Power System Protection and Switchgear
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Lecture No. 24
Auto-Reclosing and Synchronizing-II

So, let us continue our discussion with the same topic that is we started our discussion with the sequence of events.

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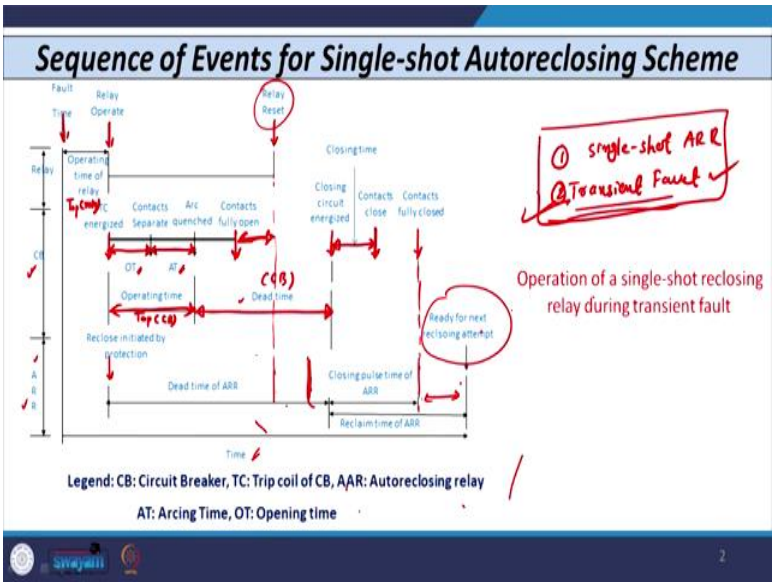

So, let us consider the single-shot autoreclosing relay, and let us also consider the fault that is transient in nature. So, this is for transient fault and second one that is we use the single-shot autoreclosing relay that is single-shot ARR.

Now with this background, as I told you whenever fault occurs at this instant, then the relay has certain time of operation, so relay will operate after some time let us say 20 or 25 millisecond. As soon as really operates at this instant let us say it gives signal to the breaker parallely it also gives signal to the autoreclosing relay which is situated here. So, it gives two signals. Whenever the signal is received by trip coil of circuit breaker so circuit breaker is here its trip coil is energized and then the contact separation starts.

As soon as its contact separates, so till the trip coil is energized and the contacts separates that time that is known as opening time of circuit breaker, that is contact opening time of circuit breaker. Once the contacts become open after that arc is formed across the contact of circuit breaker and after some time period that is known arcing time ,the arc is quenched. So, once

the arc is quenched this period that is known as the arcing time and if you add this to opening time and arcing time the total time that is known as the operating time of circuit breaker.

So, this is your T operating time of circuit breaker. So, if you add T of circuit breaker and T of relay that is your total fault clearing time. Once you have you can see that after the arc is quenched the contacts that fully open at this instant. So, once the contact that becomes fully open there is some time. If you see on the breaker side, then after the arc is fully quenched, you need to give some time to the breaker, that time is known as the dead time of circuit breaker.

What is a meaning of the dead time, dead time means once the arc is quenched because normally arc is quenched by some medium. So, once because you know that phenomena of arc that when the whatever air or medium is there that is it ionized, you have to deionize that media deionize that particular region using some medium arc quenching medium, and once the arc is fully quench your breaker is not ready immediately.

So, you need to give some rest so that the dielectric strength of whatever medium you use, that is regained so, that that is known as the dead time off circuit breaker. So, this is the dead time of circuit breaker. And you can see that after sometime at this point here if fault that is normally transient in nature that is what we have assumed. So, that is not there. So, you can see that that from this time, once the contact of the breaker that is fully open after some time delay this much delay, the relay that is now that becomes reset.

So, resetting of relay that is carried out only and only when the contacts of the circuit breaker that become fully open with some safety margin after that time period. You can also see that here in a reclosing ARR reclosing relay after some time that means, when the relay reset that becomes possible immediately when the relay reset occurs, the task of this autorecloser starts.

So, autorecloser, what will give, it will give closing command closing pulse time that is issued by the autorecloser so once it issued the closing command, then what will happen, (co) closing circuit of this breaker that is energized and once the closing circuit is energized after some time whatever is the closing time of the breaker the contact of the circuit breaker that become closed.

And once that contact become close as we have assumed the falt that is transient in nature so that has already die out. So, again when the contact close the system is healthy, so there is no need to further again, opening up the contact because we assume it is a transient fault.

So, the instant from here were the closing pulse that is issued by autorecloser and till the contact of the circuit breaker that become again reclosed, fully closed, and the contact fully closed here, so from this instance where the autorecloser give command to the breaker and this instant, if I extend here to the autoreclosers and up to this instance where autorecloser issues the command to the breaker and when breaker operates and its contact fully become close that time is known as the sometime that is known as the recap time of the autoreclosing relay.

And after this time, the autoreclosers that is ready for next reclosing attempt, as the relay reset is there similarly, your autoreclosers that is also ready for the next reclosing operation. So, this is how the sequence of event works if I assume the transient fault. Now on the other hand, if I assume the permanent fault then let us see, what are the sequence of events?

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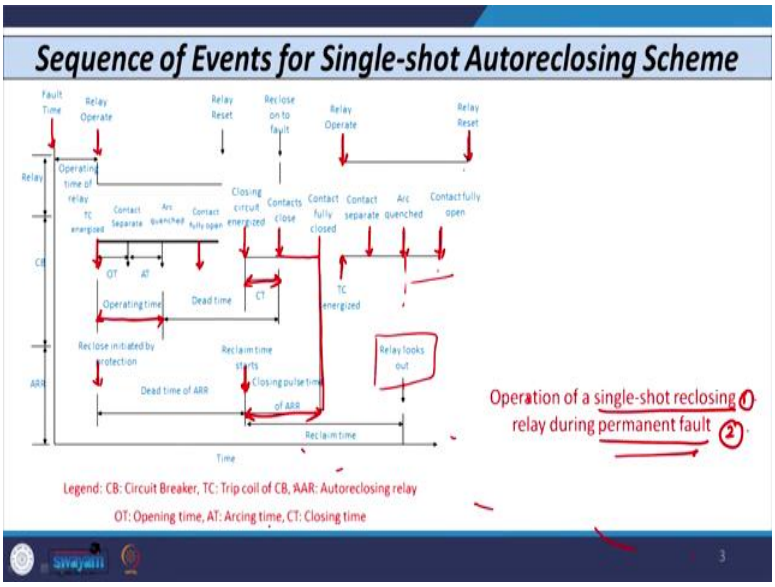

So here, we have assumed the permanent fault and we again assume the single-shot autoreclosing relay. So, this two that is the assumption. The same thing again, the fault occurs at this instant, relay operates so relay has some operating time, the breaker has also some operating time of the breaker because at this instant, relay gives command to the breaker as well as is also issues the command to the autorecloser.

After this point, the contact of the circuit breaker that become fully open. The arc is already quenched. So the after this time, again the sub dead time is also there. The autoreclosing relay that will issue the closing pulse and that issues that pulse to the circuit breaker so again the circuit closing circuit of the circuit breaker that is energized, contact of the circuit breaker

closes so this is your closing time of the circuit breaker right after the command issued by the autoreclosers.

And then, when the contacts fully closed, this is the point where the contact that is fully closed. So, this is the time up to which the closing pulse that is issued by the autorecloser. Now as this fault is permanent in nature that means, it is not going to die out so again the protective relay has to operate from here it senses the fault, again, it gives signal to the breaker as well as autoreclosers so again, trip coil of the circuit breaker is energized again, the contact separates arc quenched and then the contact of the circuit breaker that fully open that means there is no arc.

So again, wherever the contact to arc is quenched at the same time, one command is given to the autoreclosers and its contact that will go in lockout condition because it is a permanent fault. After one reclosing attempt it has been found that the fault is permanent in nature. So, the further autoreclosing attempt that is not to be carried out. And after this point, this instance, again your relay that becomes reset so it is ready for the next operation or to detect the next event of fault. So, this is all about the sequence of events that that is possible in case of permanent fault.

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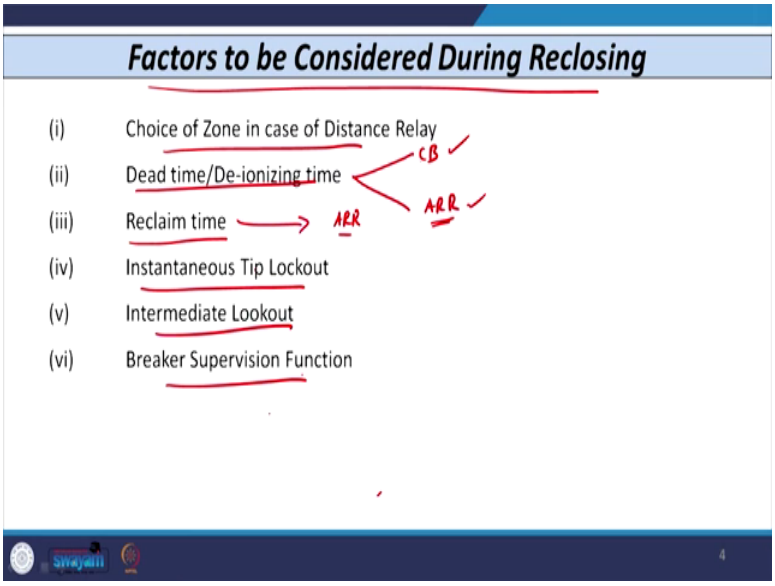

Now, if we wish to apply this autoreclosing philosophy, then we need to consider certain factors. So, let us see what are the factors that need to be considered while applying the autoreclosing philosophy for the transmission, as well as distribution system.

So there are 6 major factors we need to consider. The first is the choice of the zone, if we use the distance relay, if we do not use then this factor is not there. The second is the dead time or deionization time. It can be of circuit breaker and it can be off autoreclosing relay, so dead time or deionization time. If I use the autorecloser then we will go for dead time, if I use the breaker then we will call it deionization time.

Then we have the reclaim time, this is specifically applicable to autorecloser, reclosing relay only, it is not applicable to the circuit breaker. Then the fourth point that is instantaneous trip lockout then intermediate lockout and breaker supervision function. So, let us see each and every factor one by one.

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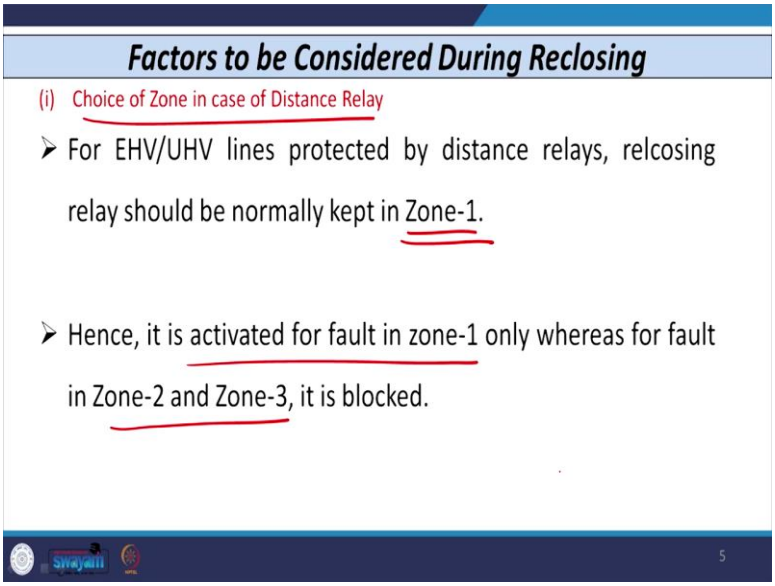

So, let us start with the first factor that is the choice of zone in case of distance relay. Now we know that when we use the, when we go for EHV and UHV lines we can, we may use the distance relay or we may go for the carrier-aided distance scheme or pilot scheme. So, if we use distance relay then it is very important point that reclosing really should be normally kept for zone 1 only.

We should run use the reclosing relay for the zone 2 and zone 3. If we use distance relay for the protection of EHV and UHV lines and if we wish to utilize autoreclosing feature in the distance relay. This is very important. So, it is activated for zone one only whereas, for zone 2 and 3, the working of the autoreclosers that has to be blocked. Why what is the reason?

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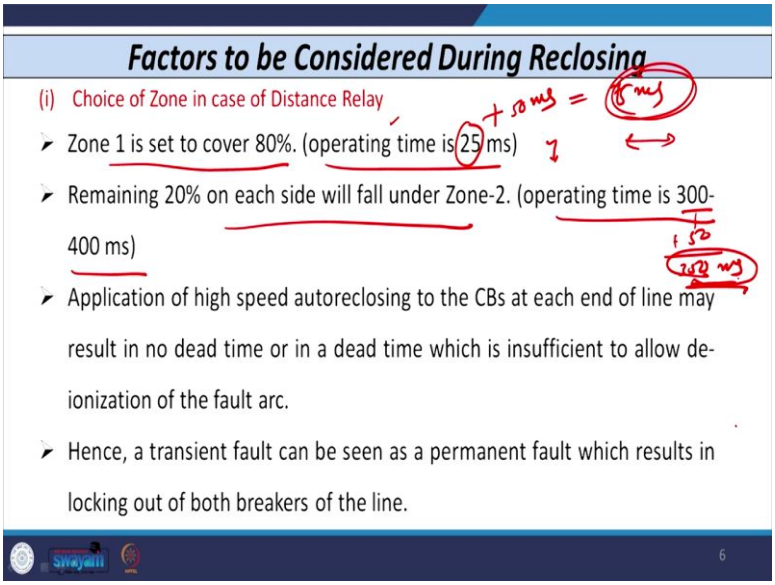

The reason is this that we know that in zone 1 normally, zone 1 of distance really that covers maybe 80 percent to 90 percent of the line length. So, in this region if any fault occurs, then the relay operates in 25 to 30 millisecond one to one-and-a-half cycle, if fault occurs in remaining 20 percent on each side, so total 40 percent then the dead fault that is covered or sensed by one of the distance relay on either side in second zone, so the operating time in this job is 30 to 40 milliseconds.

So, if fault occurs or this 20 percent margin on each side, then the you can see that the opening time of breaker at one side, which is 25 plus breaker time, let us say it is two-and-a-half cycle so 50 milliseconds. So, that is the 75 millisecond and here let us go for minimum plus the 50 so that is 350. So, you can see that on one side relay breaker become open in the 75 millisecond whereas the other side the breaker becomes open in 300 millisecond.

So, simultaneous opening of the breaker that is not possible if we use the distance relay, any fault that occurs in the remaining 20 percent of the region on each side. So application of high speed autoreclosing to the circuit breaker at the end of line that is for remaining 20 percent we should not go for the reclosing attempt, so we should go for reclosing attempt only for the 60 percent of the region from the middle, midpoint of the transmission line where both the relay sense the fault in its first zone. So, this is very important.

One more thing is that when we apply a high speed autoreclosing to the circuit breaker at each of the line, then it may result in no dead time or the or the dead time, which is insufficient to allow the deionization of arc, so that means sometimes transient fault that can

be seen as a permanent fault and which results in the operation of the breakers unnecessarily, so that's why we should not go for the reclosing attempt for the remaining 20 percent of the fault in the region on each side of the distance relay.

So, if we go for distance relay, only 60 percent region only we should go for reclosing, we should not go adopt reclosing for remaining 40 percent. If we go for that, then what will happen on one side fault is cleared in the 75 millisecond, but on the other side fault may take 350 millisecond to clear.

So, it may possible that consecutively if some other fault occurs then the breaker that is not going to get the sufficient deionization time, so the dielectric strength of the medium of the breaker that is not recovered and there are fair chances of re-striking of the arc. So, that is why we should do not go for the reclosing attempt in the remaining 40 percent.

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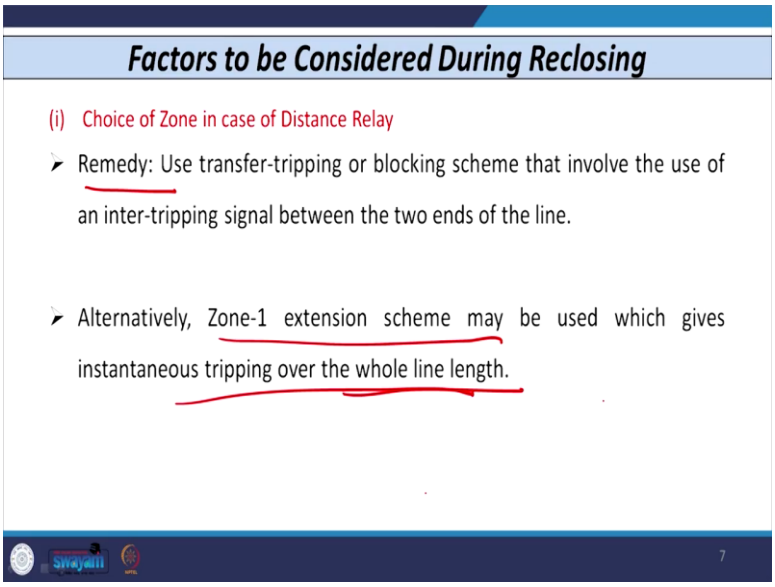

What is the remedy? So, the remedy if we want to rectify this, then we should go for either the tripping scheme or transfer tripping scheme or we should go for the blocking scheme. So that involve the use of the transfer of the any signal from the other end on each side. So, if we use this type of scheme then this type of problem that is not going to occur.

Alternatively, the other solution is we can also extend the zone one of the distance relay, so it is known as acceleration of zone one, so that whatever remaining 20 percent on each side the zone 2 that is converted into zone 1, and the entire line transmission line that is protected by distance relay in its first zone only, but if we go for if we adopt this then there are fair

chances of the mal operation of relay because the how to extend the zone one or how to convert zone one into zone two, that is a very difficult task.

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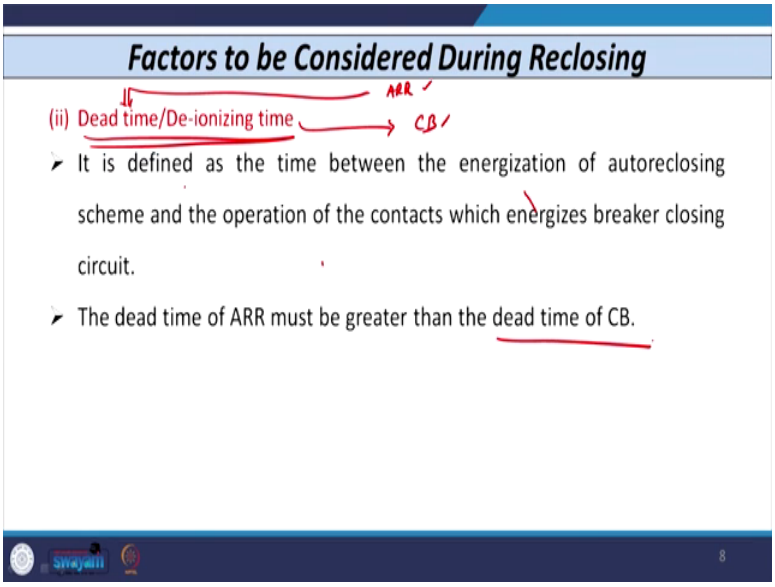

Now, let us see the second factor that is known as the dead time or deionization time of the circuit breaker. Now, when we go for dead, when we consider the dead time we consider it for autoreclosing relay and when we consider the deionization time, we will consider the circuit breaker. So, how the dead time or deionization time for both the cases whether autoreclosing relay or breaker how it is defined. So, it is the time between the energization of autoreclosing scheme and the operation of contact, which energizes the breaker closing circuit.

So, if I go further you can see that what is the dead time. As soon as the if I consider the circuit breaker then the dead time of circuit breaker start from this instance, you can see once the arc is fully quenched and it will go up to when the next that is the closing command that is issued to the closing coil of the circuit breaker.

And if I go for auto closing relay, then the date time of auto reclose it really starts once the relay operates this our original protective device operates and it gives signal to the autorecloser. And when the reclaime time start that means with the closing circuit of the circuit breaker that is energized, so this is the region of the dead time of the autoreclosing relay**.** So, normally dead time of autoreclosing relay that is always greater than the deionization time of the circuit breaker that is correct.

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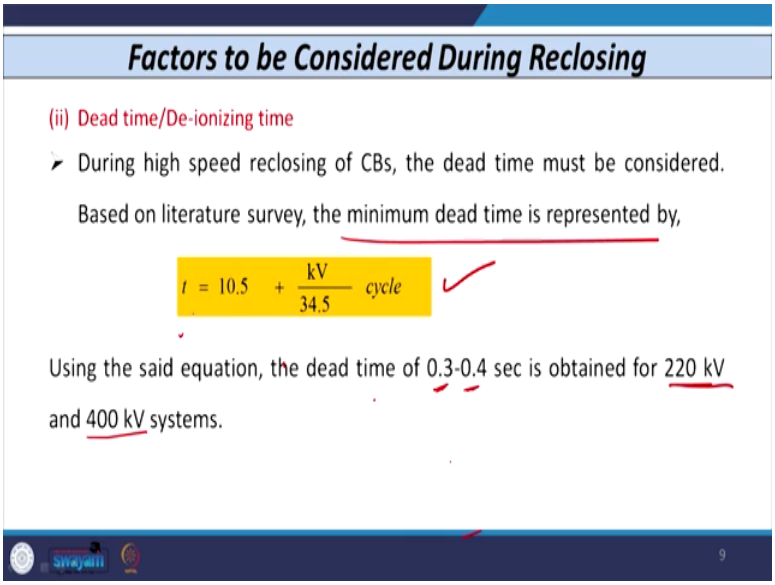

Now, how to determine the dead time or deionization time of the circuit breaker or autoreclosing relay. So, if we consider the any high speed reclosing of circuit breaker then the according to the some IEC standard the minimum dead time that is given by this formula that is given by T is equal to 10.5 plus kV divided by 34.5 cycle. So, you will get the dead time in terms of cycles you can convert into milliseconds.

Now here, in this formula kV stands for the line to line voltage or system line to line voltage right, so if line is 220 kV then that value that should come here. So, if I go for 220 kV line then the dead time is 0.3 seconds and if I go for 400 kV line the dead 0.4 second according to this formula. So, you can calculate it

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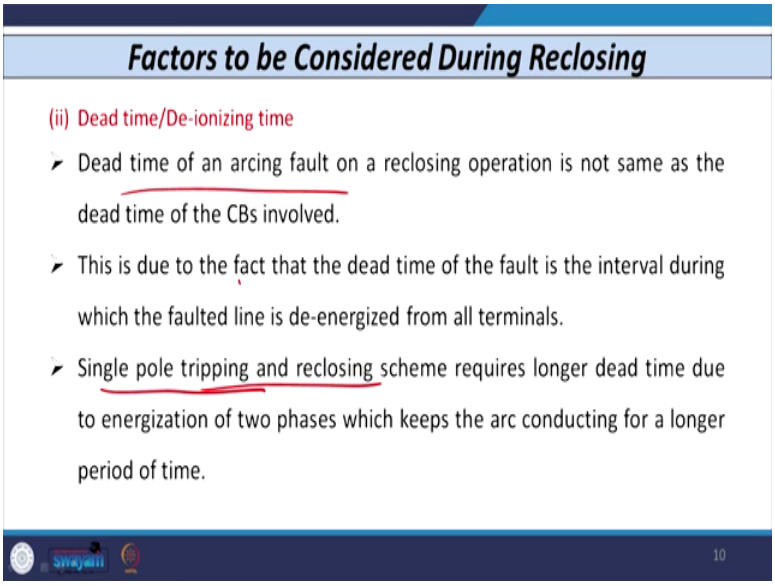

Now, when we consider the dead time in case of arcing fault, because we know that whenever fault occurs then most of the faults are solid in nature that means that does not involve any fault resistance path, but if the wherever fault occurs and that involves fault resistance path, then that may convert into the arcing fault.

So, archaic fault is basically because of the high resistance fault and that may create a danger to the person working in the field. So, whenever we consider the dead time of arcing fault on a reclosing operation then that is not same as the dead time of circuit breaker that is involved in the network or system.

This is because the date time of default that is the interval during which the faulted line that is deenergized form all the time. So, it is mandatory that wherever fault occurs the faulty line that should be deenergized from all the sides, it is not that only a line is a deenergized from local and from the remote and it will take some more time to deenergize that is why simultaneous opening a breaker for both decide that is very important.

Now, when we consider the single-fold tripping and reclosing scheme, then that requires the longer dead time because of the in this case only the particular phase in which fault occurs that means faulty phase that pole of the breaker becomes open and another two poles that is healthy folds that remain in close condition. So, because of this the when we use single pole repeated reclosing scheme that may take some a longer dead time compared to the some other type of reclosing scheme.

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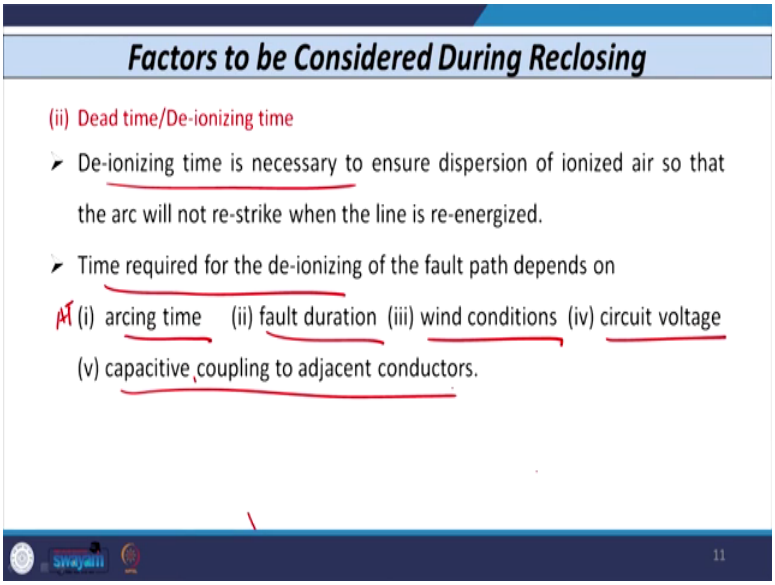

Now, if I consider the deionization time, then it is necessary to ensure the dispersion of ionized air so that the arc that is not going to restrike when the line is energized. So, as I told you, we need to give the breaker sufficient time because whenever breaker contacts of the breaker becomes open that means, whatever arc is quenched and whatever medium is used maybe air or pressurized air or oil or some gas then that medium has some dielectric strength.

So, that dielectric strength that has to be utilized to quench the arc, and then and then the contact of the circuit breaker that become open, fully that become open. So, after that we need to give some time, that is known as dead time or deionization time so that the dielectric strength of the medium that is again regained and that is ready for the next operation that is the opening operation of the circuit breaker.

So, time required for deionization the fault path that depends on many factors. So, that depends on marking time normally denoted by AT, it also depends on the duration of fault right up to fault time interval the fault persist, wind calculations that also we need to consider what is the system voltage or circuit voltage, and what is the capacitive coupling between the adjacent conductors. So, this all are the important parameters that is to be considered when deciding the time required for the deionization of the fault path.

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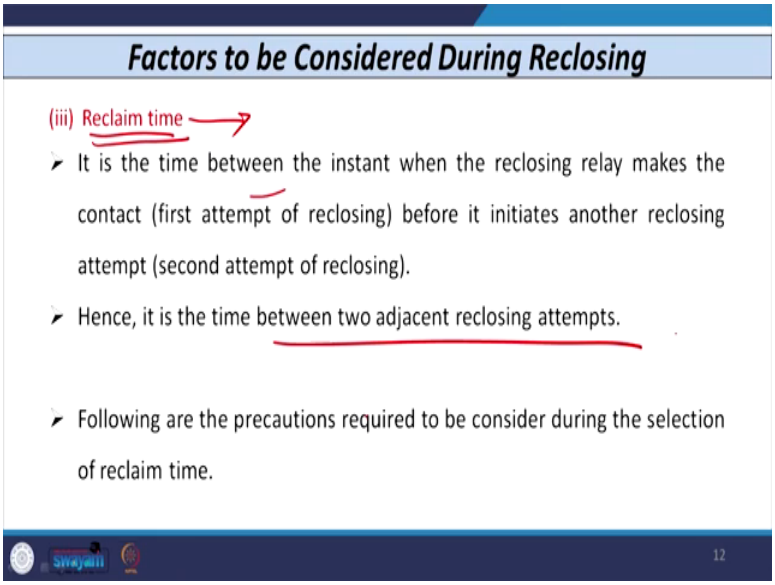

So, now with this background let us consider the third point that is the reclaim time. So, what is the reclaim time? So reclaim time that is nothing, but the time between the instant when the reclosing relay makes the contact that is the first attempt of the reclosing relay before it initiate the another reclosing attempt. So, it is the time between the two adjacent reclosing attempt that is nothing but the reclaimed time of the autoreclosing relay.

So, if you go further here in this sequence of events, then you can see that the reclaim time of the auto reclosers that is mentioned like this. So, this is the first reclosing the time starts and whenever it goes in lockout condition here although, but if other second reclosing attempt is required, then it starts from this instant and first reclosing attempt starts from this instant, so this is nothing but the reclaimed time of the auto reclosers.

So, this is the all about the reclosing time. Now, when we consider reclaim time of the autoreclosers, we need to take certain precautions right. So, let us see, how we can select the reclaim time of the autoreclosers. So. when we consider the reclaim time of the autorecloser that means when line is energized due to reclosing attempt, and if new faults occurs before the reclaimed time of the autoreclosers that get elapsed then it is mandatory to block the operation of reclosing relay. What is the meaning of this?

Meaning of this is that, you can see that here, this is a permitted fall for single short reclosing really, so first reclosing attempt that that is adopted at this point. And whenever the it gives a signal to the breaker, breaker contacts become fully closed, then again relay operates, it gives

signal to the breaker as well as to the autorecloser contacts of the breaker becomes open arc quenched arc fully quenched, contact becomes fully open.

So from this instance, when arc is fully quenched next reclosing attempt that should take place, but you can see that as I told you that before the reclaim time gets elapsed if any event is there, then at this instant we should stop and the your recloser should go in the lockout condition. So, that is the meaning of that things.

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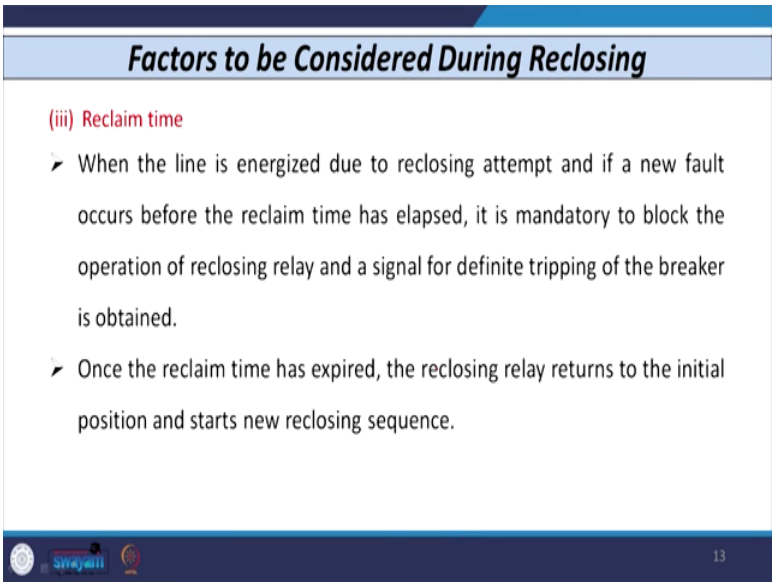

Once the reclaim time has expired the reclosing relay that can return to its initial position and that will ready for the next reclusive attempt.

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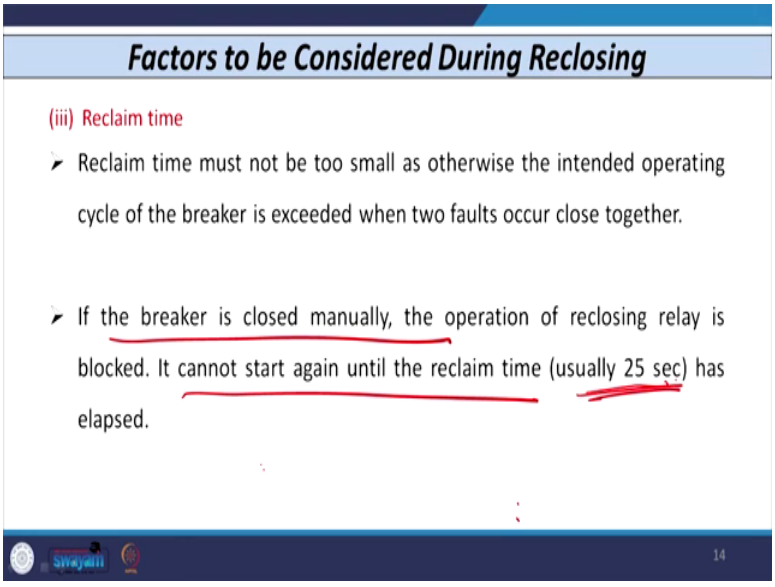

Now, the reclaim time that must not be too small otherwise the intended operating cycle of the breaker that is affected because particularly when the fault occurs, two consecutive faults occur very close together within the close time, so that is why the reclaim time that is not to be very slow.

If the breaker is closed manually, this is also another important point that when we close the breaker or when breaker operation is carried out manually, then the closing operation or reclosing attempt that is to be blocked, it is ready for the next operation once you convert this breaker operation from manual to the auto, and useful it will take the time delay of 25 seconds.

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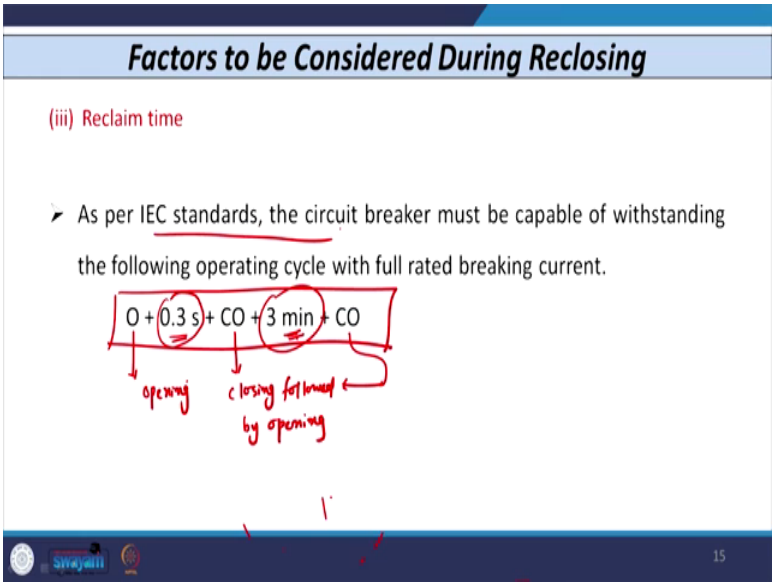

Now, how to find out the reclaim time? So, as per the IEC standard, the every circuit breaker that is capable to withstand the operating cycle for particularly fully rated breaking current, so, the operating cycle that is defined by IEC standard that is this. So, here in this equation O that indicates the opening of the breaker. So this is nothing but the opening of the breaker.

Then there is a delay of 0.3 seconds, that is 300 milliseconds. Again, thereafter, the command issued that is CO that is nothing but the closing followed by opening closing followed by opening. And again, between two closing followed by opening command there is a time delay of 3 minutes is there and again, there is a closing followed by opening.

So, this sequence of events, whenever we consider then we can find out the reclaim time. In this case the time is 300 millisecond, and in this case the time is 3 minutes. So, this we need to consider based on this standard empirical formula given in IEC standard.

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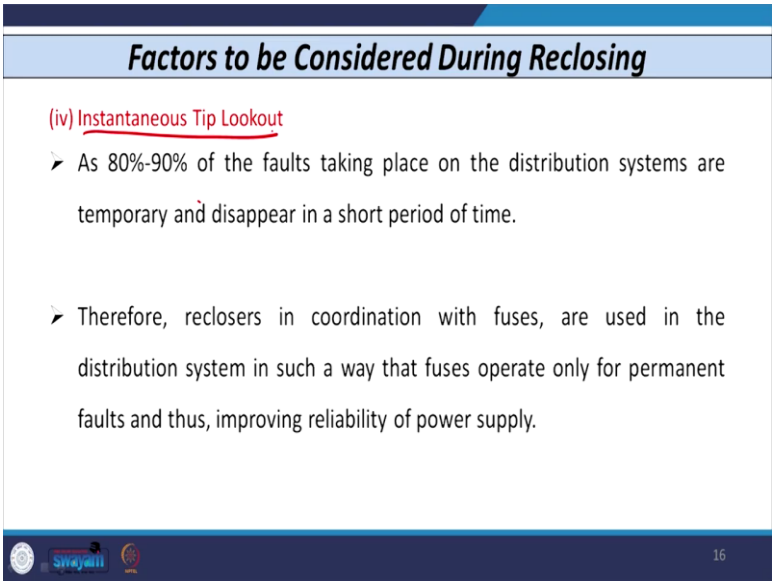

Now, let us consider the one more point that is known as instantaneous trip lockout.

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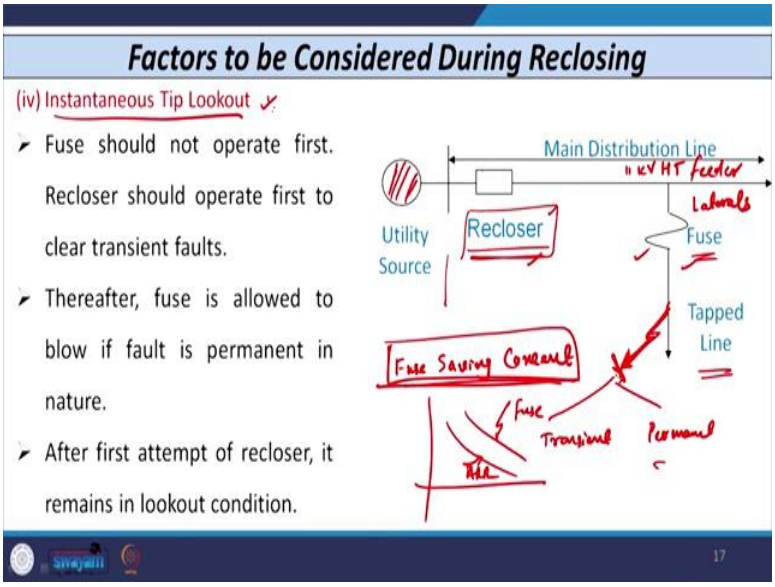

So, now we know that let us consider one diagram. So, in this diagram you can see the utility source is there, there is a recloser, the recloser I have installed here. So, this is your recloser right, and this is a main distribution line or 11 kV HT feeder right let us say 11 kV line and then the further laterals are there this is nothing but the laterals and then you have the some tapings are and this tapings or laterals are protected by the fuse.

Now, if fault occurs somewhere here at this instant, then obviously, we know that the fuse has to operate, and once the fuse detects the fault its filament melts fuse operates. So, again

from here we need to send the lineman to see whether what happens and that he has to change the wire. Instead, if we wish to avoid this whole this operation, then what we need to do wherever fault occurs over here then we assume that the recloser that is going to operate fuse that is not going to operate.

So, what will happen for any here fault whether now this fault can be transient or temporary or this fault can be permanent right. Now we do not know whether the fault is permitted or transient. So what we will do, if any fault occurs here somewhere here then recloser characteristic that falls below the fuse characteristic so recloser has to operate first. If fault is transient in nature that is going to die out, so again, when you go for reclosing attempt, then obviously, the system becomes healthy.

If fault is permanent in nature, then when you go for reclosing attempt, again, as the fault is permanent in nature, so reclosing attempt is not successful, so recloser again comes to the or breaker again comes to the opening position and recloser again goes into the lockout condition, then fuse that is going to operate.

So, this type of philosophy where the fuse has to operate only for permanent fault and for all transient or temporary fault recloser has to allow to operate first this is known as the fuse saving concept. This is known as the fuse saving concept, and this is widely adopted particularly at distribution level.

Now, if we wish to achieve this concept that means a fuse has to operate only in case of permanent fault and it should not operate for any temporary or transient fault, then characteristic of recloser that should follow below the characteristic of fuse, so this is fuse characteristic and this is the characteristic of autoreclosers. So, in this case what is necessary is, whenever recloser reclosing attempt is carried out then if fault is permitted at nature then breaker becomes open and this recloser should go in lockout condition.

So, this type of feature that is known as instantaneous trip lockout so that means, after one week closing attempt if still it is not that reclosing attempt is not successful then your recloser should go in lockout condition immediately instantaneously that is why it is known as instantaneously trip blackout.

If we wish to avoid this fuse saving concept, then proper coordination between the recloser and the fuse that is necessary otherwise mal operation that is also there. So, this is also one of the important features or important factors that need to be considered when we apply the

recloser or autoreclosing relay at the distribution level where fuse that is used as one of the protective device.

So, in this class, we have discussed the various factors to be considered. We started with the zone one of the distance relay, then we have discussed the dead time or deionization time, then we have discussed the reclaim time and then finally we have discussed the instantaneous trip lockout, which is very important feature when we apply the autoreclosing or autoreclosers at the distribution level along with the fuse.

We have also discussed the sequence of events that happen in case of the transient fault and permanent fault. So, I stop here and we will continue our discussion in the next class. Thank you.