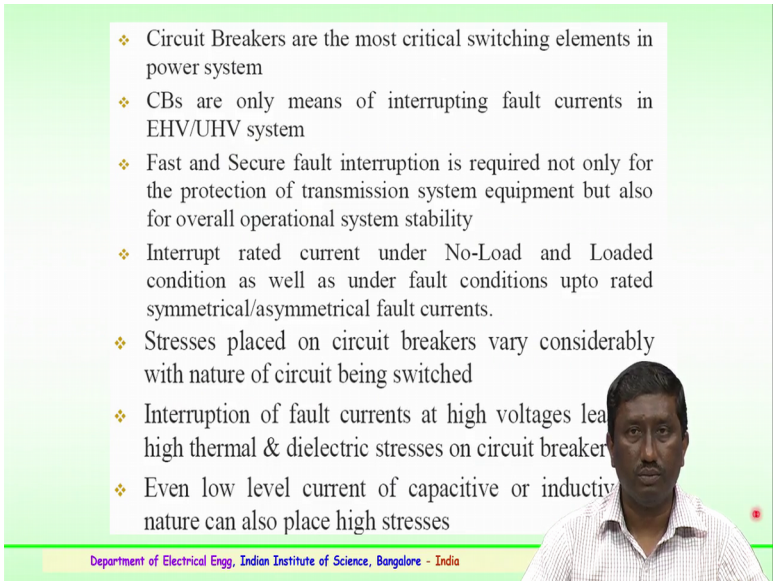

So, these circuit breakers are very important component as said and are most critical switching elements in a power system and circuit breakers are only a means of a interrupting fault currents in the extra high voltage or ultra high voltage a system are very important component. So, we will just focus about the importance of the circuit breakers the type of circuit breakers which are used in the EHV and UHV substations the circuit breakers are very fast and secure fault interruption is required not only for the protection of the transmission system equipment, but also for a overall operational system stability is a at most important point.

The interrupted rated current under a no load and the loaded condition and also under the fault conditions up to rated symmetrical fault currents which should be able to operate circuit breakers are placed on a variably considerable with nature of a circuit involving the being a switched on to the required time and interruption of a fault currents at very high voltage levels could lead to high thermal and the dielectric stress on this breaker.

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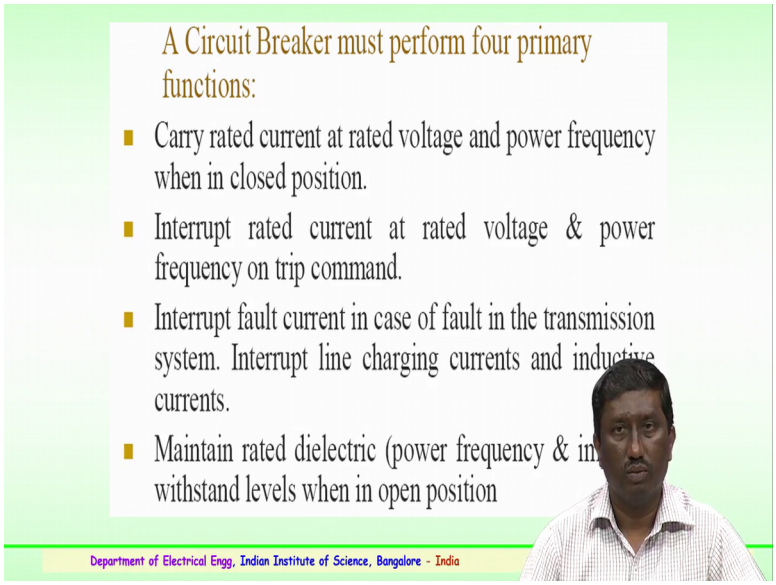

So, this has to be considered in forgoing infer the proper design of the requirement of the breaker even low level fault currents which are of capacity or inductive in nature can also place a very high stresses on the equipment that is in a circuit breaker. So, what are the main the important functions or the circuit breaker has to perform are classified as a follows. So, the circuit breaker should primarily focus in to the 4 important functions it should carry the rated a current at the rated voltage a very important point it should carry

the rated current at rated voltage and power frequency whatever the power frequency voltage which it is intend to operate continuously when in closed position.

So, when the circuit breaker is closed it should able to carry the rated current of the bus bar or the rated voltage which is to be operated and the power frequency 50 hertz or which is a designed in the closed position and it should interrupt the rated current at the rated voltage and power frequency on trip commands. So, once the command pertaining to the opening of the circuit breaker is given it should be able to interrupt at that supply current or rated current which it is being operated.

So, these interrupt fault current in case of fault in the transmission system also interrupt line charging currents and induction currents. So, it should be able to interrupt any fault currents which are generated because of the transmission system and the final point to ways in his it has to be maintain the rated a dielectrics that is the insulation properties both for the power frequency and the impulse or the search withstand levels when it is in open position.

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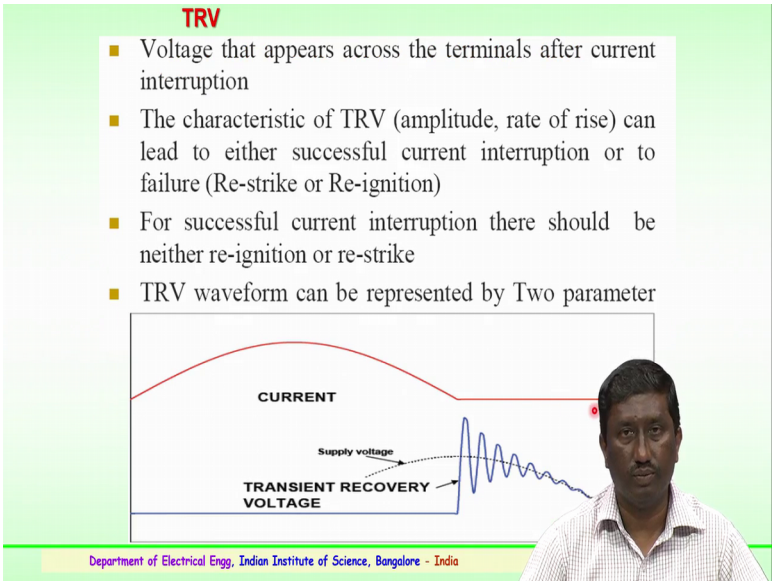

So, the insulation properties of the circuit breaker are also equally important for power frequency and surges which it withstand during the opening of the circuit breaker with the transient recovery voltage is a very important term in the characteristics in the circuit breaker, so voltage which appears across the terminals of the current interruption. So, the characteristics of the transient recovery voltage that is both the amplitude and the rate of

a rise this could lead to either successful current interruption or to the failure because of a re strike or re-ignition a re-strike or re ignition.

So, for successful current interruption there should be neither re-ignition nor a re-strike. So, this has to be done. So, that the characteristics have to be successfully quenched without the re-ignition or the re-strike. So, the transient recovery voltage waveform is generally represented by the 2 parameters which are senior the current waveform which is indicated in the here and the transient a recovery voltage or waveform you can see the transient and the recovery voltage the supply voltage is somewhere here the which is the dotted line and this is the transient recovery voltage over a period of time. So, very important it should be able to see the successfully interrupts the re-strike or the re ignition which is happened.

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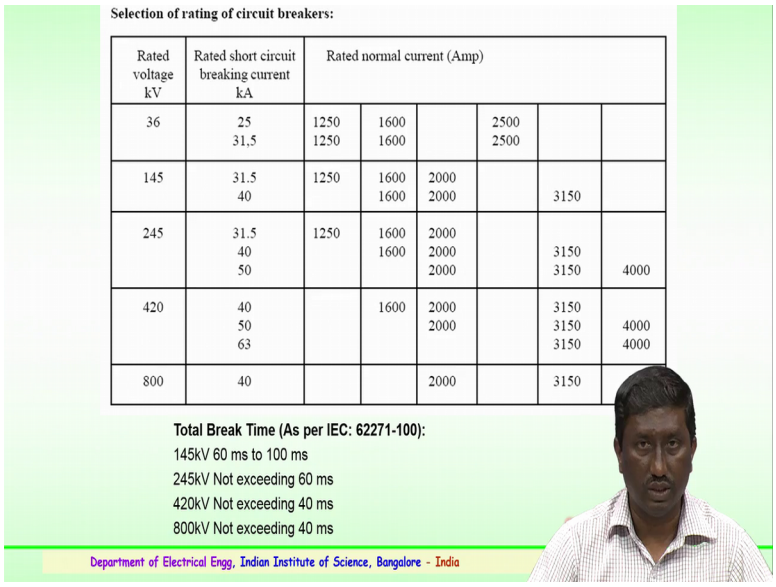

So, how to select the rating of a circuit breaker is again an important planning which has to be carried out by the substation designers for various voltage levels. So, some of the typical technical details are given here as per the international standards which are available you can see the rated voltage levels from a very low 36 kV to the 800 kV a voltage levels the requirement for the circuit breaker the rated a short circuit a breaking capability or the current in terms of kilo amps for a 36 kV it should be able to break the current at 25 on 31.5 kilo amps as the voltage level increases you can see for a 800 kV or a EHV that is a 420 and above the rated short circuit breaking current should be able to

break 40 to 263 amps; kilo amps sorry and for a 800 rated voltage minimum of 40 kilo amps should be the rated short circuit breaking capability of circuit breaker and the normal rated current in terms of amperes you can see for a 800 kV system the normal rated normal current could be anywhere between 2000; 2000-3150 amps for a voltage, it becomes for a lesser voltage it could be a 1600 amps the rated normal current which it sees.

So, the total break time as per the international standard that is 62271 clearly mentions about in case 145 kV voltage level the circuit breaker should be able to operate within a 60 minutes milliseconds to 100 milliseconds and in case of 245 kV, the total break time which is mentioned as per standard should not exceed more than a sixty milliseconds and for UHV transmission substation or EHV transmission levels more than 420 kV, it should not exceed 40 milliseconds and for 800 kV it should not exceed 40 milliseconds.

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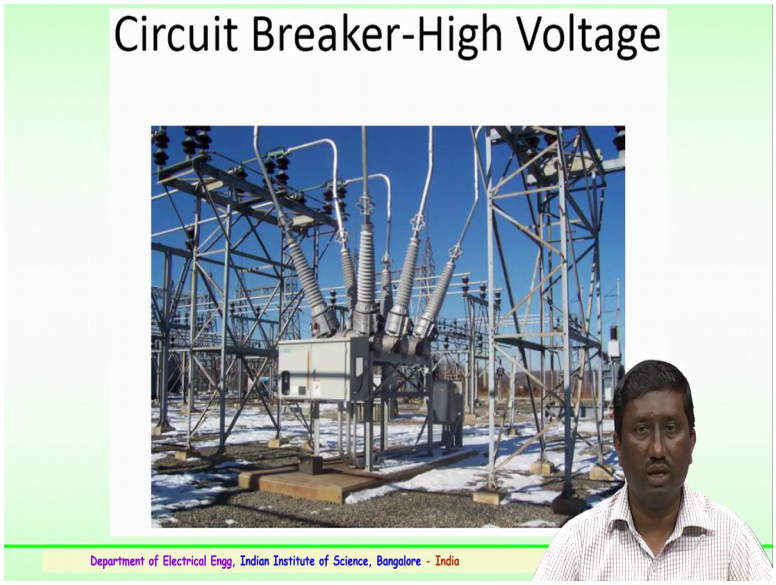

So, these are the a total break time as per the international commission which has been specified for the selection of the circuit breaker a ratings.

So, this is a typical example for a high voltage or extra high voltage circuit breaker looks you can see it has to perform a various functions has mentioned earlier a huge equipment which is to be in the circuit and it has to properly function either making or the breaking of the circuit whenever it is required.

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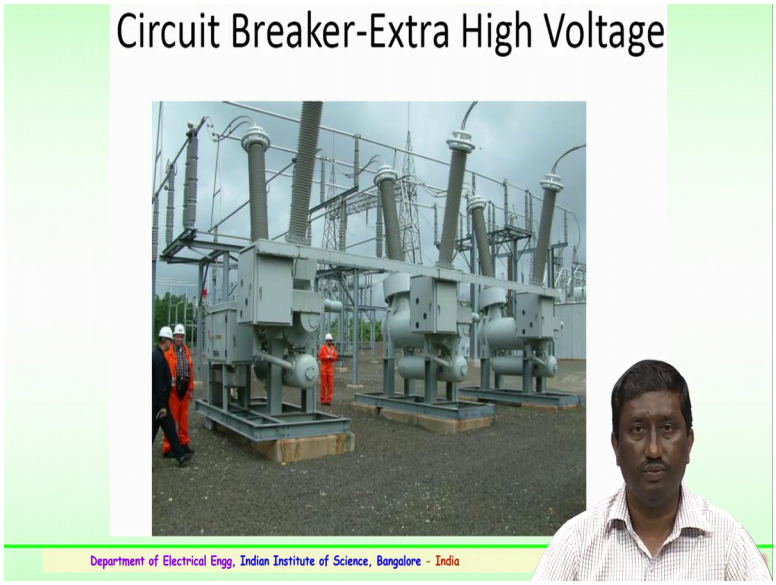

So, this again is one of the typical example for the extra high voltage circuit breaker which is being employed for a very high voltage or ultra high voltage levels.

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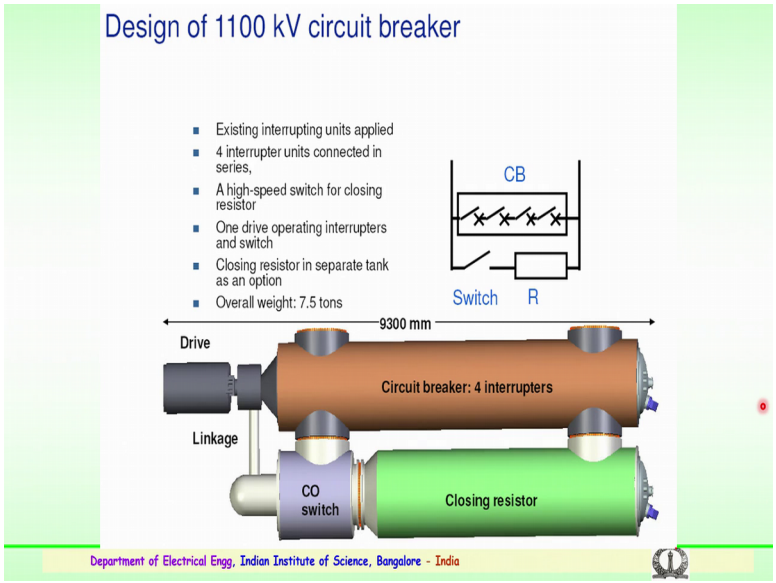

Further with the development of the SF6 technology a sulfur hexafluoride insulating media is used as a insulating a property. So, here again design of the circuit breakers with SF6 technology as a gained a importance in the recent us and several of the breakers with SF6 technology are being employed for the a higher the voltage EHV and UHV air transmission levels consisting of above the interrupting units with several interrupting

units are connected in series it is an advantage and also high speed a switch for a closing the resisters. So, several options are been available and designs are available from various manufacturers as the globe.

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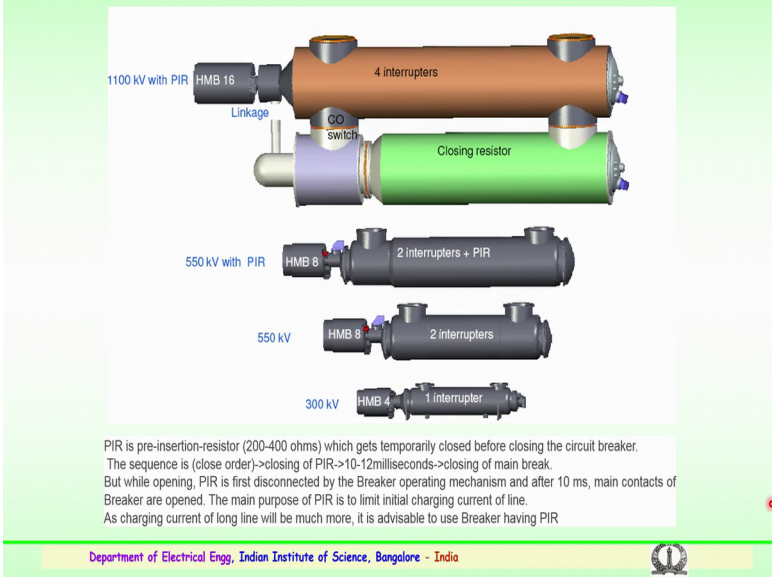

So, the weight of the circuit breaker has also drastically reduced by going infer a SF6 technology. So, for thousand the 100 kV various type of circuit breaker from different voltage levels are just highlighted here you can see for 300 kV with single interrupter for 550 kV with 2 interrupters and 550 kV with PIR, what is PIR is very important pre insertion resisters. So, why this pre insertion registers are used for circuit breaker we will discuss about this and this circuit breaker again is used for 1100 kV with the PIR. So, the technology as advanced and the compactness of the breaker as also been achieved by going in with the SF6 technology. So, this a PIR; a pre insertion resister is a very important which is being used in the circuit breakers generally it is 200 to 400 ohms and which this gets temporarily closed before closing the circuit breaker the sequence is operation of the circuit breaker use the closing of the pre insertion resister after closing of the pre insertion resister with a gap of 10 to 12 milliseconds the closing of the main circuit takes place a circuit breaker contact takes place. So, this is the important function how it is important see when again in opening the pre insertion a resister is first disconnected by the breaker operating mechanism and after ten milliseconds the main a contact of the breaker are generally opened.

So, this is the mechanism of the use of the pre insertion resister in the circuit breaker the main purpose the main important purpose of using the pre insertion resister used to limit the initial charging current of the transmission line. So, as the charging current of long line will be much more. So, it is advisable to use the breaking breaker with a pre insertion resister. So, few of the examples are shown here for the very high voltage with for a 550 kV with the pre insertion resisters similarly for 1100 kV. So, the PIR serves to limit the initial charging current of a long line and it is advisable to use the breaker for better protection above EHV levels with the PIR inserted with the breaker.

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So, that was about the in some of the important components which are in the substation continuing that a insulation a coordination is a very important aspect for the proper design of the substation or the transmission or any of the equipment electrical equipment which is a being used for the very high voltage levels.

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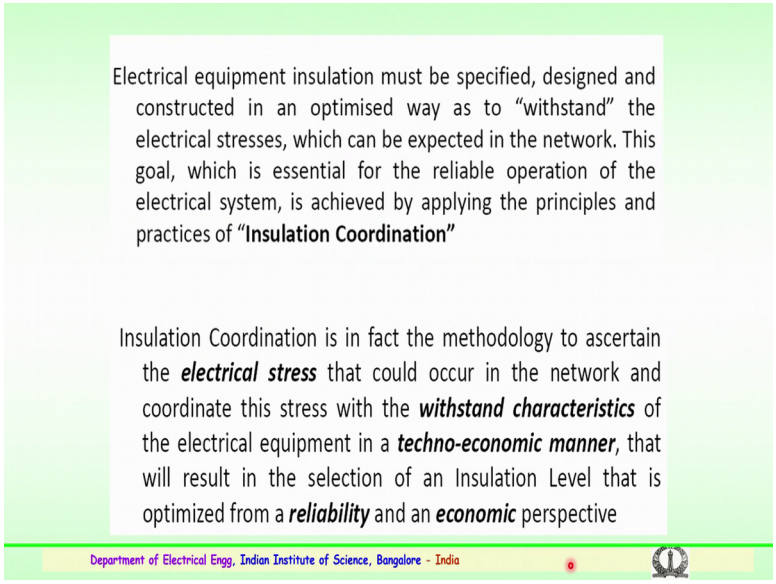

So, the electrical equipment we know that the insulation or dielectrics must be specified a designed and constructed in an optimized way this we have try to discuss with the comparison and the main intension of going infer insulation withstand not only to see that it has to be in optimized way and also to see that it withstands the electrical stresses for a long period of time which can be expected in the electrical network the main goal is also to see that it essential for the reliable operation of a any electrical system and this has to be achieved by applying the principles and practices of a insulation coordination as the voltage level goes high higher and higher at extra high voltage and ultra high voltage the planning of insulation coordination gains are very important or is considered to be an important aspect for a very high voltage levels.

So, the insulation coordination is in fact, the methodology which will help to a certain the electrical stress that could occur in maybe electrical network and this will coordinate with the stress with the withstand characteristics of the electrical equipment in a techno economic manner that is important point to be considered techno economic manner. So, it should be also economical it should be technically viable. So, that the result in selection of the insulation level that is optimized form reliability and an economic perspective so, the insulation co-ordinate coordination a place a very vital role above a 400 kV or EHV or UHV transmission substitution or insulation aspect.

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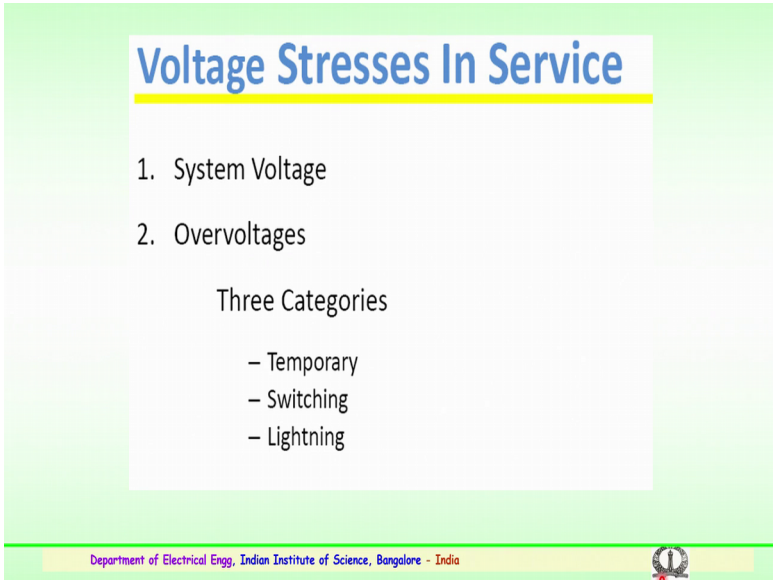

So, various voltage stresses in service we have discussed earlier the main is the system voltage and the overvoltages again the overvoltages are categorized into a temporary overvoltages which could be for a few cycles a few tens of milliseconds and light switching surges again it switching could be of the operation of the a circuit breakers a closing and opening of the circuit breakers or any other switching activity and lightning is mainly caused by the natural lightning the lightning surges which impinge on the transmission or the distribution network could create the voltage stresses in the insulation of the equipment in service.

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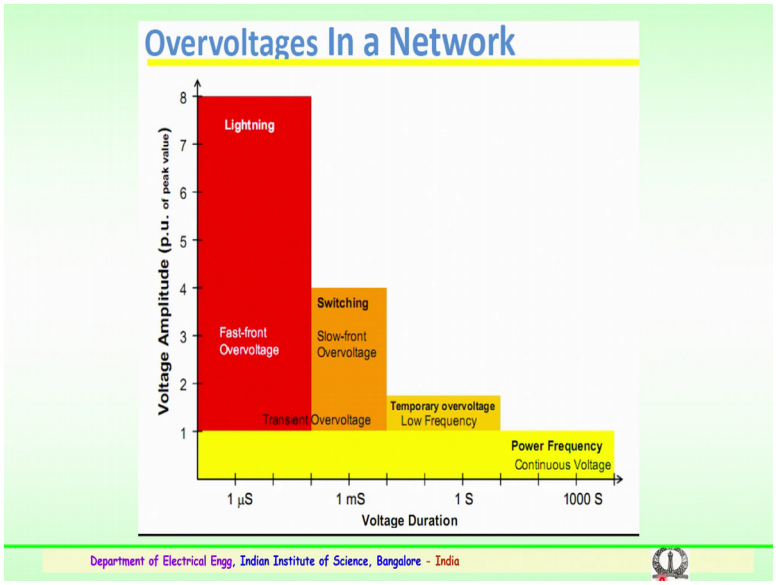

So, this overvoltages in any network when you look in to this graph which shows the amplitude that is a voltage amplitude in per unit of the peak value was the y axis and x axis become is shown as the voltage duration that is of time period in a seconds you can see here for the lightning aspects in case of the lightning the surges which are developed because of the lightning activity could be a very fast fronted type of a overvoltage surges.

So, earlier we have discussed. So, lightning a overvoltages could be of the fast fronted nature that is a very stiff fronted or could be of in microseconds that is 1.2 microseconds could be a front and the tail could be anywhere between 50 microseconds. So, this lightning surges could be of a very high magnitude and fast fronted the second surges are of switching in nature the switching again because of the closing or the opening of the circuit breakers this switching surges are comparatively slow fronted surges are overvoltages this low front again it could be 250 milliseconds there it is a microseconds 1.2 microseconds this 250 milliseconds sorry microseconds and 2500 microseconds.

So, the surges of switching have a typical level shape of 250 by 2500 microseconds apart from lightning and switching surges we have a temporary a overvoltages which could last for few cycles this again are of low frequency could be of the power frequency or related overvoltages slightly above the normal operating voltages and finally, the entire power frequency voltages which are in continuous in nature where the electrical stress on the insulation lies this will be for a longer period of time. So, this gives the clear differentiation between a various surges or the transients overvoltages light switching lightning and temporary overvoltages which are of low frequency and the power frequency which could be for a very long period of time these are various overvoltages which occur in a transmission or a distribution network.

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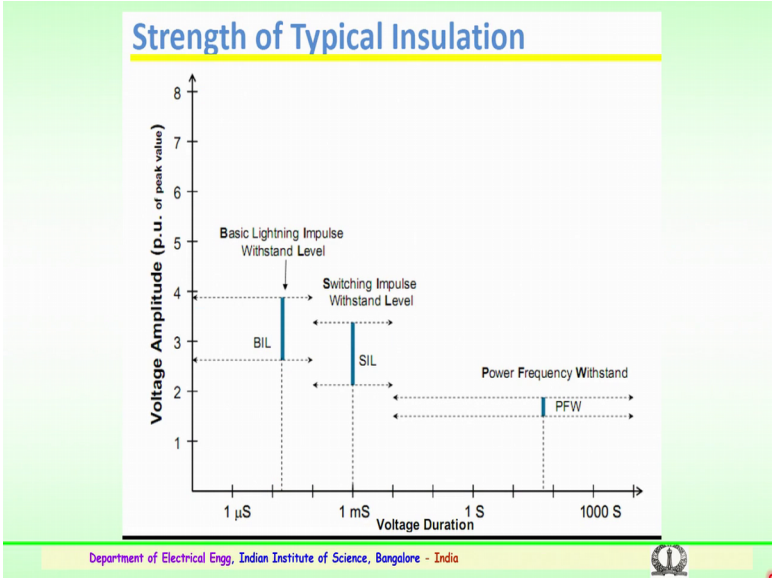

So, how the strength of a typical insulation is estimated you can see here this graph gives the voltage amplitude per unit of peak value again versus the voltage at duration this gives you the basic insulation a level in case of the lightning impulse a withstand of the equipment or the switching impulse or switching surge withstand impulse level including the surge impedance a loading of any equipment. So, the power frequency withstand is given for the voltage amplitude which is shown as the per unit. So, you can see the basic lightning impulse withstand level could be anywhere between 4 a per unit, but the basic insulation level is 2.823 per 2 point less than 2.8 per unit for switching impulse or switching surges withstand it could be 3.5 with surge impedance loading on lesser than that it could be 2 to 2.2 per unit and for power frequency it could be around 2 per unit of the peak value where this surges or the typical insulation strength of the equipment is considered what are the insulation levels and the clearances this also have been discussed earlier.

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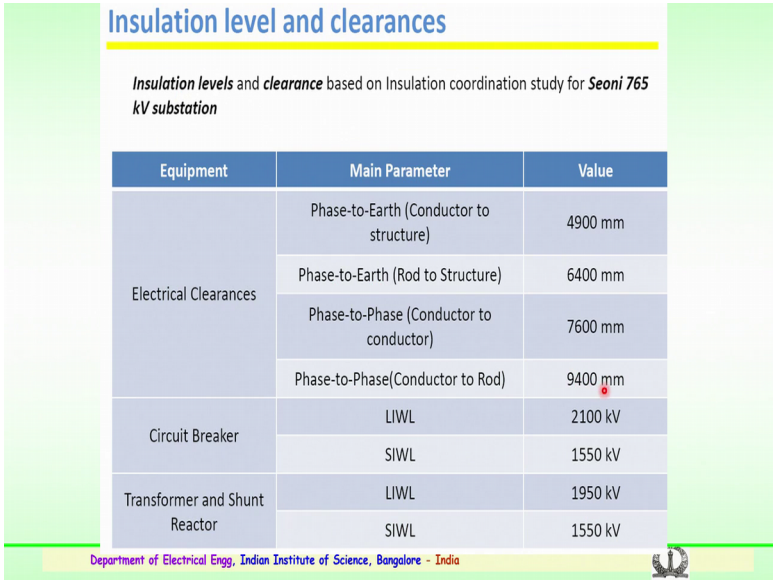

So, insulation levels and clearances are very important and this will be based on the proper a design or insulation coordination studies which are to be conducted a typical example for one particular substation in the country that is a Seoni substation of 765 kV is given here how the parameters are been identified and how the insulation coordination has been done for the actual system of 765 kV substation very clearly you can see electrical clearances which are designed the main parameters and the value are given here the electrical clearances from a phase to earth that is a conductor to the structure the required coordinate value is 4900 millimeter for a phase to earth that is a rod to structure it is 6400 millimeter phase to phase that is a conductor to conductor clearances is 7600 mm for 765 kV substation and the phase to phase conductor to rod it is given estimated to be 9400 mm in the circuit breaker requirements that is a insulation level requirements for a circuit breaker the lightning impulse withstand level LIWL is 2100 kV switching impulse withstand level is 1550 kilovolts for the transformer and the shunt reactor the insulation level required for 765 kV substation is lightning impulse withstand level is 1950 kV and for switching impulse withstand level is 1550 kilovolts.

So, some of the practical information which is being used in the country for a 765 kV ultra high voltage substation these are some of the clearances for the transformer circuit breaker in the shunt reactor.

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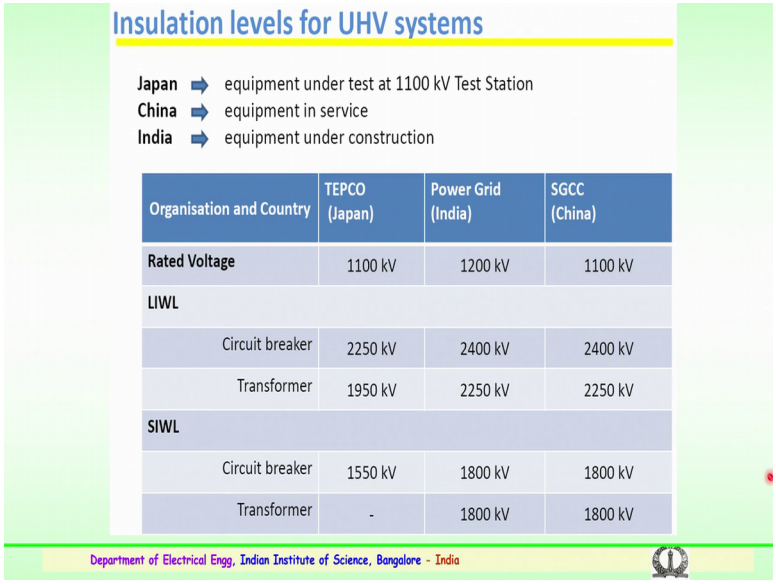

And the values prescribed based on the insulation level and the clearances required similarly insulation levels for a very high ultra high voltage systems a comparison is generally done here we can see for a equipment which are used at a 1100 kV test station in Japan and the equipment which is in service in china and the equipment under construction in India is been given here we can see the first row corresponds to the equipment under test at Japan for 1100; the power grid in India for the values at 1200 kV and in China 1100 kV comparison is been made you can see the lightning impulse withstand values the rated voltages are being 1100 in case of Japan 1200 in case of India and 1100 in case of china the lightning impulse withstand voltage level for a circuit breaker in case of Japan 1100 kV the requirement has been estimated to be 2250 kilovolts in India for 1200 kV it is 2400 kilovolts and the similar voltage level 1100 for in china it is follow 2400 kilovolts for transformer it is nineteen 50 in case of the comparison Japan 1100 kV system it is 2250; 2250 both in china and India for 1200 and 1100 kV respectively.

It is about the lightning impulse withstand for switching impulse withstand for the circuit breaker and the transformer the values are given here you can see both for 1200 kV and 1100 kV the values are identical that is 1800 kilovolts both for circuit breaker and the transformer are being estimated and being planned to be used in the substation for ultra high voltage substation.

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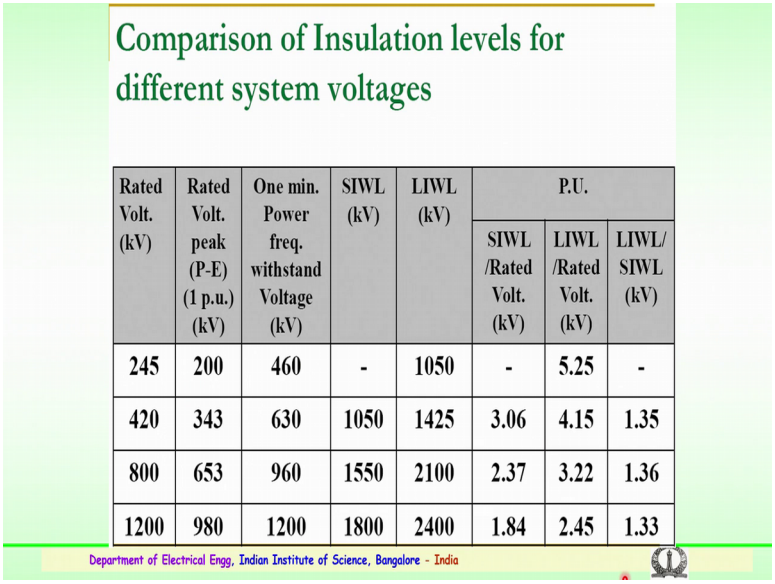

Rated Volt. (kV)	Rated Volt. peak (P-E) (1 p.u.) (kV)	One min. Power freq. withstand Voltage (kV)	SIWL (kV)	LIWL (kV)	P.U.		
					SIWL /Rated Volt. (kV)	LIWL /Rated Volt. (kV)	LIWL/ SIWL (kV)
245	200	460	-	1050	-	5.25	-
420	343	630	1050	1425	3.06	4.15	1.35
800	653	960	1550	2100	2.37	3.22	1.36
1200	980	1200	1800	2400	1.84	2.45	1.33

So, comparison of the insulation levels for a different system voltages are given here based on the estimation. So, you can see here a various a voltage levels from a voltage levels of 220 kV to the EHV level ultra high voltage a levels 800 and 1200 kV the rated voltage a peak one per unit per kV is very clearly given here for 240, it is a 200 for 420 kV it is 340; 3800, it is 653 and for 1200 it is 980 kilovolts.

So, 1 minute power frequency withstand voltage for this insulating system for 245 kV the requirement is 460 kilovolts and for 400 it is 630, 800 kV it is 960 and for 1200 it is 1200 kV. So, it has to withstand for one minute operating voltage power frequency withstand and switching impulse withstand lightning impulse withstand values are also given here for 220 kV system the lightning impulse will be 10 50 and for 2400 kV, it is a 1050 in case of switching and 1425, in case of lightning impulse for 800 it is 1550; 2100 kV and for 1200 it is 11; 1800 and 2400 kV is the specified limits; for the lightning and switching impulse high voltages in case of per unit these gives the values for switching impulse voltage lightning impulse and lightning impulse withstand a level for rated a voltage these are the a per unit values which are being given you can see for a 420 kV, it is 3.06 and for 1200 it is 1.86 and in case of 800; it is 2.3 for switching impulse and for lightning impulse it is 4.15; 3.22 and 2.55, this is a very important aspect to be considered for the various insulation level this gives an idea of the insulation coordination which is being done for the various voltage levels which are being adopted.

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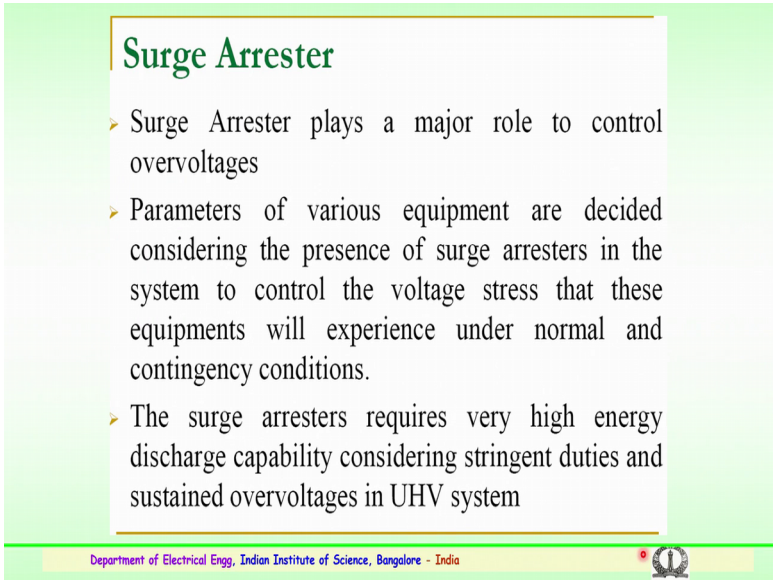

So, the important component of the substation is the surge arrester which is a pays a major role to control or to contain the overvoltages which have been discuss it could be lightning it could be switching or either overvoltages. So, surge arresters plays a major role and proper planning coordination of this is very important the parameters of various equipment are decided considering the presence of this surge arrester in the system and these surge arresters are connected to each phase and ground. So, the system to control the voltage stress that this equipments will experience under normal and also any contingency conditions.

So, the surge arresters require very high energy discharge capability very important as the voltage level goes the current carrying capability the power requirement will be high. So, the substations which the surge arresters are housed have to see the energy discharge capability; so, very important. So, again the energy it could be a distribution it could be a class 1, 2, 3, 4, 5. So, various class of surge arresters are being used for a different a voltage levels to see the energy which is discharge and the surge arresters should be capable of discharging surges are to the ground in a to see the equipment is being a properly protected.

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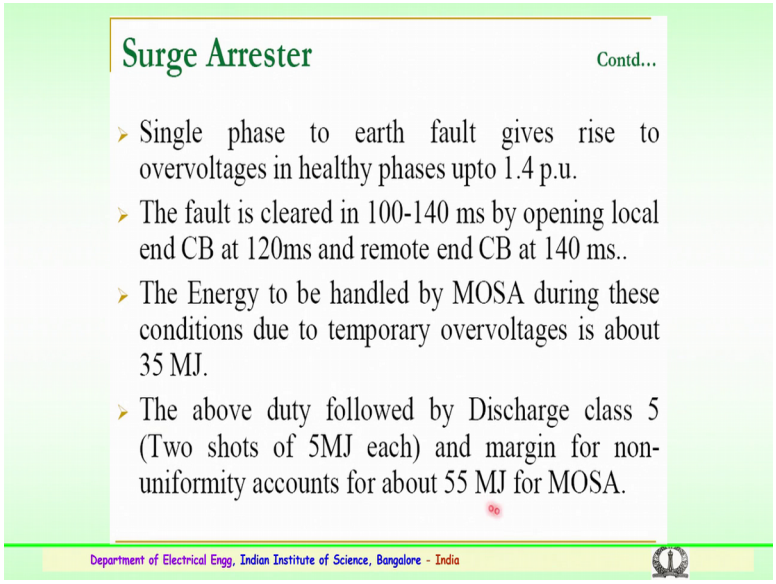

So, the discharge capability is considered with stringent duties and sustained overvoltages particularly in the ultra high voltage system and extra high voltage systems. So, a single phase to earth fault gives rise to overvoltages in healthy phases up to 1.4 per unit. So, the fault is generally cleared in hundred to 140 milliseconds by opening local end circuit breaker at one twenty milliseconds and the remote end of the circuit breaker at one 40 milliseconds.

So, the energy which is to be handled is very important the energy which is to be handle by metal oxide surge arrester during these conditions during the fault clearance conditions or the fault is to be cleared with the opening and closing conditions such a huge energy is to be handle by this metal oxide surge arresters and due to the temporary overvoltages could be about 35 mega joules so, high energy up to 35 mega joules. So, the above duty followed by the discharge class that is a class 5 of the surge arresters the 2 shots of 5 mega joules each and a margin for non uniformity accounts usually for about 55 mega joules per metal oxide surge arresters are used for such a high discharge class.

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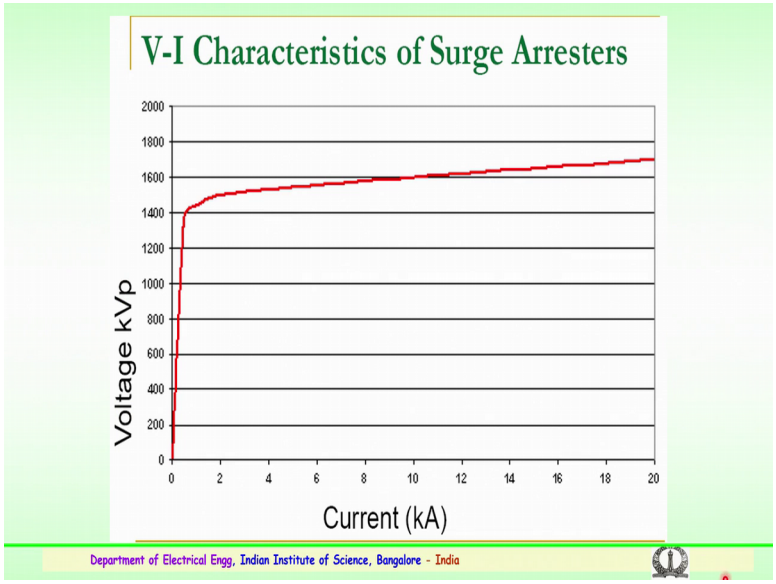

So, when we look into the vi characteristics the volt current characteristics of any a typical surge arrester the y axis shows the kilo volt per peak in magnitude and the current kilo amps in a x axis you can see the characteristics of the surge arrester is typically looks like this where initially rises and tries to stabilize at a current rating after say 8 kilo amps.

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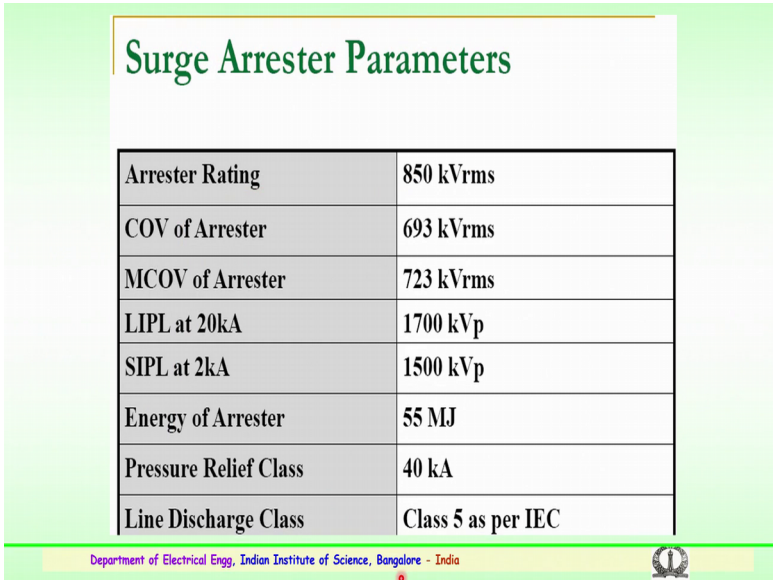

And you can see that disability is emended what are the surge arrester a parameters the surge arrester rating in case if it is 800 and 50 kVrms the continuous operating voltage of

the arrester will be 693 kV. So, for a rating of 850 kilovolts the continuous operating voltage of a surge arrester will be six ninety 3 kilovolt rms.

The minimum continuous operating voltage MCOV of arrester is seven twenty 3 kilovolts and lightning impulse protection level at 20 kilo amps is the 1700 a kilovolts per peak and switching impulse a protection level at 2 kilo amps is 1500 kilovolts per peak the energy of the arrester which is to be diabeted will be 55 mega joules and pressure relief class is 40 kilo amps the line discharge class is class 5 as per the international electro technical commission. So, this technical parameters are for UHV ultra high voltage range more than 765 kV level protection system which is being used in the substation so, or higher the 1100 kV or 1200 kV systems.

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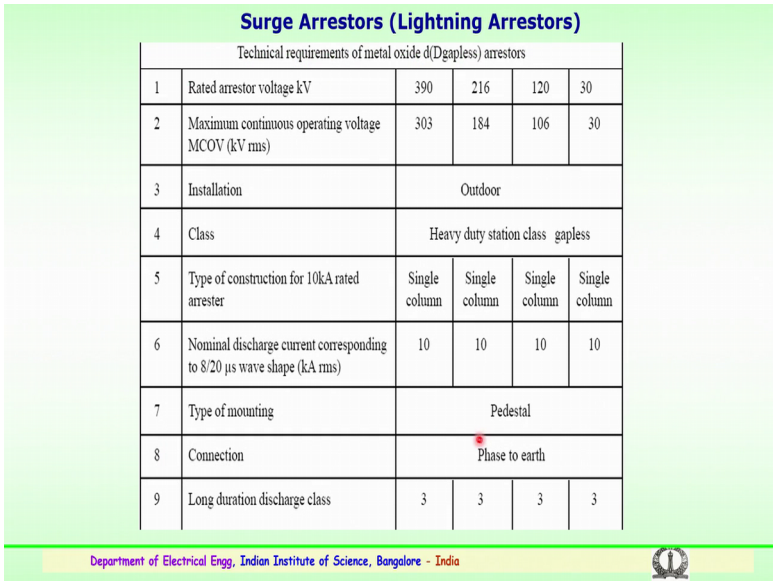

So, similarly some of the technical requirements or is a metal oxide gaplessed arresters again arresters are basically a classified into gapped and gapless liked to mention here the old technology the technology which was earlier used was gap type of arrester containing the silicon carbide elements stack one above the other with gaps in between each blocks the recent technology is using the metal oxide a zinc oxide based arrester elements which are stacked one above the other without a gap. So, that is a reason which is known as a gapless a type of arresters which is of a recent technology being used for the extra high voltage and a ultra high voltage a transmission a system.

So, this table gives information about various voltage levels of the arrester which is being used rated arrester voltage 322 116 120 33 kV class and the maximum continuous operating voltage level is given here and typically installation is outdoor a class could be heavy duty station class that is a gapless type of arresters are employed. So, type of construction for ten kilo amps rated arrester it should be single column it will be single column if the voltage level goes higher and higher the surge arresters have to be imparallelly connected and going for 2 or a multiple columns and normal discharge current corresponding to the lightning impulse of the surge arrester at eight by twenty microsecond wave shape will generally be a 10 kilo amp rms for all the type the type of mounting will be pedestal these are some of the technical aspects of the lightning arrester which are used for lower high voltage class less than 400 kV and the long duration class is class 3 and there are class 2, 3 and 4 and 5.

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10	Ratio of switching impulseresidual voltage to rated arrester voltage	2	2	2	2
11	Minimum prospective symmetrical fault current for pressure relief unit (kA rms)	40	40	31.5	25
12	a) Terminal connectorsuitable for ACSR conductor size b) Take off	Single moose/ Zebra vertical	Single moose/ Zebra vertical	Single moose/ Zebra vertical	Single panther/ Dog vertical
13	Corona extinction Voltage (kV rms)	Rated voltage of the arrester			
14	Maximum radio interference voltage when energized at MCOV (micro volts)	1000	1000	1000	500
15	Whether insulator base and discharge counter with milli ammeter are required	yes	yes	yes	yes
16	Minimum creepage distance of arrester housing (mm)	10500	6125	3625	900

So, ratio of switching impulses these are some of the technical parameters for switching and a symmetrical fault current in case of pressure relief has to be operated. So, these are the values particular amps rms and the corona extension it depends on the rated voltage of the arrester the corona extension voltage as to be defined by the rating of the arrester and what is the maximum interference in a radio interference with the energized minimum continuous operating voltage it should not exceed 1000 micro volts or 500 micro volts if the voltage is very less and the minimum creepage distance of the arrester housing a requirement again it depends on the voltage level here.

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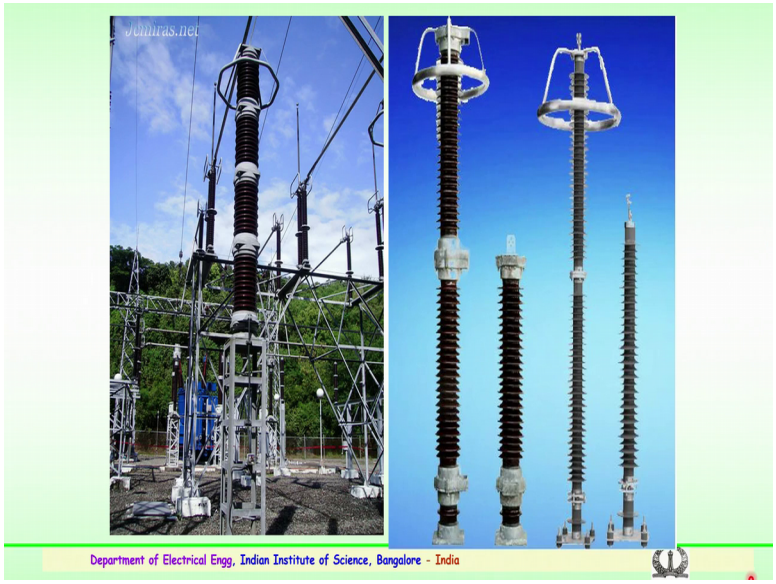

This is the creepage length which has been technically given. So, this shows the typical surge arrester which is being used for a EHV or a UHV transmission the column of the ceramic bushings containing the number of elements in blocks zinc oxide blocks which are housed in this a ceramic housing a similar surge arrester is shown here.

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So, these are typical examples which are used for the EHV and UHV transmission systems again this figure shows the surge arrester or a zinc oxide blocks these are the zinc oxide blocks which are a stacked inside the porcelain housing with suitable pressure

relief arrangement and pressure valves in case of emergency. So, this is how the blocks are rated for a various classes from the distribution class 1, class 2, class 3, 4 or 5 which are being used for ultra high voltage systems a very important component and the insulation coordination is mainly to see that the equipment like the transformer the switch case are protected.

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So, surge arresters plays a very important role in the substation for the coordination of the insulation this is one of the example which of a first prototype of a 850 kV surge arrester which is being used for 1200 kV system is shown here it consists of a multiple a stacks 4 stacks parallel stacks combined with several zinc oxide elements housed in this ceramic shells. So, this is one of the first type of a design when required for a 1200 kV experimental line in the country was developed.

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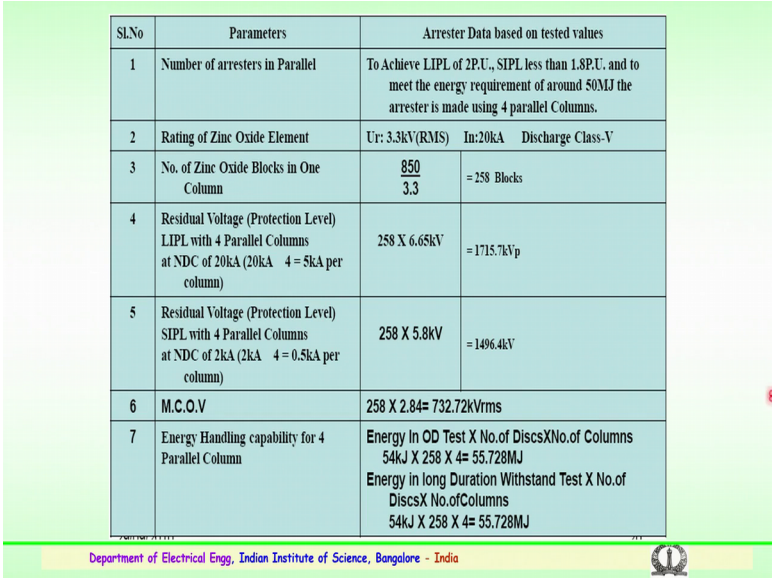

Some information about the parameters and some arrester details are based on the values how the rating of the element is calculated the information is available in the a standards pertaining to the surge arresters, but anyhow could i would like to give some information on how the number of a blocks are chosen for a particular a rating. So, you can see here depending upon the discs number of disc in case it is used for the discharge class 5 the rating of the disc continuous the rating of the disc could each be 3.3 kilovolts.

So, in case of the 3 point rating of the zinc oxide element that is a block is 3.3 kV rms used for 20 kilo amp level and the discharge class is 5. So, how many blocks in one column it is estimated that 850 kV is the voltage level divided by the 3.3 will give 258 arrester blocks to be used. So, the residual voltage or the protection level lightning impulse protection level with considering 4 parallel columns at 20 kilo amps is 5 kilo amps per column. So, it comes down to as 4 columns are there. So, 258 blocks into 6.65 kilovolts will give you 1715.7 kV peak is the total residual voltage of the surge arrester of 850 kV rating.

So, similarly residual voltage protection level for switching impulse with 4 columns comes to 1496 kilovolts again this is calculated based on the number blocks and the voltage level switching voltage level of one single arrester. So, it comes to 1496 kV then minimum continuous operating voltage of the arrester is 2.84 it will be 3.3 kV disc. So, 2.84 is the minimum continuous operating into 258 blocks will give you 7 132 kV rms

the energy handling capability for 4 columns as shown here this 4 columns will be the operating duty test into number of discs into number of columns this will be typically 55.78 mega joules which is very high. So, the energy in long duration withstand test again it depends on number of discs into number of columns say 54 kilojoules into 258 into 4 it is 58; 55 mega joules of energy has to be handle by the arrester elements.

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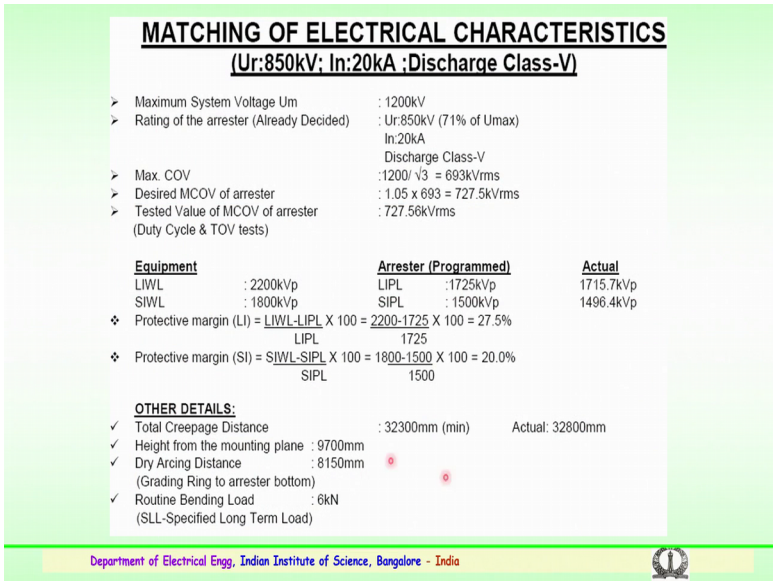

So, this is again the matching of electrical characteristics which are used for 1200 kV a system operating voltage is 850 kV for a voltage current rating of twenty kilo amps in discharge class as mentioned earlier class 5. So, the maximum system voltage is 1200 kilovolts the rating of arrester which is already decide is 850 that is seventy per one percent of the maximum voltage which is operated 20 kilo amps discharge class. So, maximum continuous operating voltage will be 1200 by root 3693 kilovolts; the desired minimum continuous operating is 725 727 kilo volt rms.

So, the tested value of the minimum continuous operating of arrester both for duty class and for transient conditions is seven twenty seven. So, the equipment which is tested is lightning impulse withstand and switching impulse withstand high voltage levels is 2200 and 800 kV respectively and in case of programmed case lightning arrester lightning impulse protection level is 1725 and a switching is 1500 kV, but actually it is 1715 and 1496. So, the protective margin is higher for both lightning impulse and switching

impulse. So, other detail of estimation like the total creepage distance of the entire arrester housing is 32300 mm which actual requirement is 32800.

So, height from a mounting plane is nine thousand seven hundred mm and dry arcing distance 8150 mm the grading ring to arrester bottom and the routine bending load specified long term load is 6 kilonewton. So, these are some of the technical parameters which are required to be estimated for the 1200 kV lightning arrester which is being housed in the substation.

Thank you, we will continue.