Recent Advances in Transmission Insulators
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Module No # 02
Lecture No # 09
Cleaning methods adopted for insulators (Cont)

So continuing with the cleaning of insulators in energized conditions this involves various methods and techniques which are discussed earlier.

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So helicopter based methods nozzles which are being employed are particularly used for very high voltage transmission systems in EHP and UHP ranges and this many of the times or where it is difficult for the transport to reach like truck mounted arrangement in such cases and the tower situated at the high altitude regions, mountainous areas. So in places where the land route if difficult in such cases helicopter based arrangement for cleaning are being employed by the utilities in India as well as in several other countries.

So this pictures as we were looking into sees how the cleaning of insulators are being done for single string or double tension or quarter full type of arrangement. So as mentioned earlier in case if the stringing arrangement of the tower is V type of insulter here it should be noted that the cleaning as to be performed from the two sides so that the contaminants does not

carry from the which is been side which is being cleaned to the other side which is not been done.

So proper cleaning method have to be planned and then executed in case of the V type of arrangement in tension mode and suspension mode this difficulty will not arise as the contaminants will be washed away during the nozzle arrangements where that is directed from the distance as we discussed. So this about the live line techniques which are being employed so there are methods in case of the de-energized condition or the supply is being switched off and the maintenance is being done for the cleaning purpose.

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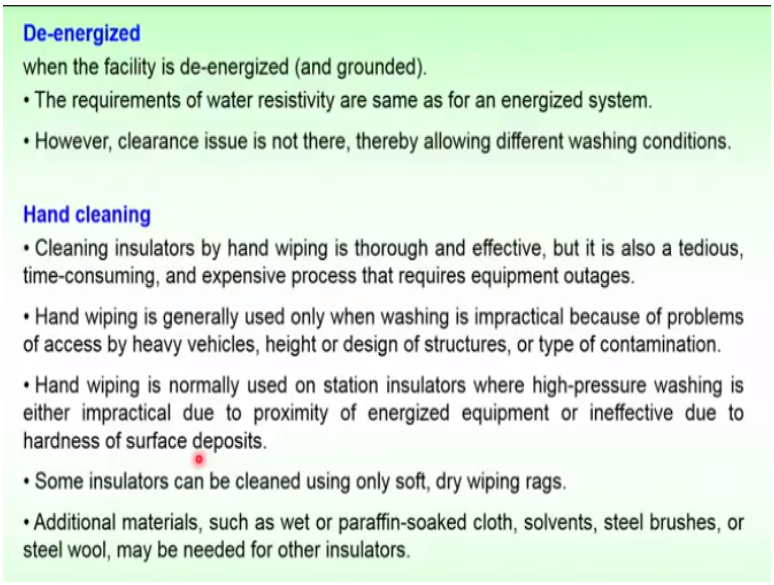

This involves various methods again techniques during the de-energized condition where supply is not there and were equipment is taken up for maintenance. Here the requirement of water resistivity of similar or same for energized condition like the resistivity and conductivity of the water does not change whether it is thee energized or de-energized conditions.

However the point is the clearance issue is not there whereas in energize conditions or the live line washing we have to maintain a minimum clearances for he cleaning purpose here the purpose is re-energized the cleaning portion which is being carried out the clearance is not a serious issue so thereby allowing different washing conditions from the methods which are being used.

So here again various methods are being adopted for the cleaning we will discuss some of the method and the techniques which are used for the de-energized situations one if the hand cleaning it is basically the cleaning of insulator by hand wiping it thorough and effective on insulator surface dirt and pollutant which are spread on the surface but it is a tedious time consuming and also expensive process which require lot of equipment outages so the outages or the maintenance or the time which is taken out or de-energized of the equipment is being take request long process of time and also a tedious job.

So hand wiping in generally is used when washing is impractical because of problem of access by heavy vehicles or it could be height or design of it particular structure or a type of contamination in such cases hand washing is recommended and hand wiping is normally used on station insulators in substation where high pressure washing either impractical or due to proximity energized equipment in the system.

So it will be difficult to completely de-energize the entire substation and take for maintenance so in such cases because of the proximity of other equipment's which are nearby insulator to be cleaned in such cases hand washing is preferred or where other methods are difficult to be used or in sufficient due to sometimes harness of surface deposit if it is surface deposits on the insulator surfaces it could be on deposits later or any of the busing where normal washing or by pressure washing could not be cleaned in such cases this hardness of material deposited has to be used by the hand cleaning methods.

So some insulators can be cleaned only using soft or dry wiping racks in some cases you may require some hardness of the surface to be removed. So additional materials are such as wet or paraffin soaked cloth here various methods have been formed few of the things being discussed so some are wet or paraffin soap cloth solvent sometimes steel brushes all this cannot be generalized and this things cannot be used for four type of insulating material.

So particular the steel brushes or steel will which may be needed for other some of the insulators cannot be sued for polymer insulator which are of soft. So care has to be taken by mentioning this depends on the surface conditions and material to be removed the hardness

of the material is deposited in the surface. So such material are being used to clean the insulation or bushing in or substation equipment's where this equipment's are being housed.

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These are some of the practical conditions where de-energized cleaning is carried out you can see here in case of tower or in case of the tower arrangements for single suspension string the utility people physically clean the insulator by hand washing methods which over a period of time the contaminants cumulate the surface become harden.

So here proper measures have been taken the supply switched of an necessary grounding is done based on that the cleaning of insulators is taken up and the surface which the pollutants make it hard as to be removed and takes a longer period of time. So this one of the example which is being carried out the cleaning process on insulators using the de-energized method.

This is again the one of the different method is being done particularly hand held water jet of known spray is being targeted to insulators surface both on the surface or petty coats the cleaning is being done to the insulators in the de-energized condition. So you can see the as mentioned the water resistivity the solvents are also being used play a role in this aspects.

So this one more example in the substation where the busing of the equipment it could be a a current transformer or lighting arrestor bushing of the ceramic disk is been maintained cleaning higher using the hand held water jet here. So various methods are being suggested

for the cleaning purpose during the de-energize condition. These are few of the practical methods which are being employed.

So several other as mentioned whether using the dry cleaning method using a paint cloth or if the hardness is more if the hardness is being remove if the help of solvents or liquids which can be sued to clear the pollutants on the surface. So very importance this cleaning has to be carried else we can physically see this effects over a period of time and the creep age reduces and flash over or the string happens during the monsoon condition where it is unwarranted or unwanted for the past system utilities.

So necessary procedures necessary plan and ah regular periodic maintenance is essential is essential so different method either energized or de-energized condition have to be carried out.

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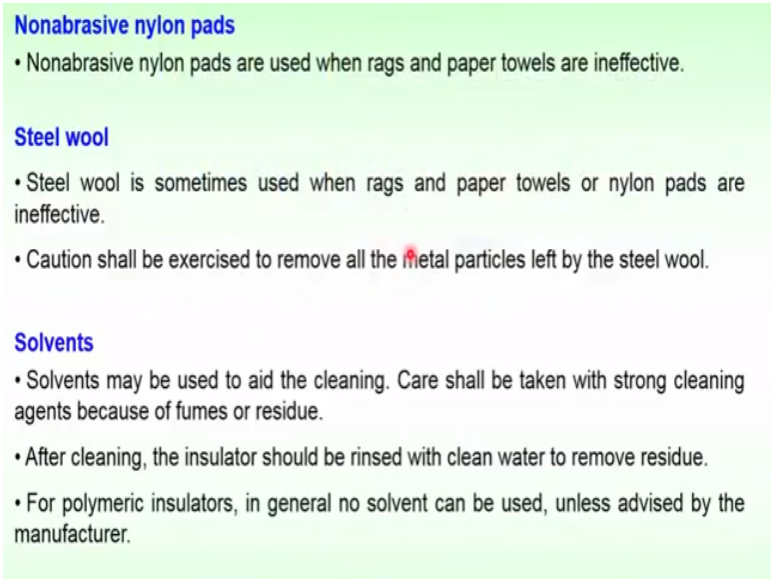

So again various types of equipment's materials are being used we will look into some of the utilities they use various use for cleaning. We go for non-abrasive nylon pads where this nylon pads of non-abrasive nature are used when the cloth or paper towels are ineffective in case the hardness which is on the insulators surface is difficult to clean with normal cloth or paper towels in such chase to remove the hardness hardened pollutant on the surface of the insulator or on the bushings.

Non-abrasive hard type of nylon pads are being employed by the utility personal in removing the contaminants or the deposits it could be from the cement industry example. So such cases cleaning with ordinary cloth or paper tower may not be effective in such cases high non-abrasive type of methods are being used.

The second is the steel wool again steel is used when the cloth or rages or paper towel or iron such cases even nylon pads do not be effective in such cases steel wool is being employed the caution again is maintained and exercise to that it removes all the metal particles left by the steel that is very important. This small particular which from the steel wool is deposited in the surface of insulation could lead to the creak down early breakdown on the surface.

So care as to be taken once the cleaning is being done any traces or metal particle which is left on the surface of the insulators have properly to be completely cleaned after the cleaning is done to check whether any metal traces or left over. Third is the solvent again as mentioned earlier this may be used in aiding the cleaning sometimes when this may help for better cleaning so care as to be taken particular with strong cleaning agents because of residue.

So some solvent may cause fumes or the residue may left on the surface could again cause problems to the surface of the insulators. So picking the solvents is also an important aspect for cleaning so after cleaning with the help of the solvents the insulators should be rest with clean water to remove the residue which is being rest by the solvent on the surface of insulators. In case of polymer string are insulators and in general no solvent can be used is a important point to be considered and particularly unless it is advised by the manufacturer.

So polymer insulator here again I am stressing here this are of organic in nature the rubber surface of the sheds in case of using the solvents the chemically react the surface and this could degrade the hydrophobicity characteristics of the rubber surface. So solvents steel wool and non-abrasive type of method should not be employed for polymer insulators unless there is direction from the manufacturer to which solvents to be used for the cleaning of polymer insulators.

So care as to be the ceramic or porcelain or glass insulators in case of polymeric insulators the general methods cannot be used.

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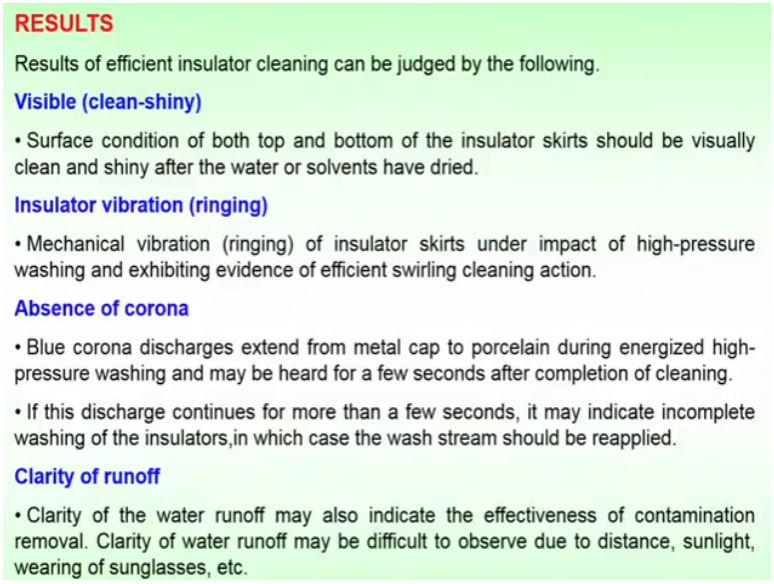

So how the results of cleaning this is a important decision has to be taken by the personnel or the technical who do cleaning for the insulators how to check the efficiency of the cleaning or the result of efficient insulator cleaning this can be judge by the following ways one is the visible through the naked eye where the surface should be very clean and it should be shiny.

So once the surface condition of both top and the bottom of the insulator petty coats or skirts should be clean shiny and the solvents are dried so care as to be checked in case there is some residue left on the surface after cleaning and if the surface is not clear you can spot some of the patches on the insulator surface so this is not proper cleaning so proper cleaning has to be made so that insulator is completely after dry looks visibly clean and use a because of the in case of ceramic insulator the glaze show the shining appearance this has to be observed.

Second is the insulator vibration or a ringing sound here again the mechanical vibration or ringing of insulator skirts particularly the petty coats of the sheds is which we call for the polymer sorry porcelain insulator under impact of high pressure washing and exhibiting evidence of efficient surely cleaning action. So this based on the experience the personnel or technicians could feel the vibration or noise of the high pressure washing on the surface or on the sheds of the insulators.

So this could also be noticed during the high pressure washing for efficient cleaning action. The third is absence of corona activity here because of the contaminants on the surface it could be metallic parts it could be the hard dust comprising of conductive does which settle over a period of time because of the fog or a mist where the activity corona starts on the surface showing dry band and wet band and arching partial discharges.

And also corona discharges which could extent from metal cap to the porcelain or pin after the pin to the cap of the insulator depending upon the surface conditions during energized conditions. So here corona if it is during the energized condition so it should be noticed that corona discharges which extent from metal cap from porcelain at the energized high voltage washing may be hurt for few second after completion of the cleaning aspects.

So once insulators are completely clean the discharges have to be reduced so this discharge in case continue for more than few seconds and even after the insulator is complete dries this may indicate complete washing of insulators in which case the wash should be re applied that is an indication.

So once the cleaning with high pressure washing is done corona activity should completely down or completely disappear in case if activity persist this is an indication of the insulator request more cleaning method or better cleaning method to see the corona activity is not there on the surface. The clarity of run off so importance of this is the clarity of the water enough may also indicate the effectiveness of contamination removal.

So once the insulator the contaminates which are spread or polluted which are spread on the surface are removed then water run off may indicate the effectiveness. Here again the clarity of water run off may be very difficult to observe because of the distance some time we were even the utility personal or operating for cleaning this form the distance it is very difficult to physically observe and see this so where in during the sunlight also it is difficult.

So wearing of sun glasses or looking through the binocular could help to see the clarity of water knob in which indicate the effectiveness of contamination the insulators surface.

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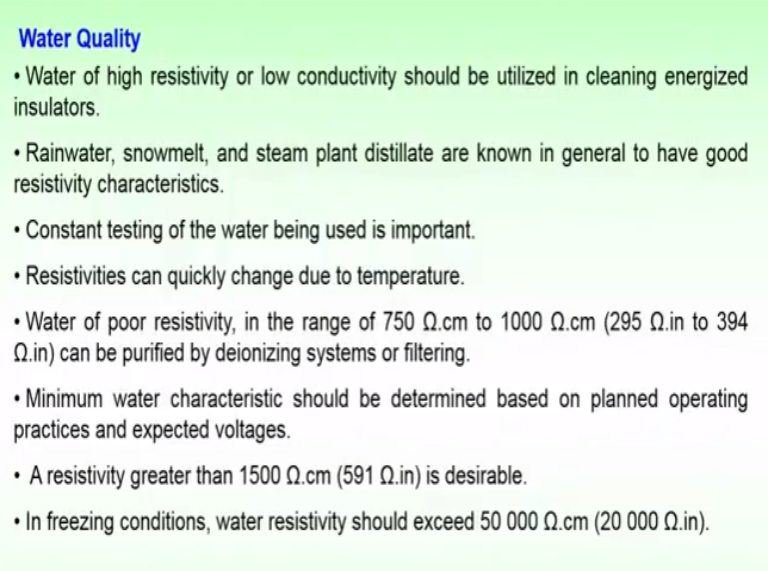

The other is the water quality here again the quality of water is important which is being employed for he cleaning purpose of on the surface of the insulators. So water of high resistivity or low conductivity very important should be utilized in cleaning eh energized insulators or de-energized insulators rain water or snow metal water or steam melt water which distillates our one in general to have good resistive characteristic.

So this type of water can be used for a cleaning purposes the constant testing of water being used is also equally important the resistivity and conductivity to monitor so that hard water is not being used for the cleaning purpose where this again deposits and which could again which may not be properly used for cleaning. So the water quality is at most importance similarly resistivity's can quickly change into temperature also this point has to be considered.

So water of poor resistivity which is the range of 70, 750 ohm centimeter to 200 ohm centimeters that is 295 ohm inch to 394 inch can be purified by deionizing system or by filtering so in case the places where high resistivity or low water is not available in such cases the water is to purified by deionizing systems later on this purifies or deionized water is generally employed for the cleaning purpose.

So the minimum water characteristic should be determined based on the planned operation practices and also for the expected voltages so this characters can be determined based on various practices these are being employed and also for the voltage level which is being

used. So the resistivity greater than 100 ohms centimeter or 590 ohm inch is generally desirable used for cleaning purpose the recommended values.

In freezing condition or cold conditions water resistivity should exist 500 ohm centimeter to 20000 ohm inch for the cleaning purpose. These are the some of the broad guidelines pertaining to the quality of water and there is resistivity of the water and by usage of cleaning system particular for any insulators or to substation bushings or equipment's which are housed using there.

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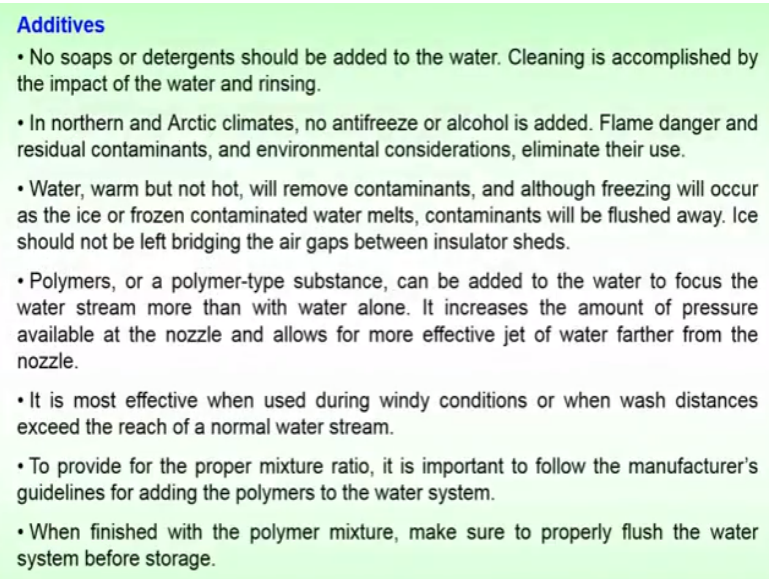

The further is additives for the water the various additives which are being used for cleaning the insulators. Water quality and the resistivity we have discussed so additives no soaps are detergents to be added to the water this is the point to be considered the soap solution or the detergent used for cleaning we will again leave deposits on the surface if it is not properly cleaned or washed.

So soaps or detergents could never be used for cleaning generally is accomplished by impact of water and rinsing the water. So countries in northern and arctic climates no anti-freeze or alcohol is added. Here because the flame danger and residual contaminants and environmental consideration eliminate. So no anti-freeze or alcohol is added so alcohol or soaps or detergent not be employed of the cleaning as this mainly because of the danger or

the flame or the residual contaminants could have a discharge activity of arching could be same.

So the water which is warm but not hot will generally remove the contaminants of the oil contents and so on. And although freezing will occur at the ice or frozen contaminant red water belts. Contaminant will generally flushed away. In Such cases the eye should not be left bridging the air gaps between insulators and this has to be noted.

So well removing with the hot water or a warm water the care as to be seen that the ice which is been frozen on the insulator have to be completely melted removed and between the petty coats of sheds air gaps between the sheds it is be verified that there is not bridging which is happening as this bridging the sheds will bring down the creep age length of creepage distance of the insulator or insulator.

So proper cleaning in case of fog deposits are freezing condition have to be additives for polymer or polymer type of substances can be added to water. So this polymer types substances which can be used focus the water stream more like the water alone so the mix of the polymer could be used in the water to clean. It generally increases amount of pressure available at the nozzle and allows for more effective jet of water for the depend on the nozzles.

So some substances related to polymers can also be used it is most effect particularly when this are used during windy conditions or high windy situation or when wash distance is exceed each of the normal water string so some cases it is difficult to go near the as prescribed distances in such cases a polymer or polymer types of substances are employed and used for effective cleaning condition which also help in the wind or high windy conditions.

To provide proper mixture issue it is also important to follow the manufacturer guidelines for adding the polymer to the water system the quantity type of polymer or the substance before it is added use to follow the proper manufacturer guidelines when this additives are done when finished used to be polymer mixture it is to be showed that properly flushed out water system before storage.

So this water as to be clear before the system is being employed for cleaning activity the water along with the polymers have to be properly mixed and it should be used effectively for the cleaning purpose. This is about the various additives to be used which are not to employed for cleaning purpose with the water.

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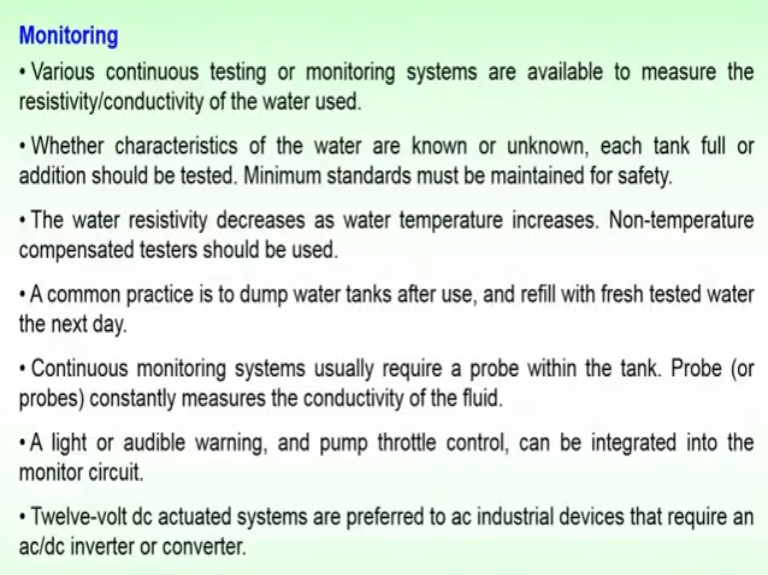

Next is monitoring the cleaning systems this is the equally important aspect for the utility engineers here various continuous testing or monetary systems are available to measure the resistivity or the conductivity of the water being used. So continuous monitoring is essential to check for better performance. So whether characteristic of water is whether known are unknown whether each of tank full of addition to be tested.

So in any time the contaminants could be affected to the water so the water as to be tested before it is to be used and the minimum standard as to be maintained for safety aspects while using the cleaning methods either energize or the de-energized conditions the water resistivity decreases as the water temperature increases. So non temperature compensated tested should be used for checking the resistivity also because the water which is stored for long period of time it could the resistivity change and it has to be tested it before is being used.

The common practice is generally to dump the water tans after use and refill with fresh tested water and the next day or the next over the cleaning aspects. So this as to be followed else

the water which is left should not use again and again so that there could be change in resistivity of water because of the contamination.

So proper common practice is generally is to be followed and continuously monitoring systems generally usually required probe within the tank where a probe or probes constantly measures the conductivity or fluid or the water from the new tanks for a better monitoring for this also we will give a better system or a better information or a water quality. So light or audible warning and pump throttle control can be integrated on the monitoring circuit and so in case if it is required.

In general the 12 volt diesel actuated systems are preferred to AC industrial devices that requires a AC DC invertor or convertors to give a information about the noise or little light mentioning about the activity of the pump for the water monitoring systems. So this also are being used so the quality of water the contaminants and also the monitoring is also essential as the contaminated water should be not be employed for cleaning where these could leave the traces to the surface and performance of the insulators will may not be improve even after the cleaning aspects.

So care as to be monitored and also the safeties at most important in case of the live line washing methods being employed.

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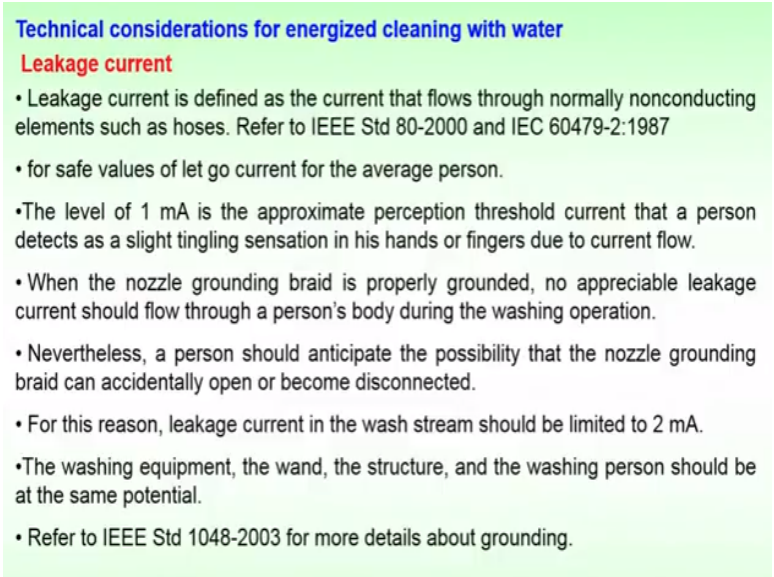

We look into the technical consideration in particularly for energized condition cleaning with water. So what are the technical consideration which can be looked into apart from the quality of water measurement from resistivity or measurement of conductivity or addition of solvent so on.

Here one of the important aspect being the leakage current which of important here the leakage current which is defined as the current that flows normally in non-conducting elements such as hose which is being used water hose the pipe and water hose this details of the leakage current and the particular information is described in the activity standard and IEC standard as mentioned where it gives the minimum values for the leakage current for the hoses and equipment which is being used for the cleaning for energized condition.

So for safe value the let go current for average person also is to be considered here the level of one milliamp is the approximate perception old current that a person deducts as slight tumbling and insertion in his hands or finger due to the current flow. So when the leakage current flows through properly grounded no abrasive leakage current should flow through a person body during the washing of operations.

So the current which is being leakage current as to be flowing through the ground not to the body of the person. So never the less some time the person should anticipate to the possibility that nozzle ground in can be accidently open or become disconnected in such cases proper arrangements or care or safety measures have to be employed for this reason the leakage current and the wash string should be limited to two milliamps.

So this is the worse condition where the connectivity of the ground using he copper blade can accidently come out open or becomes disconnected in such cases also the current should not increase two milliamps. So the wash string equipment the wand structure the washing person should be at the same potential is to be noted. So the person is standing at the arrangement where is being used for cleaning the insulators for live line conditions have to be same potential.

So that the rise in potential as not seen and the safety of the personal who is cleaning the insulators has to be taken care. So these details further or very clearly explained with reference to IEEE standard and 48 about the grounding of the hose pipes and the current to be contained and how it is to be done is different so further information is available so you can read the standards for details about grounding aspects particularly for the nozzles and the force which is being used for operations.

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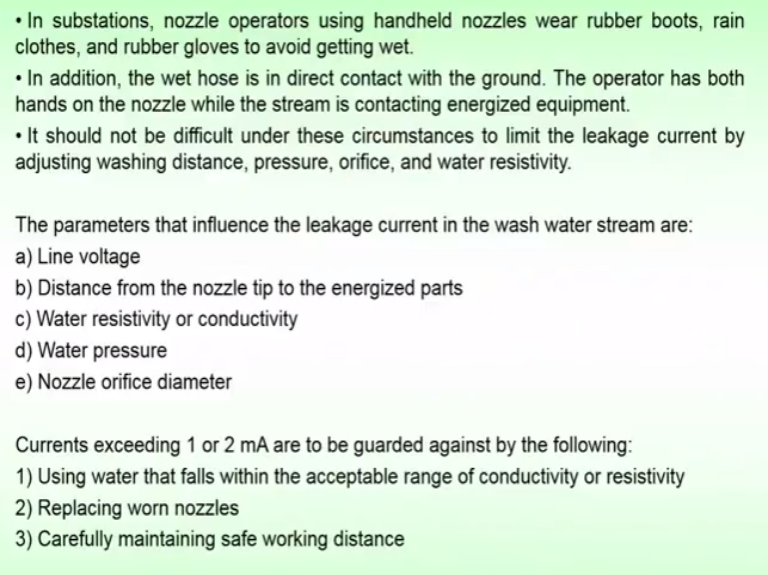

In substations that is about the transmission part the substations these nozzle operator generally use a hand held nozzles they were rubber shoes rain clothes or rubber gloves to avoid getting. So this as to be taken care in case the surface person becomes wet the conduction happens and this has to be avoided. So proper clothing and proper gloves has to be used in addition the wet pose which is direct contact with the ground the operator has both hands on the nozzle while the stream is contacting energized equipment.

So it could not be difficultly under this circumstances to limit the leakage current by adjusting a washing distance. So the distance is very important the pressure of water spray they horrifies the diameter of the nozzle sets and the nozzle resistivity. Several of things have to be adjusted to see the person does not get contacted with the current flows through the body of the person.

So the parameters that influence the leakage current in the washing or waste stream or the line voltage important. What is the voltage which is being the insulators are being cleaned what is the voltage level the equipment is being operated the distance from the nozzle tip to the energize part. This is a very important point water resistivity or conductivity which is being used water resistivity or conductivity plays around water pressure operation of the water jet which is being used at a certain pressure is also important term parameter which could influence the leakage current.

And the nozzle or a orifice diameter the nozzle diameter which is being used this also plays a part in the influence of leakage current. So as mentioned earlier current leakage which is exceeding on of the one or two milli amps are to guarded against by using water that falls within the acceptable range of conductivity or resistivity replacing over nozzles or carefully maintaining the safe working distance.

So this points have to be considered to see that the leakage current do not flow or leakage current is being contained by using the methods.

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8.2 Working distance

Table 4—Minimum distance for energized washing[a]

Line voltage	Minimum nozzle-to-conductor distance	Minimum water resistivity	Minimum nozzle pressure	Maximum orifice diameter
(kV)	(m)	(Ω·cm)	(kPa)	(mm)
13 & below	1.82	1300	2758	4.76
13 & below	1.82	1300	2758	6.35
16	2.13	1300	2758	4.76
34.5	2.44	1300	2758	6.35
34.5	2.44	1300	2758	4.76
69	2.74	1300	2758	4.76
69	3.66	1300	2758	6.35
115	3.05	1300	2758	4.76
115	3.96	1300	2758	6.35
230	3.66	1300	2758	4.76
230	4.57	1300	2758	6.35
345	3.92	1300	2758	4.76

This tables gives the information about the minimum distance where a personal or cleaning as to be done in particular during the energized washing or cleaning conditions the working distance minimum distance to be employed here earlier also we have looked into this similar

arrangements. So depends upon the this gives the line voltage for various voltage levels this is the minimum nozzle to conduct her distance for the cleaning.

Minimum water resistivity the minimum nozzle pressure and the maximum orifice or the diameter in millimeters. So a few consideration here in case of 13 K and below you can see the minimum nozzle to conduct proper distance should be maintained at 1.82 meters the motor resistivity is 1300 ohm centimeters the minimum nozzle pressure to be 2758 kilopascals and the maximum orifice diameter is for 4.6 milli meter.

So here you can see most of the voltage levels as increases the minimum nozzle have 2 diameter of the conductor various but the minimum resistivity remains the same you can see 1300 diameter in whatever voltage levels similarly the minimum nozzle to pressure you can see the depends on the voltage it is not depending upon the voltage level it is particular pressure as the insulators are being claimed.

And maximum orifice diameter also changes as the voltages level you can see various types of nozzles of diameters are being employed. So this table gives an important information as the voltage level increase a similar pattern is being observed for further 400 or 765 KV transmission system. Similar distances have to be maintained which are also given this standards. So working distance is very important care as to be taken safety at most importance in the cleaning of the insulation.

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Table 4—Minimum distance for energized washing[a] *(continued)*

Line voltage	Minimum nozzle-to-conductor distance	Minimum water resistivity	Minimum nozzle pressure	Maximum orifice diameter
(kV)	(m)	(Ω·cm)	(kPa)	(mm)
345	5.22	1300	2758	6.35
500	4.27	50 000	5516	6.35
500	6.10	3000	3792	7.94
500 dc	6.10	50 000	5516	6.35

NOTE—The 345 kV distances were interpolated using 230 kV and 500 kV and found to be in line with industry practice.

[a]The distance is limited by tower dimensions and configuration. Because of the limited nozzle-to-conductor distance, demineralized water with resistivity of 50 000 Ω·cm (19 685Ω·in) or greater can be used.

The table 4 here shown gives the minimum distance again for the energized conditions here further voltage above 345 KV are shown here line voltage 345, 500 and also 500 KVDC is also given here. So you can see her again the minimum nozzle to conduct a distance is been given here. So you can see here again the minimum nozzle to conduct the distance as to be maintained in meters. This is the minimum water resistivity which as to be above 400 KV he water resistivity changes.

And here you see the minimum nozzle pressure changes after the 400 KV or 45 KV further there is a change in the pressure and also the maximum orifice diameter changes depending upon the voltage level and the surface conditions. So point to be noted up to 345 KV distances where generally interpolated using a 330 KV and 500 KV and are found to be in the industry practice. So most of this the feedback which being taken from the industry the guidelines have been set for cleaning.

So the distance is generally limited by the tower dimensions and the configurations because of the limited nozzle to conduct a distance thing realize the water with resistivity of 5000 ohms and centimeter are greater than can be also employed for the cleaning one such example for 500 KV in and 500 KV's which is shown here. So this is typically because of the nozzle to conductor a distance which is employed.

So changes could be done the instant where it is being used so this is the generalize procedure or methods which are being employed locally some minor changes depending upon the manufacturers information can utilized for proper cleaning.

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Table 11—Contaminant types and washing types

Contaminant	Water washing		Compressed air dry cleaning		Wiping	
	Flood/ low pressure	High pressure	Corncob w/nut shell	CO_2 pellets	Hot wiping	Hand wiping
Salt	√	√				√
Cement/lime			√	√	√	√
Earth dust	√	√	√	√	√	√
Fertilizer dust	√	√	√	√	√	√
Metallic dust			√	√	√	√
Coal dust	√	√	√	√	√	√
Volcanic ash	√	√	√	√	√	√
Bird excrement	√	√	√	√	√	√
Chemical	√		√	√		√
Smog (vehicular)	√	√	√	√	√	√
Cooling tower effluent	√	√	√	√		
Smoke/coal soot	√	√	√	√	√	√
Organic	√	√	√	√	√	√
Ice/snow		√	√			√
Petroleum/grease			√	√	√	√

So various contaminates which we have described summary of this contaminant and also the washing and cleaning types which are used you can see various contaminates we have discussed this is the water washing various types either low pressure or a high pressure types of washing compressed air dry cleaning using the corncob or walnut shell or carbon dioxide or sometimes wiping the using the cloth it could hot wiping or hand wiping.

So several methods are being used for cleaning the insulators both for dry and wet conditions so you see the various contaminates which are here like the salt cement line earth dust, fertilizers. Metallic dust, coal dust, volcanic, ash, bird excretions, chemical, smog because of vehicular pollution, then cooling tower effluent smog or the coal cut which coming from plants or organic or ice or snow and petroleum or grease.

So for all these contaminants the procedure are being shown here the adoption for clearing method using in various types of methods either dry cleaning or dry washing or water washing or wiping methods are generally used. So this gives the summary of the contaminants type or washing methods are to be employed in case of various contaminates very important information's.

So that completed the cleaning procedures employed for the insulators both for ceramic and polymer types methods and also the techniques employed the distances to be maintained various types of arrangements which have to be followed further we will discuss about the coatings for the insulation on ceramic as well as the polymer insulators further thank you.