Advances in UHV Transmission and Distribution
Prof. B Subba Reddy
Department of High Voltage Engg (Electrical Engineering)
Indian Institute of Science, Bangalore

Lecture – 08
Planning of High Voltage laboratories

Good morning. Before actually going in for the high voltage testing in the laboratory, it is very important to plan the laboratories to conduct the high voltage test and also the laboratories which could be useful for the research activity and training aspects. So, proper planning of high voltage laboratory is essential before the equipment is being evaluated.

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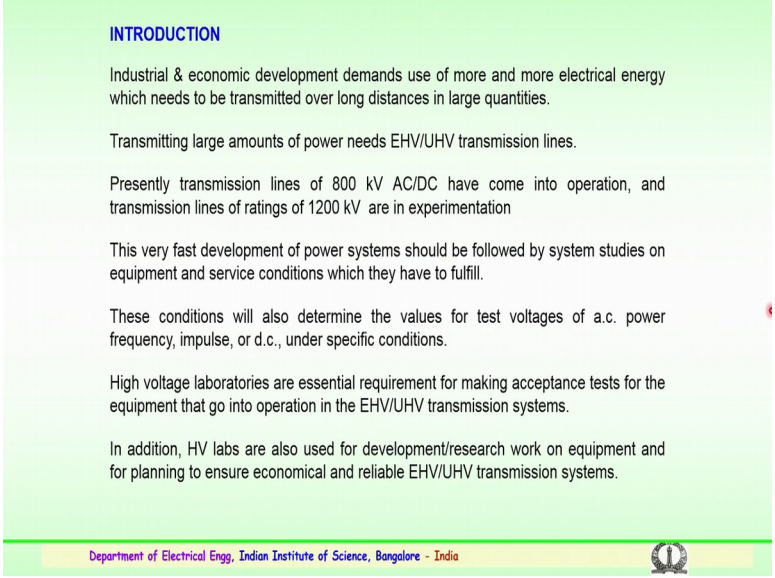

So, we were discussing about the importance of the industrial and economic development which demands the use of more and more electrical energy. This electrical energy needs to be transmitted over long distances and large quantities. So, in case of HVDC line large amount of power could be transmitted.

So, large amount of power needs you know that extra high voltage ultra high voltage transmission lines. So, in the country presently there are several 765 or 800 KV AC and few 800 KV DC lines which have recently been in operation. And also the transmission voltages of 200 KV are in experimentation. So, this very fast development of power systems should be followed by the system studies on the equipment and the service

conditions which they have to full fill in the field. So, these conditions will also determine the values of the required test voltages, it could be of AC power frequency voltages of 50 hertz or impulse of lightning which is 1.2 by 50 microseconds or switching impulse of 250 by 2500 microsecond or an oscillatory type of impulse which is seen in the field. Or it could be a DC voltage under specific conditions.

So, the high voltage laboratory switch are to be plan should be or essential requirement particularly for making the acceptance test for the equipment that go into operation. Particularly in case of extra high voltage and ultra high voltage transmission systems, in addition, these high voltage labs are also used for the development work and research work on various equipment and do plan to ensure that the economical and reliable equipment needs to be used in the EHV and UHV transmission systems.

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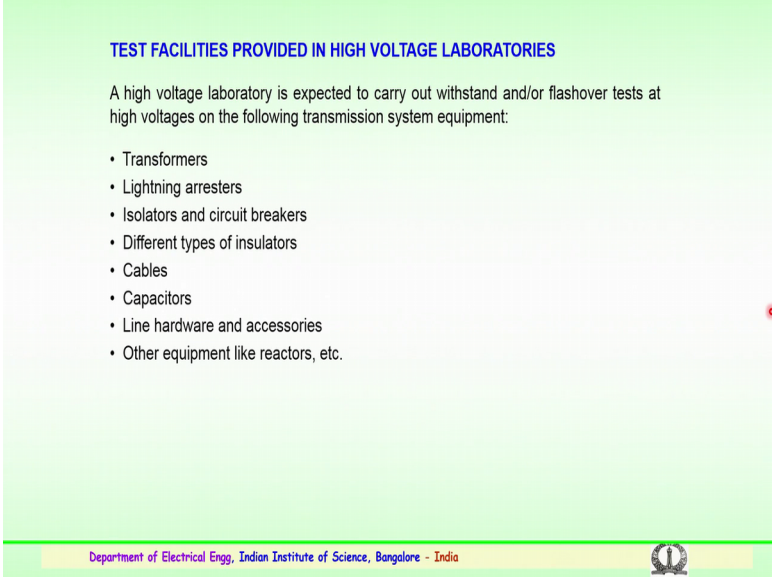

So, what are the test facilities which could be provided in the high voltage laboratories for the research developmental and testing aspects? So, the high voltage laboratory is expected to carry out withstand that is for a duration specified by the standards, for what time the equipment could withstand in case of the searchers which it is in the field conditions, and could be a flash over tests. So, it could be a withstand test or a flash over test at appropriate high voltages.

And this withstand or flash over tests could be conducted on the following transmission equipment like transformers again transformers will be tested for AC withstand impulse

withstand chopping wave chopped wave and so on lightning arresters again lightning arresters have to be tested for a various (Refer Time: 04:31) it could be lightning impulses of 8 by 20 a switching impulse of 30 by 60 microseconds a high current test of 4 by 10 microseconds. And a long duration test which ranges upto few milliseconds. So, apart from that there is also the operating duty cycle test which the lightning arrester will undergo in the laboratory where both the AC and the impulse currents are (Refer Time: 05:03) on the surge arrester on lightning arresterso apart from that the tests on isolator and circuit breakers it could be different types of insulators ceramic porcelain glass or a polymer type of insulators.

Various types of cables capacitors test on line hardware like the corona control rings Euclid's various type of accessories could be of midspan compression joint repair sleeve vibration damper so on and so forth. Apart from this some other equipment like the reactors etcetera are also to be tested in the laboratory. So, any high voltage lab is expected to carry out both withstand or a flash over test and certify this equipment for the use in the field.

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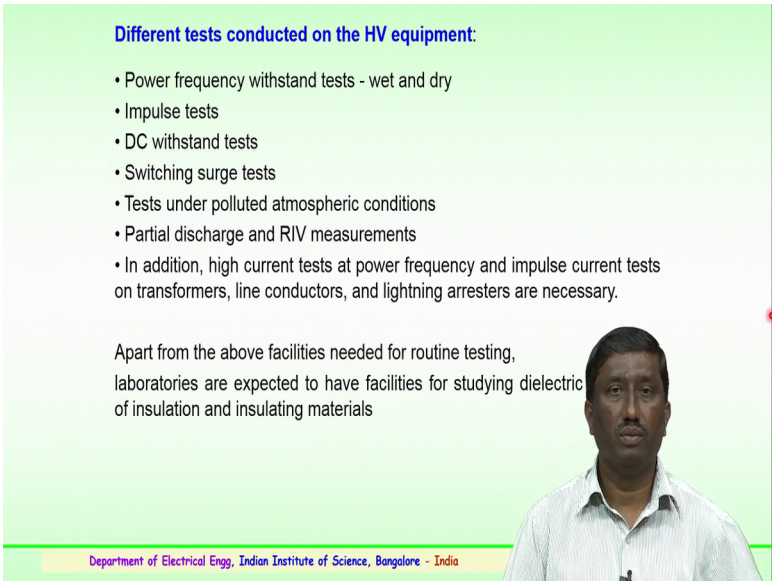

So, as mentioned earlier various type or different test are normally conducted on HV or high voltage equipment include the power frequency at which scientist wet and it has to simulate the rain conditions and dry condition. So, the equipment will be tested for the power frequency withstand could be a 1 minute or a 5 minute time interval wets with

rain and dry conditions. So, impulse test again impulse test appropriate to the voltage of the equipment which is to be tested. Impulse test could be of lightning impulse a very short duration or switching impulse of higher duration, and sometimes it could be a oscillatory type of impulses which are required to test the laboratory or a chopped type of impulse either it could be on the front side front or in the tail.

Then DC withstand test again it is specified voltages specified time would be of 1 minute or 5 minute with standard DC test for a cables capacitors and so on. You have switching surge switching surge again is of 4 voltage applications it is 250 by 2500 microseconds in case of lightning arresters could be 30 by 60 microseconds.

So, apart from this test under polluted or contaminated environment have to be carried out on various type of high voltage equipment most of this equipment will be operating in the outdoor environment. So, the contamination or a polluted test is essential for the equipment. Apart from the polluted or contaminated partial discharge very important for the cables transformers and other equipment which are to be performed in the lab then radio interference voltage measurements this is a very important measurements which are carried out in the high voltage laboratory for various high voltage equipment, it could be for insulator strings the line hardware the conductor transformer or many equipment where this test is important needs to be done at the laboratory. In addition high current test power frequency and impulse current tests on transformers line conductors and lightning arrester are equally necessary.

So, apart from the above facilities which are normally needed for routine testing the laboratories that is a high voltage laboratories are expected to have facilities for studying the dielectric properties are important very important to study the electric properties of insulation and the insulating materials so very important. So, lab should be equipped with all the facilities and also should have to cater to the requirement of the studies on insulation insulating materials.

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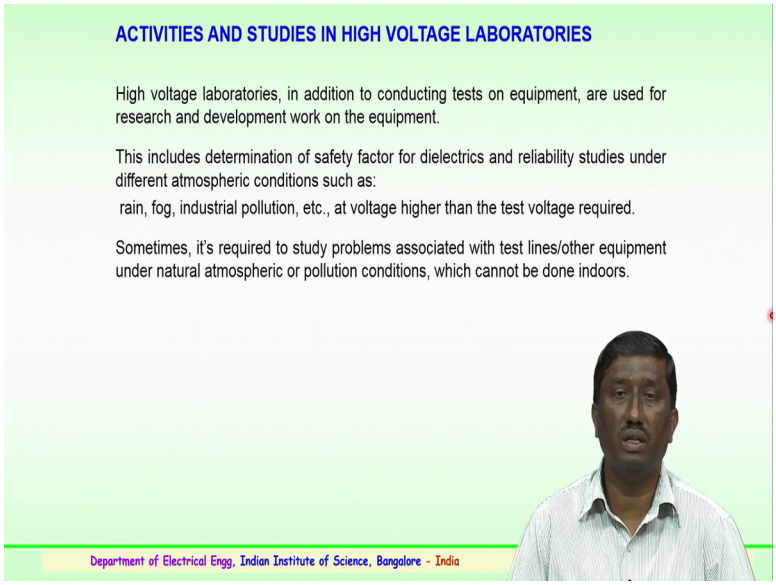

So, activities and studies which could be done in the high voltage laboratories: in addition to the test which mentioned earlier on various equipment. The lab should cater for the research and developmental work which could be carried out on various equipment this is very important. This could include determination of the safety factor particularly for dielectrics and reliability studies under different atmospheric conditions. This could be due to the effect of rain fog mist or industrial pollution or contamination extra at very high voltages than the test voltage required.

So, sometimes the laboratory should be able to provide and required to study the problems which could be associated with the test lines and other equipment under natural atmospheric or pollution conditions, which normally cannot be done indoors so very important. So, laboratory should be able to cater these requirements.

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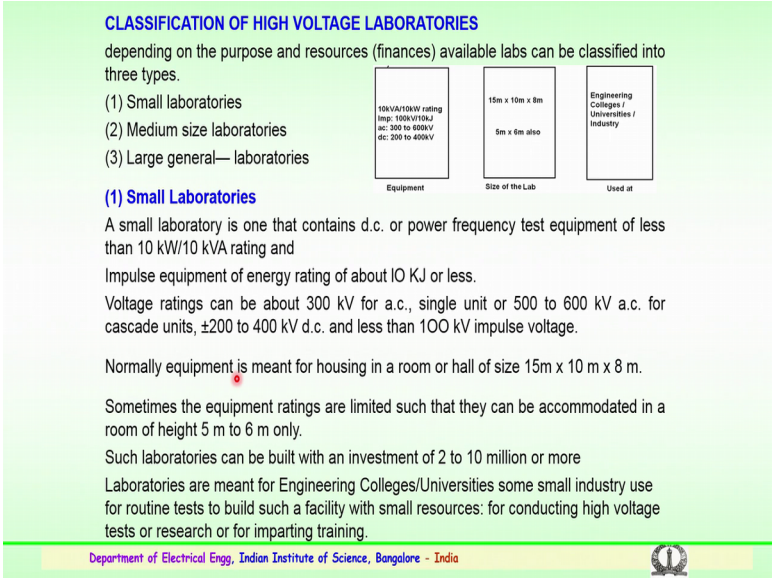

So, coming down what are the various types of classification of high voltage laboratories. So, depending upon the purpose and resources available the laboratories can be classified broadly into 3 types. One is the small laboratory the second being the medium size laboratories the third being the large laboratories or high voltage laboratories which could be used for testing and certification of the high voltage equipment. So, we will discuss one by one the importance of the laboratories and where these laboratories are useful.

So, first we focus on the small laboratories. A small laboratory could be a one that is (Refer Time: 11:50) that could contain DC or power frequency AC equipment of less than 10 kilowatt or 10 KV rating and here in the small laboratories impulse equipment could be of energy rating anywhere between 10 kilojoules or sometimes less, the voltage ratings of the equipment could be about 300 KV in case of single transformer or of a 100 or a 600 KV AC. So, any of these choices for a cascade arrangement in case of 2 or 3 more units of transformer used sometime small laboratories could also have a cascade units of plus minus 200 to 400 KV DC and less than 100 KV impulse voltages is this is a normal ratings of the equipment which are housed in a small room or a hall a typical size been 15 meters by 10 meters by 8 meters this could be laboratory layout. So, sometimes the equipment ratings may be limited such that they can be accommodated in a smaller room then the size specified it could be 5 meters by 6 meters or so.

So, such laboratories what we call small laboratories can be built with an investment of a 2 to 10 million or slightly higher than this. Here the laboratory are meant for the engineering colleges universities or some small industries use for other products evaluation. So, to build a such a facility with small resources particularly for conducting high voltage test or research or important training so, but in case of engineering colleges and universities most of the labs do have a facility for lower level of AC voltage a DC and impulse: particularly to maintain or to impart the training of the undergraduate or the postgraduate students. So, this lab will be known as a small classified as small laboratories.

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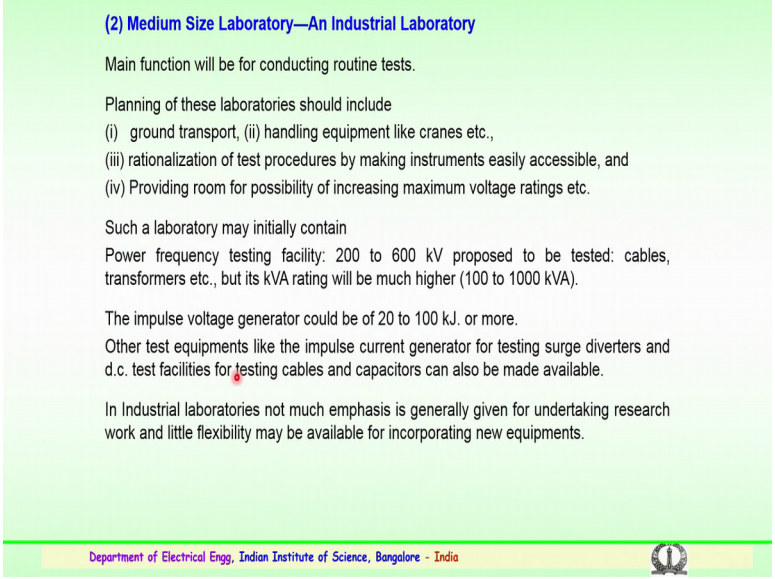

The second type of the laboratory the high voltage equipment known as a medium size laboratory or basically known as an industrial type of laboratories, usually used the medium size labs are normally used by the industries. So, here the medium size laboratory main function will be for conducting the routine test routine test carried out on each and every component of each and every product of the which is manufactured in industry. So, planning of these laboratories should include the transportation ground transportation they handling equipment like cranes or the rationalization of the test procedures by making instruments easily accessible and also providing room for possibility of increasing maximum voltage ratings and so on.

So, such a laboratory may initially contain power frequency testing facility that is AC facility anywhere between 200 to 600 kilo volts it could be proposed to be tested for cables or transformers etcetera, but it is KVA rating will be much higher could be anywhere between 100 to 1000 KV. And in medium size laboratories the impulse voltage generator could be of 2 to 100 kilojoules or sometimes could be higher. So, other test equipment like the impulse current generator for testing of surge arresters are diverters and DC test facilities for testing cables and capacitors can also be made available in such medium sized laboratories.

So, normally in industrial laboratories not much emphasis is generally given for undertaking research work and little flexibility may be available for incorporating new equipment. So, this is generally used for routine type of testing on the products manufactured in a particular industry.

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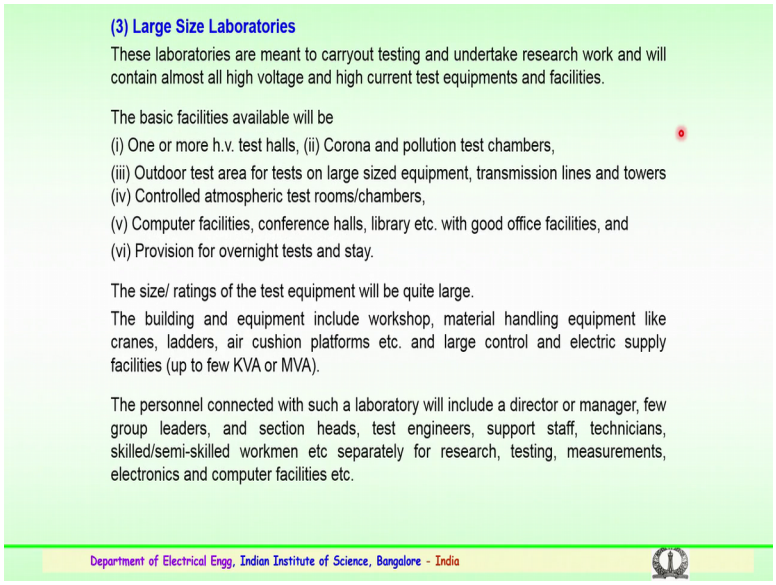

The third is a large size laboratories a very important laboratories these laboratories are meant to carry out testing and undertaker research and development will work. And will contain almost all high voltage and high current test equipment and the facilities which are required for the certification of any equipment which are to be carried out. So, the large sized laboratories contain the basic facilities like the laboratories could have one or more high voltage test also be huge halls, the facilities could be for the testing of corona and pollution test chambers separate chambers for contesting the contamination of the

equipment or the products like insulator string or any other equipment. There could be outdoor test area for test an large equipment on transmission line components and very large area where the towers also could be tested towers have to be tested in for the mechanical loading and so on.

So, this type of laboratories could have a facility for both outdoor and indoor arrangements. The laboratories will have a controlled atmospheric test rooms and chambers for conducting experiments or testing or certification of components pertaining to this atmospheric condition test. These laboratories in general will have computing facilities a conference halls library with good office facilities and a provision for overnight test and also stay. So, these are very large laboratories a certification type laboratories one example in the country could be the central power research institute where they have the outdoor and also the indoor facilities the testing aspects and several of these are available. The size the ratings of the test equipment will be quiet large the building and equipment include workshop material handling equipment like crane ladders, air cushion, platforms at cetera and also large control and electric supply facilities could be up to few KVA or MVA rating.

The 5 the personnel who are connected with the such a large size laboratories normal include a director or manager of the laboratories. Few group leaders section heads test engineers support staff technician again technician could be of skilled or semi skilled workman etcetera. And these people are available separately for the research as well as the testing measurements to be made on electronic computer facility so on and so forth. So, large size laboratories will employ all this requirements where the products to be tested certified to the requirement of the national and international standards have to be followed. So, very important and this labs are normally recognized by the national and international accreditation boards.

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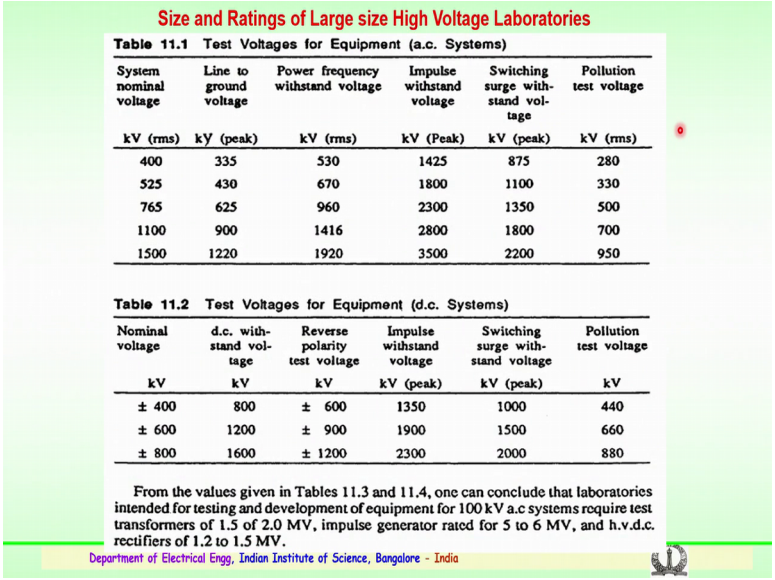

So, typical size and rating of large high voltage laboratories: a few of the shown here the test voltage of equipment of AC is shown here system nominal voltage the voltage could be 400 525 765 1100 1500 KV. So, the line to ground voltage is indicated here for 400 it is 35 525 it is 420 1100 it is 900 and 1500 it is 1220 KV. So, the power frequency withstand for this components of a 400 KV has to withstand 530 KV. In case if 520 withstand 760.

So, on for 1500 KV it is 1920 is the requirement of power frequency withstand voltages again withstand could be for a 1 or 5 minutes again this is dependent on the instructions or the standard procedures to be followed. So, impulse withstand again impulse withstand for a 400 KV system the impulse withstand level will be 1425 kilovolts and in case of 1500 or 1100 KV it is 2800 and 1500 it is 30,000 3500 KV.

For switching surge again a lightning impulse withstand is 1.2 by 50 microseconds for switching surge voltages it is 250 by 2500 microseconds. Where for a 400 KV system the switching surge will stand level could be 875 KV where the equipment should be able to withstand these surges for a specified number. It could be a 10 positive and 10 negative applications or a 5 positive and 5 negative application. These are normally specified in the standards and an agreement between the manufacture and the utilities.

So, similarly for 765 KV you have to see that the switching surge withstand voltage is 1350 and higher the voltage 1100. It is 800 KV and so on for pollution or a

contamination very important as a voltage level goes higher and higher EHV and UHV contamination on pollution is a very important criteria to be considered for the design applications. Here the voltage level for 400 KV you can see that the withstand for the pollution or a contamination is 280 KV in case of 765 KV it is a 500 KV and in case of 1100 it is 700 kilovolts and for 1500 it is 950. These are the various values for the power frequency a lightning impulse switching impulse and pollution test with stand voltages.

So, for AC systems in case of DC systems you can see the table we shows here, test voltages is for various equipment with the DC systems. This could be in case of plus minus 400 KVA nominal operating voltages the DC withstand voltage should be 800 KV twice of the nominal operating voltage. And the reverse polarity test voltage for a 400 KV nominal system should be plus minus 600 KV. The impulse withstand voltage is 1350 KV and the switching surge withstand voltage is 1000 KV and the pollution test voltage is 440 KV, it is more higher in comparison to the AC 400 KV systems it is almost twice the level which is required.

Similarly, for plus minus 600 KV these are values 1200 is the withstand voltages, the reverse polarity voltage being plus minus 900 kilovolts, the lightning impulse is 1900 kilovolts the switching surge withstand voltage is 1500 and pollution test voltage is 660 KV, and for 800 KV systems HVDC systems the DC withstand voltage is 1600 kilovolts the reverse polarity test voltage being 1200 KV the lightning impulse voltage is 2300 volts, the switching surge stand voltage being 2000 and the contamination or a pollution test voltage being 880 kilovolts.

So, very important these are all as per the standard which have been specified both nationally and internationally.

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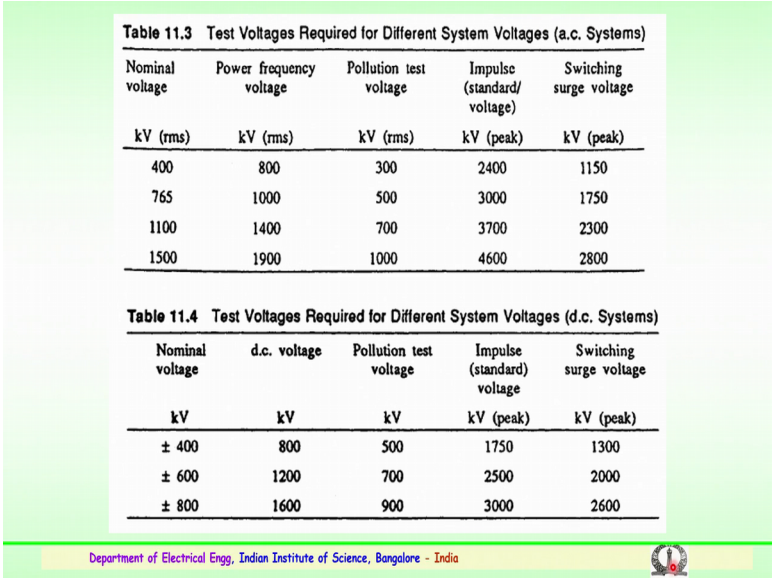

Table 11.3 Test Voltages Required for Different System Voltages (a.c. Systems)

Nominal voltage	Power frequency voltage	Pollution test voltage	Impulse (standard/ voltage)	Switching surge voltage
kV (rms)	kV (rms)	kV (rms)	kV (peak)	kV (peak)
400	800	300	2400	1150
765	1000	500	3000	1750
1100	1400	700	3700	2300
1500	1900	1000	4600	2800

Table 11.4 Test Voltages Required for Different System Voltages (d.c. Systems)

Nominal voltage	d.c. voltage	Pollution test voltage	Impulse (standard) voltage	Switching surge voltage
kV	kV	kV	kV (peak)	kV (peak)
± 400	800	500	1750	1300
± 600	1200	700	2500	2000
± 800	1600	900	3000	2600

Department of Electrical Engg, Indian Institute of Science, Bangalore - India

So, this gives the test voltage is required for different system voltages of AC and DC. Again you see various power frequency norm for nominal operating voltage of 400 KV the power frequency voltage requirement is 800 KV and pollution is 300 impulse standard is 2400 switching surge is 1150 and for 765 KV AC system you require the equipment to be tested for 1000 KV withstand power frequency withstand 50 hertz and a pollution for 500 KV and an impulse test voltage of 3 million or 3000 KV and 1750 being the switching surge voltage.

So, these are some of the values which have been prescribed for both AC and DC system second is DC 400 KV it is 800 for pollution and it is 500 KV impulse being 1750 1300 K so on so forth.

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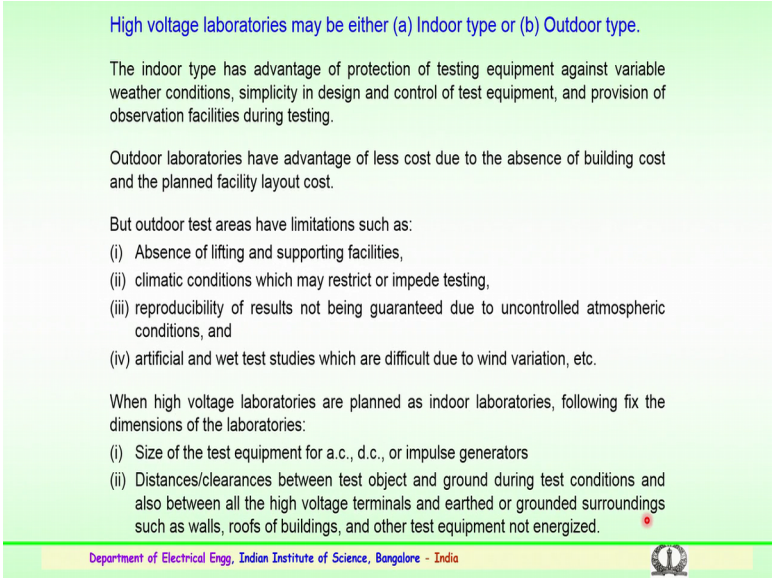

So, the high voltage laboratories which we discussed could be of either indoor type or outdoor type the indoor type facility that is the high voltage which is of indoor type as advantage of protection of test equipment against variable weather conditions. And the design will be simplicity in design and control of test equipment. And there will be provision for observation other facilities during the testing or during the experimentation which is being conducted.

So, outdoor facilities or outdoor laboratories have some advantages in case of like less cost. This could be due to the absence of building cost and the planned facility layout so, but there are few points to be noted here outdoor test areas have some limitations such as absence of a lifting and supporting facilities, because it is an outdoor facility fixing of the crane and other equipment maybe difficulty in the outdoor yard. The climatic conditions which may restrict or impede the testing particularly when the experiments are be conducted the outdoor facility during the monsoon conditions or the raining condition could be an impediment on the testing conditions. Also the reproducibility of results which are conducted outdoor not been guaranteed due to the uncontrolled atmospheric conditions because of the humidity temperature. So, on the results may be difficult to reproduce.

Next point being the artificial and vectors which are difficult due to wind variations. So, the carrying out artificial pollution or rain test facility that is the wet test facilities on the

equipment in case of outdoor it will be difficult task because of the wind direction and so on. So, it is recommended to carry this type of test in a closed and closure in a closed volume in indoor environment where better options for the reproducibility and also easy in carrying out this experimentation is possible. So, when high voltage laboratories are planned as indoor laboratories important is to see that the following are considered points which are to be considered.

So, like the size of the test equipment see in indoor, the hall the laboratory to be plan depending upon the size of the test equipment this could be for AC DC or impulse generators. The clearance is very important the distances of the clearance between the test object and the ground during test conditions and also between the high voltage terminals and the earthed or a grounded surroundings it could be a metallic structure nearby or a grounded surroundings like a walls roof of a buildings or it could be of other test equipment which could which may not be energized. So, these points have to be considered when high voltage laboratories are being planned as indoor laboratories.

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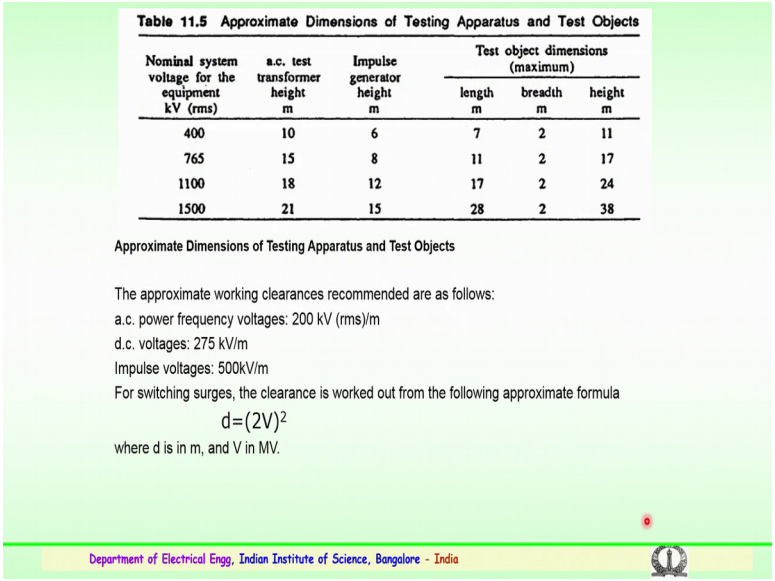

The table gives the approximate dimensions for testing apparatus in a apparatus and test objects. So, here you can see the nominal system voltage for the equipment that is in KV RMS there for a 400 KV system the AC test transformer height this is in meters it could be around 10 meters. And impulse generator the height of the impulse generator in meters could be anywhere within 6 meters for a 400 KV system level. The test object

dimensions again the equipment to be tested could be anywhere between 7 meters in length 2 meters in breadth and 11 m in height. So, this has to be kept in mind before designing the laboratories or planning for the high voltage laboratories.

Similarly for 765 kilovolts system you require the minimum the dimensions the for the AC test transformer height could be anywhere between 15 meters that is around 45 feets similarly for impulse generator it could be 8 meters and test object dimensions could be ranging from 11 meters in length 2 meters in breadth height could be 17 meters or so, on. As a voltage level has goes higher and higher for 1100 KV the dimensions also changed. So, it could be 18 in case of a transformer height which is required to 12 could be for the impulse generator and 17 2 and 24 could be the height length breadth and height for the test object is to be installed.

So, these are all the approximate dimensions of the testing apparatus and the test objects which have been indicated the approximate working clearances which are normally recommended for the laboratories are as follows which shown here. In case of AC that is the 50 hertz power frequency voltages approximately as a thumb role equal it is taken as 200 KV RMS per meter, and for DC voltages it is taken as 275 KV per meter. For impulse it is 500 KV per meter that is the clearances working clearances or the distances minimum distance to be maintained for AC approximate 200 KV per meter DC 2 7 ty 5 KV per meter and for impulse voltages 500 KV per meter to be maintained. And for switching surges the clearances is typically worked out from the following a formula that is a simplest formula d is equal to 2 v square where d is in meters the distance and v is in million volts. So, in case the voltage levels as per the voltage level this distance or the clearances are to be followed.

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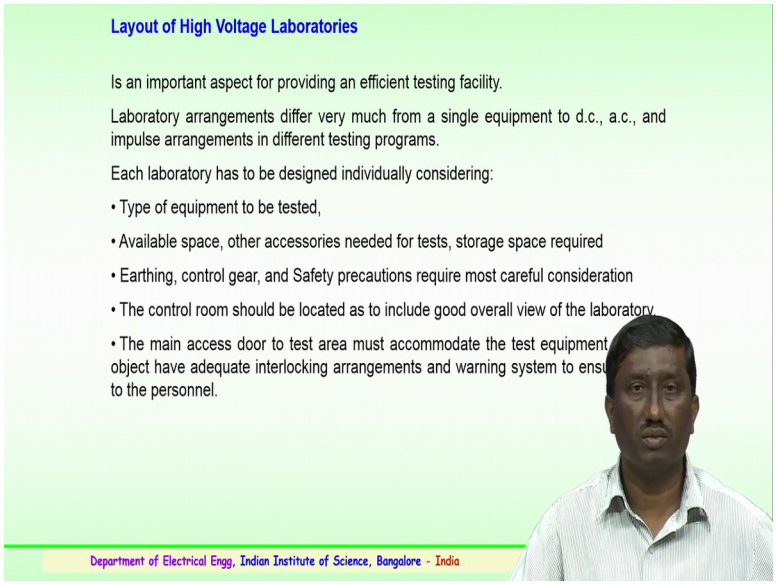

Simplest equation the importance of the layout of high voltage laboratories (Refer Time: 33:05) we were discussing about various as per the clearances and so on. So, it is also important to see that to provide an efficient testing facility very important. So, laboratory arrangements could differ very much from single equipment it could be of a DC AC and impulse arrangements in a different testing programs. So, each laboratory has to be designed individually considering the type of equipment which is to be tested. The available space in the laboratory other accessories which could be needed for conducting the test. And the storage space or the equipment housing space or any other accessories or pertaining to the test yard storage space required.

So, proper planning has to be done the grounding or earthing very important control gear and safety precautions are essential and require most careful consideration. So, without proper earthing and grounding and safety aspects the high voltage laboratory is have to be considered as a top most priority for earthings and safety precautions. The control room which facilities should be located and it should include good overall view of the entire laboratory preferably. And the main access door h which is entering the laboratory to the test area must accommodate the entire test equipment the test object have adequate interlocking arrangements and there should be available warning system particularly to ensure safety to the personal who are involved in the testing activities at the high voltage laboratories so very important factors.

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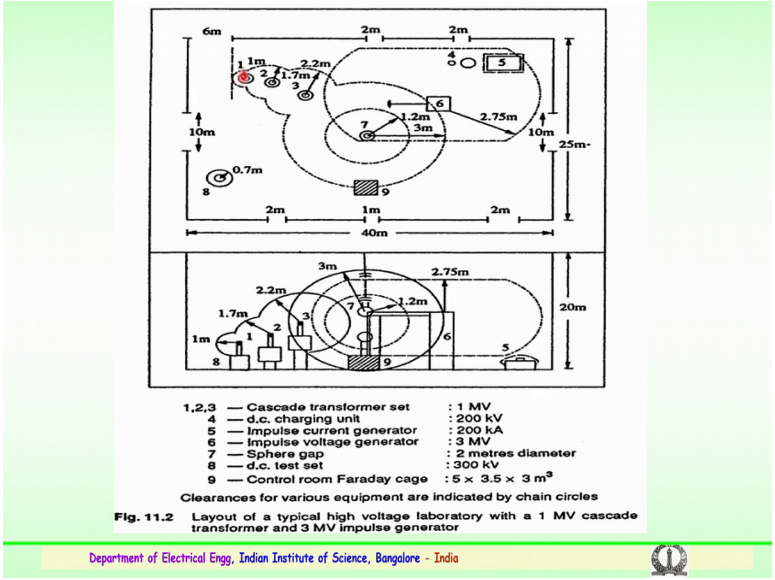

So, this is a typical layout of the high voltage laboratory with a one million cascade transformer and 3 million impulse generators. So, just to show that how the clearances of various equipment are to be considered. You can see that this 1 2 3 here is are the cascade try transformers each of a particular rating of 350 KV say it is a one million source. The minimum clearances are indicated here 11.7 and 2.5 meters are the minimum clearances which are essential to be kept away. Then you have a DC oh charging equipment which is very important.

So, DC charging equipment and we have an impulse generator we have which is here impulse current generator and you have a impulse voltage generator 6 year impulse current generator again which is having a clearance of minimum clearance these are very important. It gives the laboratory size of 40 meters by 20 (Refer Time: 36:35) meters and all the clearance are mentioned, and each equipment has been provided necessary clearances you have a spark gap arrangement which is to be used for testing and the minimum clearance have to be maintained.

Then the DC test setup. So, DC test set up again it is kept at a corner with a clearance from not interfering with other equipment. You have a control room or faraday cage arrangement here in the 9; so this again a gives the dimensions of a mentioned here. So, typically you have an impulse voltage generator sorry cascade transformer set of 3 units you have impulse generator impulse current generator DC set and also the sphere gap

arrangement. So, this typically gives the clearances of various equipment which are normally housed in a high voltage laboratory of 40 meters width by 25 meters or so 120 meters. So, very important and there could be higher voltage equipment which could be used with higher clearances.

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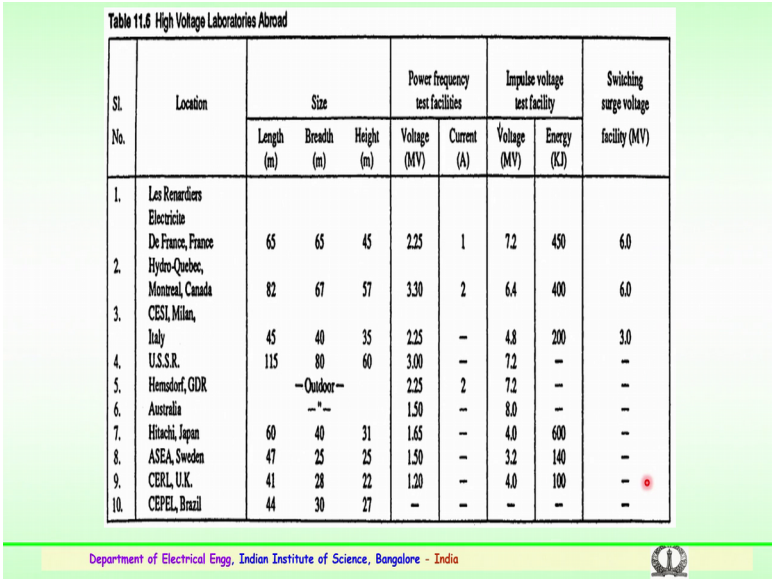

So, some of the high voltage laboratories which have various sizes for power frequency impulse switching surges are available in several parts of the globe. Few examples are here. In France you have a size of laboratory size of 65 meter by 45 meters height. Where the facilities like the power frequency you have a 2.25 million volt, current rating of one and amp and impulse test facility of 7.2 million volts and energy 450 kilojoules. And switching search facility of 6 million.

Similarly, laboratories available in hydro cubic Canada, Cesi, Italy you have you have in USSR, you have in Australia, Japan, Sweden, UK, Brazil: these are the values of the sizes of the outdoor laboratories these are the power frequency equipment with the current rating you have any impulse test facility and switching surge all the details are given here. So, several laboratories are across the globe have high voltage facilities for conducting research for testing the equipment and for certification purpose.

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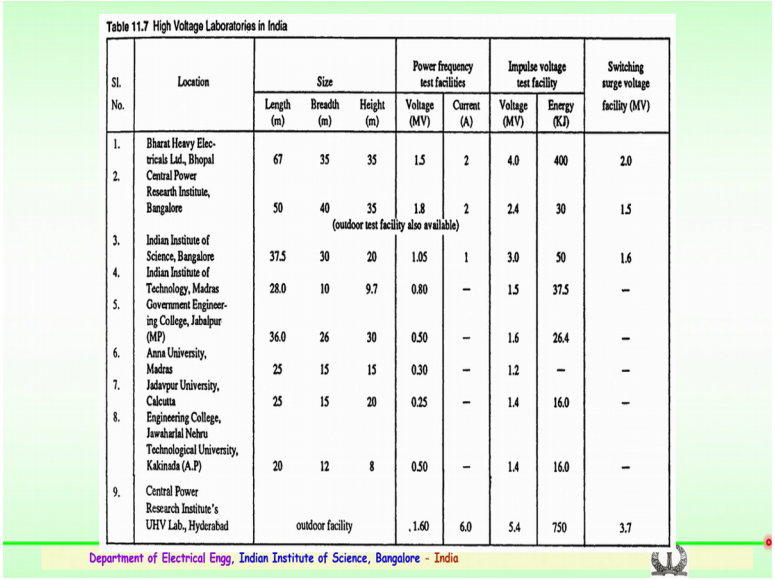

Similarly, in the country that was in abroad in the India we also have several high voltage labs both for research development and also for the industrial routine testing. The laboratories are (Refer Time: 39:33) available at Bharat heavy electrical limited, they have a size of high voltage lab of 67 meters by 35 by 35 meters in height and they have a power frequency equipment 1.5 million with the current rating of 2 amps and impulse test facility of 4 million having energy of 400 kilojoules and switching search facility of 2 mega joules.

So, then central power research institute has a lab number of laboratory across the country, they have at Bhopal they have at Hyderabad Bangalore and they have several apps one of the lab at Bangalore is given as 50 meters by 40 by 35 is the high voltage lab having a power frequency of around 2 million and a current rating of 2 amps and impulse of 2.4 million and 30 kilojoules energy and 1.5 this statistics could be of earlier values.

Now, then are equipment which have been housed and upgraded their existing earlier facilities. So, Indian institute of science we have the facility high voltage lab of 37.5 meter length 30 meters breadth and 20 meters height. We have a power frequency of 1.05 million volt having a one amp source and impulse test facility of 3 million with 50 kilojoules and switching surge rating of 1.6 KV. So, similarly IIT an institute madras has a high voltage laboratory engineering college Jabalpur Anna university, Jadavpur university, JNTU Kakinada central power research institute Hyderabad has also an

outdoor facilities. These are a few of the examples there could be some more which have been established recently with the facilities for conducting and carrying out research activity and also for the development activity.

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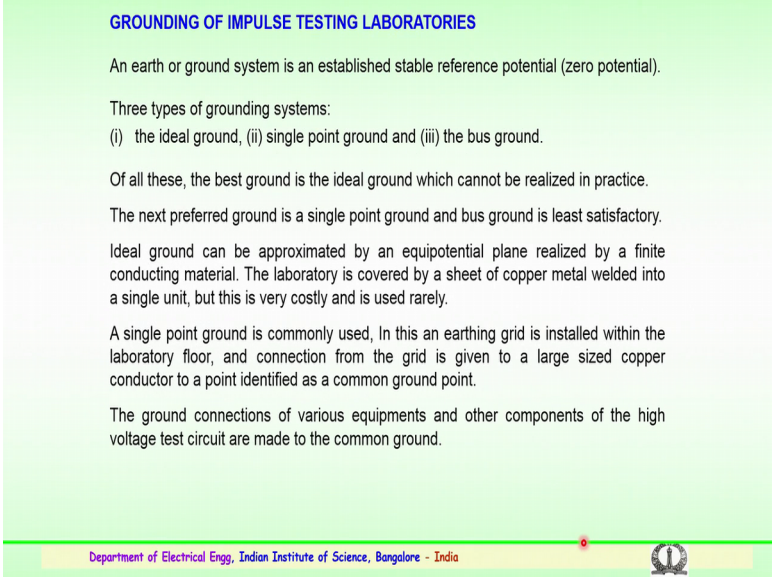

So, we have try to discuss about the importance of the planning of the high voltage laboratories for the testing of equipment. The important component being the grounding of impulse laboratory in the testing laboratory is very important. So, here an earthing or a ground system is an established stable reference potential that is 0 potential very important to be noted. 3 types of grounding systems are normally employed in the impulse testing laboratory could be ideal ground the second could be the single point and the bus ground these are the 3 different types of grounding which are normally employed of all these the best ground is the ideal ground which cannot be released in practice difficult very difficult.

The next preferred ground is a single point ground this we will like to we will discuss how it looks and third is a bus ground which is the least satisfactory. So, the ideal ground can be approximated by an equipotential plane realized by a finite conducting material. And the entire laboratory is covered by a sheet of copper metal which is welded into a single unit, but this is very costly and is used in few of the laboratory for few of the equipment to be tested limited to some test.

So, a single point ground is commonly employed. In this an earthing grid is installed within the laboratory floor and connection from the grid is given to a single large sized copper conductor to appoint identified as a common ground point. So, it is very important the ground connections of various equipment and other components of the high voltage test circuit is are normally connected to this common ground.

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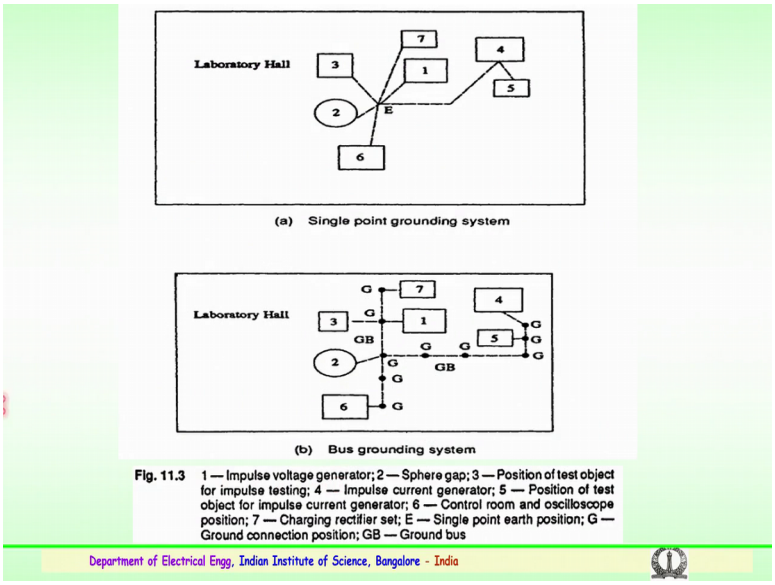

So, this gives the information about the single point grounding and also the bus grounding you can see all the equipment are connected to a single point earthing connection, where it could be the numbers which have been shown here could be impulse voltage generator a spark gap or a sphere gap position of the test object for impulse test impulse current generator position of the charging rectifiers set. So, all are connected to a single point grounding here.

Similarly, here it is shown it is connected through a bus grounding system. So, g b is the ground bus what you see here and g is a ground connection or a ground connection position at different location. So, all the equipment switch again the impulse generator sphere gap current generator AC transformer DC several of these things in a laboratory hall are connected by using the bus grounding or the ground connection position which is being shown here. So, importance of either going in for a single point ground or bus grounding is to see that the raise of potential should be brought down and the equipment which are under test and also which are to be tasted have to be properly grounded.

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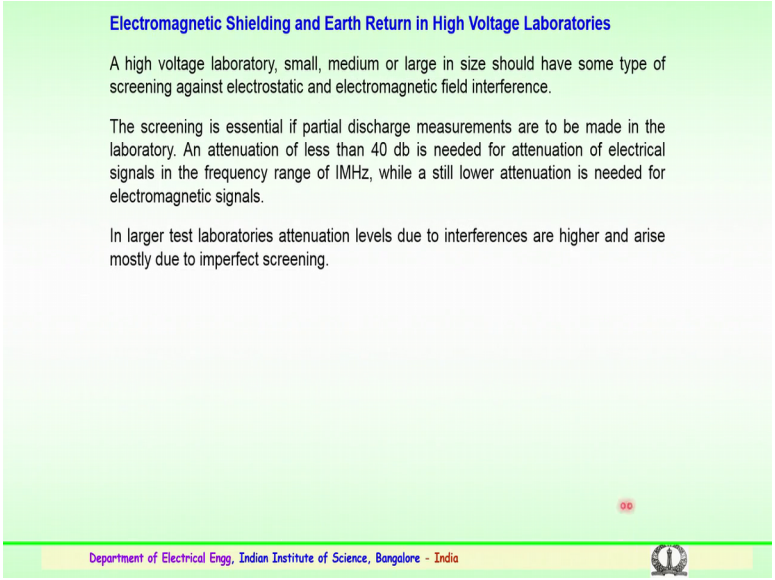

Importance of electromagnetic shielding and earth return in high voltage laboratories is also essential very important point. So, any high voltage lab small it could be a small laboratory a medium or a large size laboratory should have some type of screening pertaining to the electrostatic and electromagnetic field interferences which could be caused by the external sources. So, this screening is essential if partial discharge measurements are being made in the laboratory. So, here an attenuation of less than 40 or less than much less than this value is needed for attenuation of electrical signals in the frequency range of one megahertz, while a still lower attenuation is needed for the electromagnetic signals.

So, for large test laboratories the attenuation levels due to interference are higher and arise mostly due to the imperfect screening. So, importance is to see that the entire laboratories properly shielded and no interference is (Refer Time: 46:25) interference is seen or observed during the testing of the equipment.

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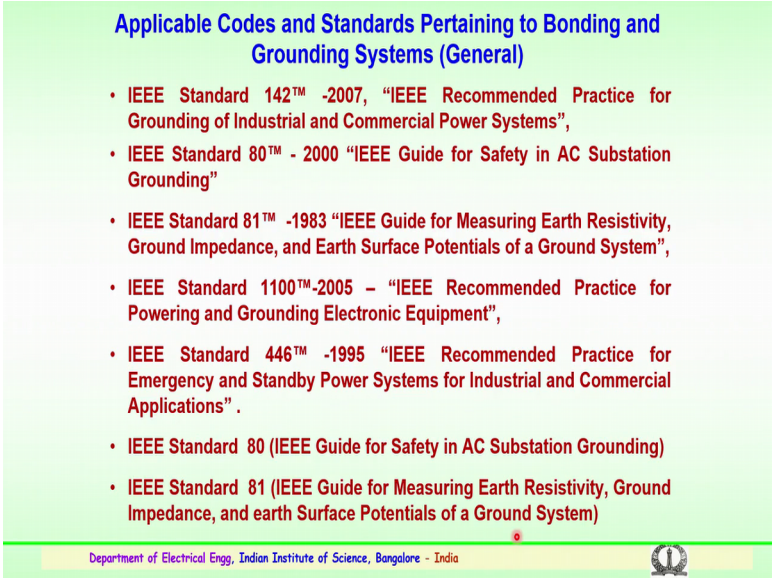

So, several applicable standards are being suggested both internationally and national standards. So, some of the standards which have been shown here are the recommended standards for grounding of industrial commercial power system. So, several standards are been given as a guide for safety in substation grounding for earth resistance for powering and grounding equipment for industrial commercial application substation groundings for checking the impedance and earth potential of the ground system.

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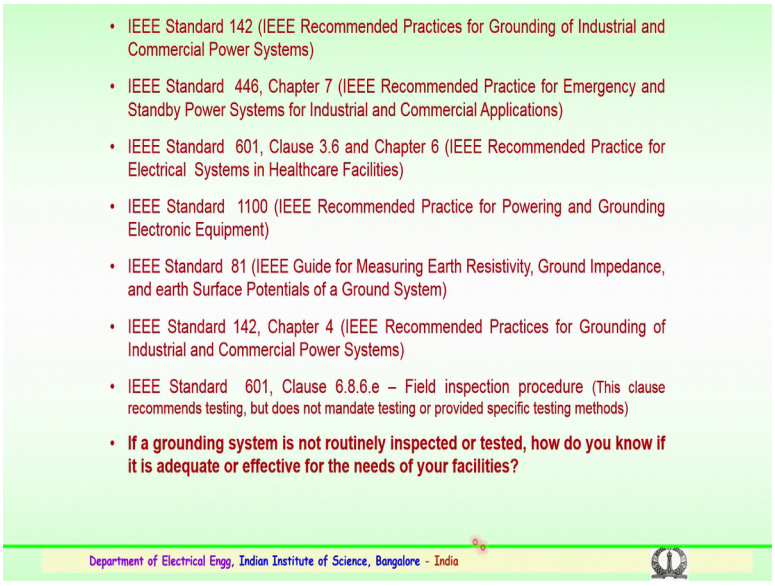

And several standards both IEEEIC and (Refer Time: 47:15) standards are available have to be properly followed for the high voltage laboratory and which have been recommended (Refer Time: 47:20) good practice for the substations or high voltage laboratory. So, this all several standards which have been available for grounding system and apart from the standards it is important if any grounding system is not routinely (Refer Time: 47:41) inspected or tested. So, it is difficult to know if it is adequate or effective for the needs of other facilities which are to be tasted. So, proper inspection proper testing routinely has to be conducted for grounding and earthing systems.

So, that concludes the planning of high voltage laboratories and importance of the standards which are been suggested.

Thank you there.