Advances in UHV Transmission and Distribution
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Lecture – 06
Failure of apparatus in the field, importance of reliability and testing

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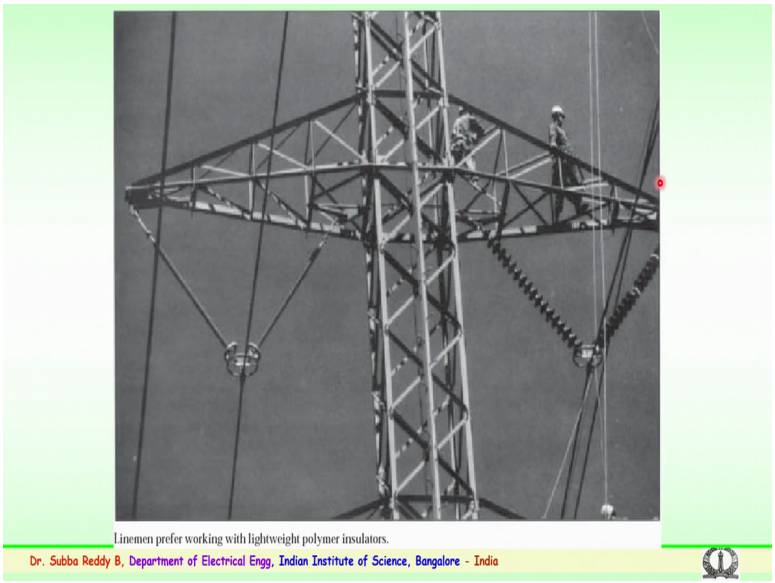

Welcome back. We were looking into the transmission tower, where the lineman prefer working with light weight polymer insulate inside of the ceramic or glass type of the insulator which are of more weight than the ceramic. Just for comparison purpose we can see the 2 insulator string polymer insulator string and a ceramic or a porcelain insulator string. In case of 400 kV typically for a 400 kV system the insulator a numbers will be some were around 23 to 25 this insulator each side.

So, 23 into 2 is 46 insulators each insulator were some were around 10 to 12kgs. So, around 500 kilos plus the hardware it comes around 1 ton in case of a ceramic insulator, were has for a polymer insulator the each will be a few a 10 to 12kgs. So, totally the weight reduction will be more than 60 to 70 percent hear that is where on the technician or the line man prefer that work with light weight polymer sings which are more acetic and which have a less bit and it is much comfortable for the people to work in the high voltage and extra high voltage transmission systems.

So, we were looking about various types of insulator which are being used for high voltage and EHV UHV transmission. We will look one by one in to the reliability and the importance of the testing for ceramic glass and the polymer waste insulators.

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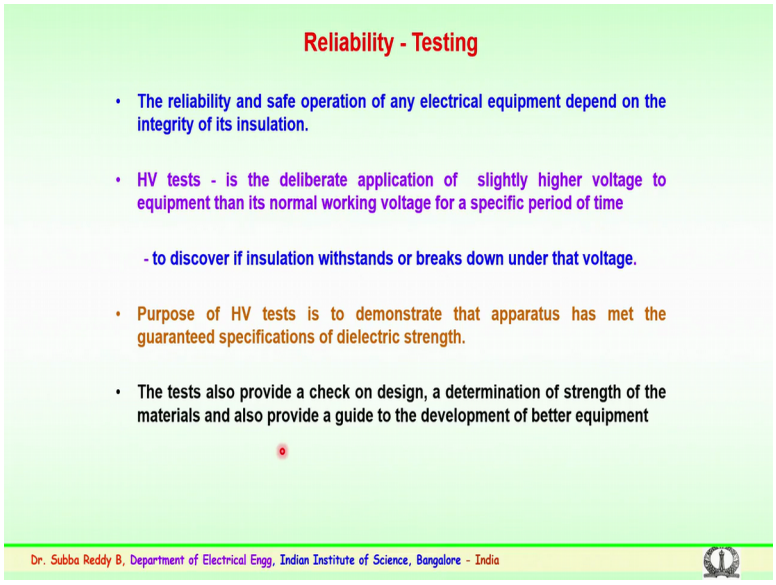

So, what is reliability and the testing is a very important aspect which for the safe operation the reliability becomes an important factor, for the safe operation of any electrical equipment which depends on integrate of its insulation for which its design.

So, the high voltage test basically is an attempt to deliberately apply a slightly higher voltage to the equipment than it is normal working voltage for specific period of time. This is how the high voltage text are being conduct in the industries that is the manufacturing unit is as well as a research laboratories or the certification laboratories. So, intentionally slightly higher operating voltage then the equipment is in the field is a applied for a specific period of time and the it is integrity is verified. So, disc or not or also help to discover if the insulation with stands for a period or breaks down under that voltage. So, these gives an idea were how reliable is a product which can be used in the field. So, the purpose of the high voltage test is mainly to demonstrate that any other test has to rewrite with the guarantied specification for the insulation or the dielectric strength which it is designed.

So, these high voltage test which are been conducted also provide a check or verification on the design which is to be a (Refer Time: 03:34) in the field. A determination of

strength of the material which are being used as an insulating media and also provide a guide to the development of better equipment in case the insulation which has been used has to be upgraded or a further improve mental aspect could be carried out. So, this helps the reliability helps to achieve a better insulation for the equipment to be used in the transmission or distribution system.

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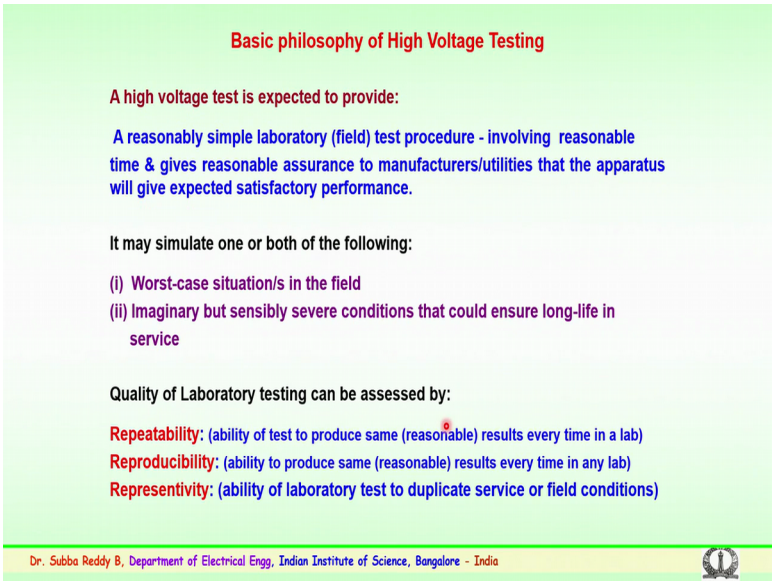

So, when we are looking about the testing aspect what is the basic philosophy which pertains to the high voltage testing why the testing is essential for the high voltage equipment. So, high voltage test or verification which is being done in the laboratories or at the industry is expected to provide a reasonable field procedure, that is in the laboratory when you are conducting the test or experiment on a particular product. It has to be reasonably simulate the field condition, which should involve reasonably horizon able time when the sense you can not a try to simulate in the lab for a large number of years or a long period of time.

So, the time should also be reasonable and also you should give are reasonable assurance to the manufactures or the utilities that the apparatus whatever it testing is being conducted will give some expected satisfactory performance and gives an idea of it is field performance. So, this is unexpected from the reliability or laboratory testing which is being carried out. And most of the laboratory testing or the experimental procedure

involves with the standard procedure laid down as per the international standards and the procedures are being described in several standards pertain in to the equipment.

So, these tests may simulate one or both of the following. The test can simulate worst case situation in the field. Sometimes laboratory experimentation the methods which are being a followed could be much more regress in comparison to the field conditions. The second point of important is these test are imaginary, but sensibly severe condition that when it is being conducted could ensure long life in service.

So, these are the 2 important conditions when we simulate the testings in the laboratory or at the industry for the unique high voltage component. Also the quality of the laboratory testing or the industrial testing or the factory testing is normally assessed by the important of these 3 factors. The first thing repeatability, repeatability is a ability of a test to produce same or a reasonable same results every time in a lab. So, this indicate that when the particular test is being conducted at a different instant of time at a different period of time the same test the results which are produced should be reasonably very near to the values which have been obtained earlier. So, this shows the repeatability nature of the laboratory of the equipment which is being used for the testing the equipments.

Second is reproducibility. Reproducibility is an ability to produce same results every time in any lab. The first one repeatability refers to a single laboratory, whereas reproducibility is a method were reasonable results of a particular test could be obtained any time the equipment is being tested in any lab with our minor variation as per the international standards. So, the third being representivity. Representivity is an ability of a laboratory test to duplicate service or field condition. These very important very few places in the world have the facility. The representivity is a testing procedure where the actual simulation of the lab or field conditions is done.

So, the laboratory which should be encrypted for testing this equipment should be able to represent similar to the field conditions. So, such labs across the globe are very few were the representivity are representivity test could be carried out for the equipment.

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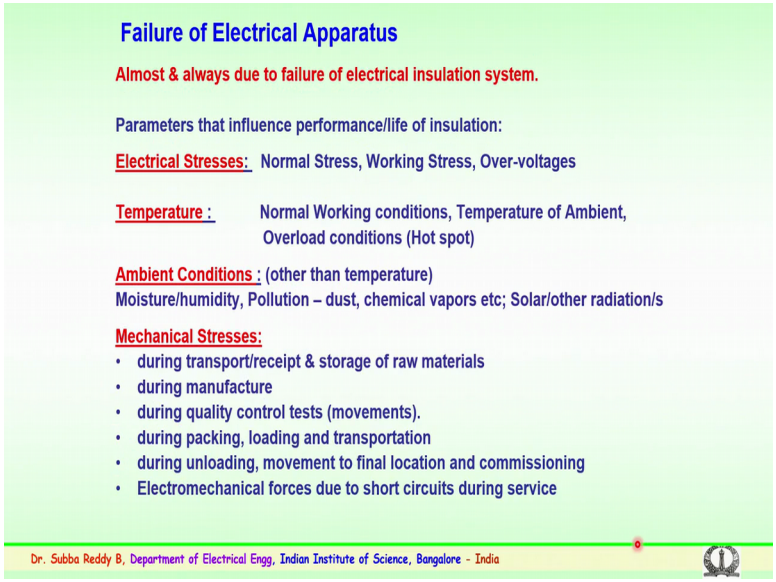

So, what are the failures of electrical apparatus or any high voltage apparatus which are normally observed in the field? So, it is known almost and always the failures occur because of the electrical insulation system. Some of the parameters which could influence the performance or the life of insulation are the following the number one being the electrical stresses. So, electrical stresses the equipment or the insulation of the equipment could lose it is a performance over a period of time this is due to the normal working stress continuously over a period of time or due to the over voltages.

So, the insulation which is in continuous stress and also test the over voltages may lose it is a properties over a period of time because of continuous electrical stresses. Second being the temperature. So, the temperature again the insulation has to with stand along with electrical stress the normal working conditions. The temperature due to over load condition particularly in case of transformers the hot spots which are developed because of the malty insulation like the oil the paper and the electrical stress. So, in such case because of over load condition, the normal are the temperature surrounding the insulation will be higher.

So, here again the temperature place a role in the life of a insulating material or a insulating system. Then ambient conditions other than temperature very important is a moisture or humidity, we have looked into how the moisture a could influence the life of the insulating material. So, the moisture humidity pollution or a contamination the dust

particle chemical vapors etcetera apart from solar and other u v radiation also have an influence on the performance of the insulating system electrically. So, this effect of moisture humidity and other things will be discussed in the testing aspects for both the polymer as well as the ceramic insulators for a the test which like the malty stress in case of the polymer insulators have to under grow all these type of stresses.

So, apart from electrical ambient conditions of the mechanical stresses particularly the mechanical stresses which are the insulation or a component or a insulator sees during transportation the storage of raw materials during manufacturing process during quality control testing movements ad various location in the industry during packaging loading transportation, see all these a could lead to a mechanical stress on the product where the insulation could be effected.

Apart from these during normal loading and un loading of the material movement to the final location and commissioning. So, several of these factors influence the insulation apart from the electro mechanical forces which could be due to the short circuit during the service.

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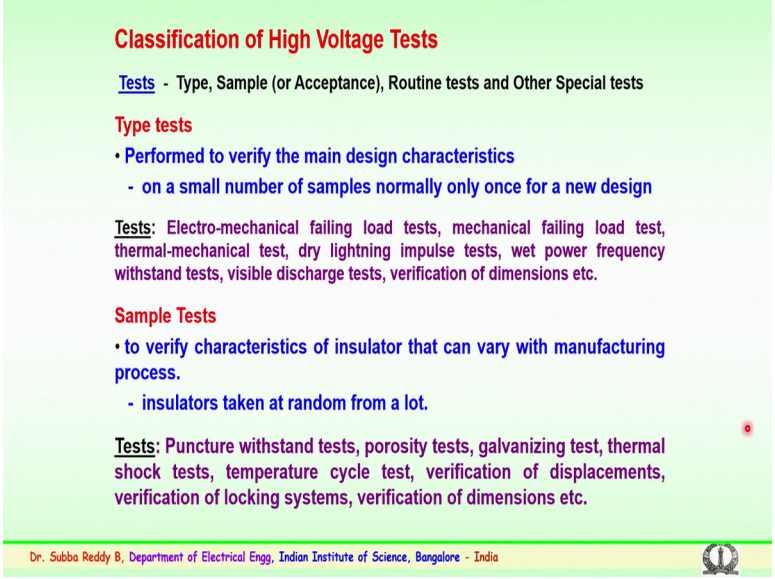

Now, coming back to the classification of the test which are conducted a for the insulations, another same could be verified as mention in the laboratories or the industries, international electro technical commission and electrical standards apart from other standard organizations have classified various test or various experimental

procedures to be adopted to satisfy or to check verify the equipment or components could be used in the field.

So, various classification of the test are classified as the type test which are normally conducted in the research laboratories or the third party testing laboratories certification laboratories. The sample or the acceptance test, the third is a routine test which are normally conducted on each and every component in the industry and some other special test as the voltage levels go up about the EHV and UHV apart from type sample routine test, few special test have also been in corporate introduce to verify the design of the insulation when the usage of for ultra high voltage or extra high voltage transmission system.

So, the type test which are normally performed is to verify remain design characteristics, on a particularly small number of samples and normally once for a new design. So, example in case of a insulators, if the design remain same for a particular voltage level for a particular creepage distance the insulator manufactured a small number of samples from that particular lot are type tested in the type testing institute or the laboratories unless the design changes the test need not be repeated.

So, these type test consist of electro mechanical failing load a test, mechanical failing load test, thermal mechanical test were both thermal and mechanical load are tested for the insulator string dry lightning impulse or dry lightning serge test which specified for a particular voltage level, then wet power frequency with stand test wet power frequency is simulation of artificial rain to the insulator strings, and verify and weather the could withstand for a particular duration for a particular voltage levels. Then followed by that is a visible discharge test or the corona test.

So, visible discharge test or corona test which are normally conducted for a the extra high voltage and ultra high voltage gives an indication where the corona which is visible from the hardware or the insulator accessories has to be contain were the discharges should not particularly for polymer insulator should not bring down the insulation level. Apart from thus the type test also contains the verification of the actual dimensions of the equipment which has been manufactured.

So, the sample test or the acceptance tests are basically to verify the characteristic of insulator that could vary with manufacturing process. So, here normally the insulators

which are manufactured are taken at a random from a lot of existing type. So, here again the sample test consist of puncture withstand test for a particular voltage level the insulator should not puncture. The porosity tests to check the material property know pores there is no porosity in the insulation. Galvanizing test proper galvanizing is being carried out for the metallic pin.

And the cap the thermal shock test this thermal shock test also will help weather the insulator can take these type lodes in the field. The temperature cycle test again the temperature higher the temperature or operating more than operating in the field is applied for a known period of time and the verification of the insulator is being done weather it could with stand or a specify period. Then again verification of various locking system cap and pin metallic hardware. So, verification of dimension etcetera fall under this expectance or a sample test category.

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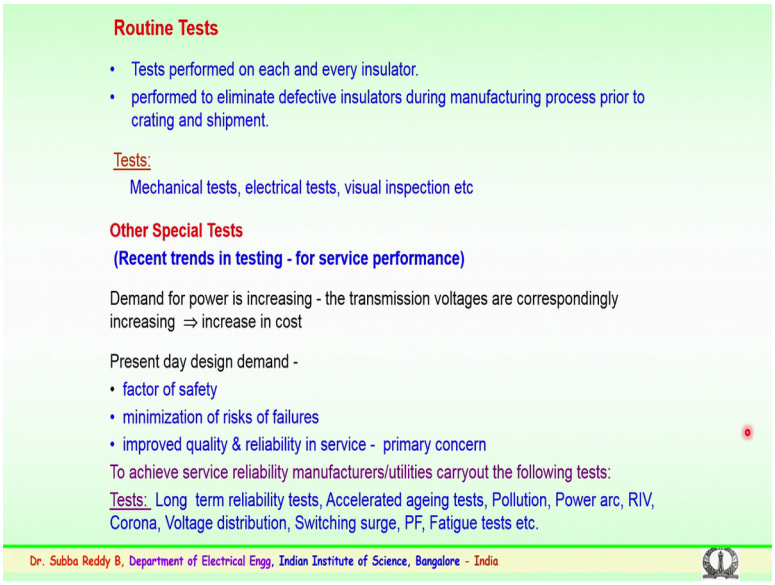

The third being the routine test. Normally as mentioned earlier routine test are performed on each and every insulator sample. So, in the factory these are performed mainly to eliminate the defective insulator, during manufacturing process and prior to the crating and shipment: in case, if this routine test or not carried on each and every sample their lightly that there may be some insulator with defect with defective which could again see the failure in the field. So, the routine test has to be performed each and every sample. A test include mechanical test some electrical test visual inspection etcetera. So, these are

the various 3 categories of test which are specified as important verification a procedural methods for the insulator string.

Apart from the type sample expectance or routine test, somehow other special tests have also been adopted particularly in the recent time as to verify the service performance for long period of time. Here the demand for power with a increasing demand for power the transmission voltages have correspondcely increasing over the period. So, presently we have reached ultrahigh voltages from 11 kV voltage levels, so subsequently 132 kV 220 400 765 or 800. So, again a it is plan to increase voltage to 1200 kV is system. So, this increases the cost of the insulator string tower and many of these things.

So, the present day design mainly demands for the factor of safety which is very important. Minimization of the risks of failures as to be kept in mind and the improved quality, and reliablity in service is a primary or an important concern at higher voltages or extra high voltages or ultrahigh voltages. So, to achieve the service reliability the manufactures or utilities normally conduct the following tests which are a categorized as the special test particularly for a EHV or ultrahigh voltage level. The test include long term reliability test accelerated ageing test again accelerated ageing, this particular test is being carried out over a long period of time it depends 1000s of hours to 5000 hours were the acceleration factors like the voltage temperature etcetera are increased to one level depending upon the voltage and the string which is going to operate and the test are conducted for a long duration of time.

Then the contamination or a pollution test this is again a very important at extra high voltage and ultrahigh voltage; power arc particularly very important for EHV and UHV voltage level. Radio interference voltage the corona test again the discharges which are emitting for the hardware the corona control rings or insulator accessories are very important and these have to be seen the discharges have should not have higher magnitude and specified limit is have to be followed as per international norms.

Next being voltage distribution in the string of for a 400 or a 800 kV the number of insulator gone increasing. In case a 400 as mention we have to 23 to 25 disc insulator in case of 765 we have in a were between 35 to 40 disc insulator. So, the voltage distribution that is from the line end to the ground end becomes essential. It has to be maintained and else if without proper voltage distribution the stress which the insulator

which is near to the line end sees very high voltage across a very stress very high stress across that and over a period of time the insulator could shutter and could lose it insulating properties. That is a reason a proper voltage distribution has to be maintained for the insulator string with proper corona control ring arc in (Refer Time: 22:34) or suitable hardware which is being employed for the string.

So, next is a switching search which is very important at EHV level. So, switching impulse for a voltage levels operating above 400 kV cause insulation break down early. So, switching surge test herb normally carried out for all the equipment for specified levels. Then power frequency over voltages, because in the transmission during the normal working voltage that is the power frequency working voltage there could be some disturbances in net transmission network over voltages for a few cycles could be a witness were the insulation has to with stand.

So, the power frequency with stand voltages or normally carried out for both the dry as well as wet condition or from some other fatigue mechanical test. So, all these come under the special test category and these are normally conducted for the voltage level above 400 kV. So, the voltage level EHV and UHV has to be maintained for the transmission without the insulation being de graded in service.

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So, this is the one of the arrangement for a 765 800 kV transmission system in the laboratory. In a typical laboratory is the source is very important the source should be of

able to deliver requires the voltage. This is 10501 million 50 KV casket transformer were the insulator string is weak consignations string is being erected testings like the voltage distribution across the insulator entire insulator string. The radio inter reference voltage and the corona are being tested before the insulator string is actually mounted in the field.

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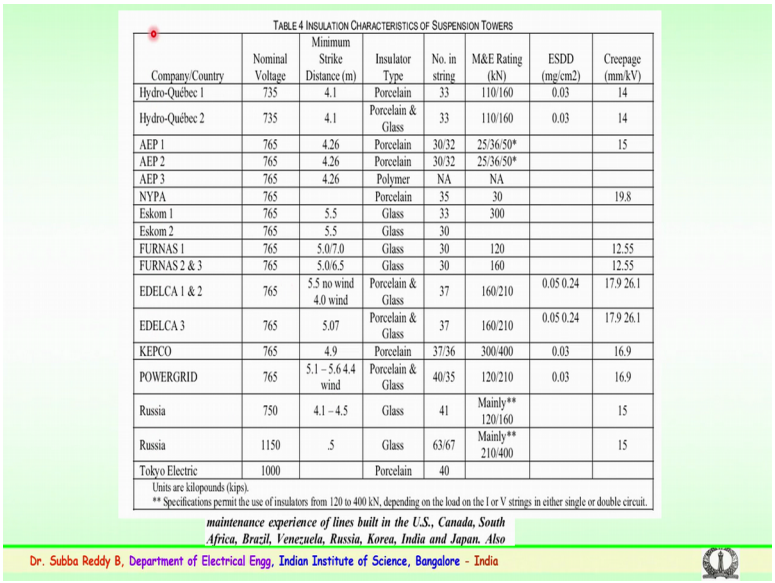

So, similar arrangements are normally carried out for various type test or special test in the laboratories before the insulator string is being energized in the field. The table gives some information about the insulation characteristic particularly for a suspension tower of various company or the countries which the voltage higher voltage level are ultrahigh voltage is being operated. You can see hear hydro Quebec 1 and 2 are the Canada there are the nominal voltages adopted as 735 kV the minimum strike distance strike distance which we were discussing should be for 735 kV 4.1 meters the insulators could be a porcelain or glass type how many number of insulator in a 735 kV is a number of insulator, 33 in numbers the mechanical rating or the mechanical rating of each disc is 100 and 10 or 160 kilo newton is mechanical strength for disc. Then the column shows the e s d equal and salt deposit density when the transmission lines are running near the pollution zones. So, that particular pole zones what is the equal and salt deposit density which is being used as also being categorize here.

Then the final colon gives the creepage in millimeter per kV adopted for the insulators. That is the 14 is a 14 mm per KV is a adopted creepage of the insulator. You can see various companies and for in different countries the voltage levels which are being adopted 735 765 and the minimum strike distances what type of the insulator are being used and how many number of insulator are being employed in a string are the mechanical rating pollution condition and the creepage employed are being given here.

So, this particular information which is adopted in the country by the power grid corporation of India; so 765 kV an insulator string were we have minimum strike distance 5.1 to 5.6 because of the wind a prevailing that particular belt, and we use a porcelain glass insulator with insulator as I mentioned earlier. 35 to 40 are the insulator disc which are connected in series and is being used in the country are the mechanical rating being 120 kilo newton and 210 kilo newton are presently being employed and 0.03 is equal and salt deposit density that is the pollution zone which were implying and 16.9 is the n per kV, this you can compare with other we have a higher pollution area that is one of the reason we go in for higher creepage per kV levels.

So, similarly Russia as employed glass insulator and japan also employed porcelain insulator for 1000 and 1150 kilo watts this gives minimum maintenance experience of lines built in various countries across the globe.