Quality Design and Control
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Lecture - 47
Design for Reliability-II (Contd.)

So, but during this lecture session on the design for reliability.

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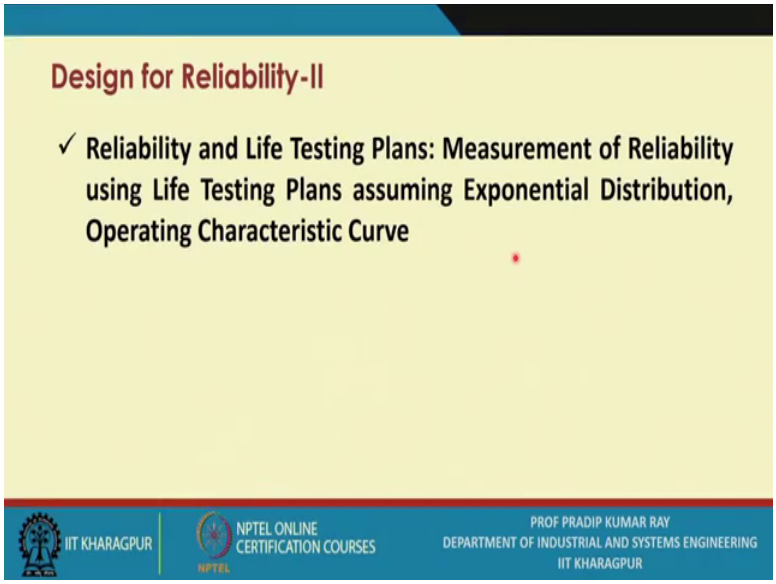

Now, I will be discussing an important topic called reliability and life testing plans ok. So, all the important life testing plans, we will be discussing one after another mainly will be concerned with measurement of reliability life testing plans the assuming exponential distribution; that means, for measuring reliability of a component we assume that the component right now exists in useful life phase.

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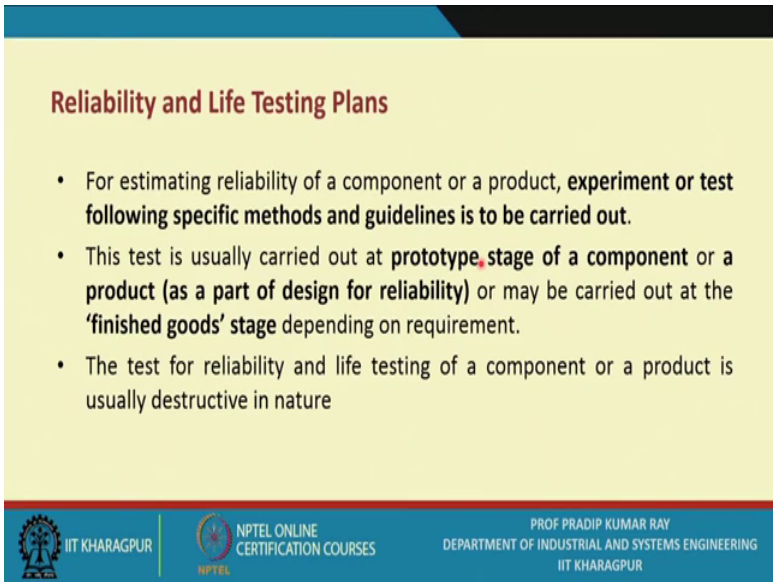

Now, let me first explain that why a life testing plan is recommended, why do you use a life testing plan. Now, what do you need to do; that means, we know; what is reliability? We know; what are the factors affecting reliability, what are the dimensions, you must consider while you define reliability of a systems or a component all these details are known to you.

The next obvious question is can you measure the reliability, ok. So, as you as you know that whenever you try to specify the numerical value of reliability of a component or the system this numerical value may lie anywhere between 0 and 1 ok, 0 means no reliability; that means, it is not functioning at all and one means that it is functioning all the time.

Now, in majority of the cases we will find that when you deal with sophisticated components of sophisticated systems. So, the implied meaning is that for a sophisticated system the component reliability as well as the system reliability must be very very high, but it just cannot be one; that means, whatever may be the sophistication level of a system or a component you cannot say that it will run for means for in for infinite time period through at any point in time it might fail, is it ok.

So, when we estimate the reliability of a component of the systems, it just cannot be 1, it is less than 1, if it is 0.99, fine, even if it is 0.95, it is fine, but if it is 0.8 or 0.7; this may be considered as very low reliability, is it ok.

So, now the question is that you must be are you in a position to prescribe certain methods with which you can measure reliability. So, during you know, this the lecture session, I will be discussing certain methods with which you can estimate, the reliability of a component as well as system for estimating reliability of component or a product experiment or test following specific methods and guidelines is to be carried out, is it ok.

So, we will come to know what are the what are the methods you should follow under different conditions; these tests is usually carried out at the prototype stage of a component is a prototyping is an important activity in product design and you know a lot of experiments lot of tests, you carry out on the physical prototype of the system and so, usually you know when you talk about the design of a product ah. So, if you are really concerned about the reliability of the product; that means, even at the design stage; that means, at the prototyping stage, you will be you must be able to estimate it is reliability, is it ok. So, these tests or these experiments in a in a particular manner, in a particular way, these experiments are conducted at the prototyping stage.

Now, if you miss this test due to some reasons ok, there could be many reasons what you need to do then; that means, a product as a part or the design for reliability, you must believe in the concept for concept of design for reliability and this test if you miss the test at the prototype stage, what you can do; that means, the test may be carried out at the finished good stage depending on requirement, is it ok; that means, before the finished goods are are the sent to the customers, as a final the test and inspection as a final test inspection and examination now you collect the data in such a way that you are in a position to measure the reliability of the concerned product.

The test for reliability and the life testing of a component or a product is usually destructive in nature, we have already you know, they refer to the destructive testing and during the acceptance sampling and in many many a time, what happens that the component the component may be very very expensive and so and unless you go for the destructive testing ok. So, the reliability the value you cannot assign to the product. So, in majority of the cases destructive testing is a must. So, if it is a destructive testing; obviously, you know you go for this sample tests and; obviously, the sample size should be as minimum as possible is it whenever you go for destructive testing.

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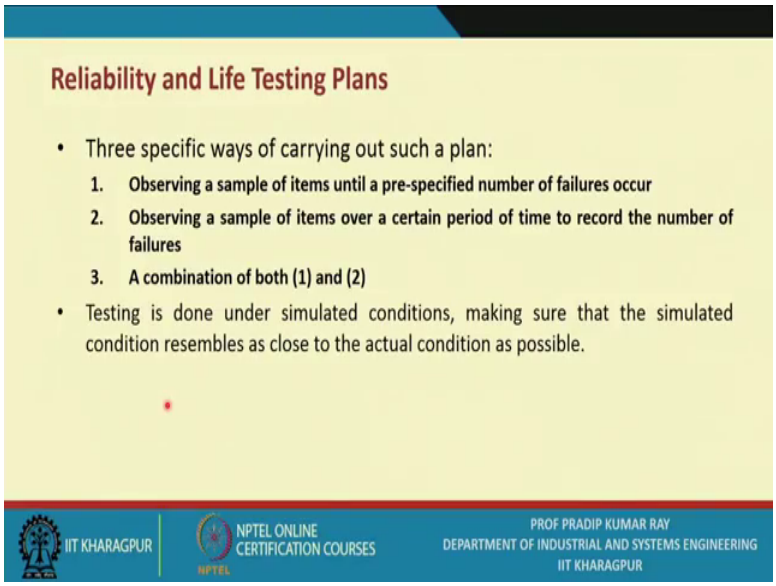

Now, as I have already mentioned that there could be many ways you can carry out such a testing and each the test we have to make a plan. So, the three specific ways of carrying out such a plan; that means, three ways you can go for testing.

Observing a sample of items that is the first you know first way; that means, this method you can apply; that means, observing a sample of items until a pre specified number of failures occur; that means, you suppose the sample size is n. So, I will I will have a sample of n items now all these into n items you will be some ultimately, you will be tested and this test will continue till a pre specified number of failures occur; that means, suppose you deal with say the 10 components or the 10 items and you start testing them simultaneously and you say I will continue my test till say the 5, you know the failures occur, so; that means, this is pre specified number of failures, what is the pre specified number of failures, in this case, it is 5. So, this is the first alternative, you may have and from you know the collected data you can compute the value of the reliability.

Second one is observing a sample of items over a certain period of time; that means, what I what I say that I will take the same number of items in the sample size is n n equals to 10. Now I will start carrying out the test for a specified period of time say 1000 hours or say 500 hours, the displeased specified and then within 500 hours or say 1000 hours, these are basically the test time I will observe I will get this data that how many units are failed, is it ok, I will record this data and after I record this data, I will go for

estimation of the item reliability. So, this is the second alternative observing a sample of items over a certain period of time to record the number of failures, is it and the third one is a combination of both one and two, it is clear.

So, here you know what you try to do; that means, you go unit by unit not by sample by sample, is it ok. So, there are certain advantages if you opt for a an alternative combining both testing is done under simulated conditions, is it ok, in majority of the cases making sure that the simulated condition resembles as closed to the actual condition as possible, is it ok; that is the basic you know in the condition you must ensure that the simulated condition is should be you know as you know the close to the actual condition as possible ok.

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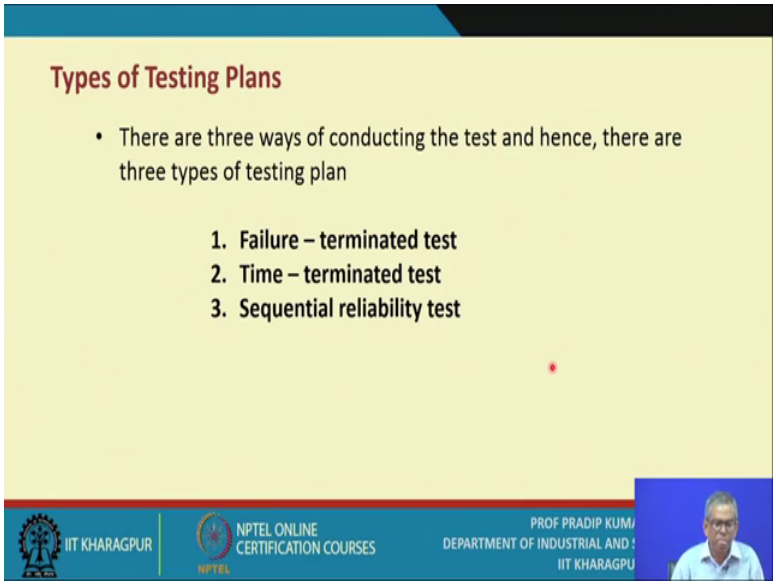

Now, how many types of testing plans you have already I have mentioned three alternatives ah. So, so, the depending on which alternative you select. So, you say you select a particular testing plan there are three ways of conducting the test I have already mentioned and hence there are three types of testing plan.

First one is the failure terminated test, the second one is the time terminated test and the third one is referred to as a sequential reliability test sequential reliability test ok.

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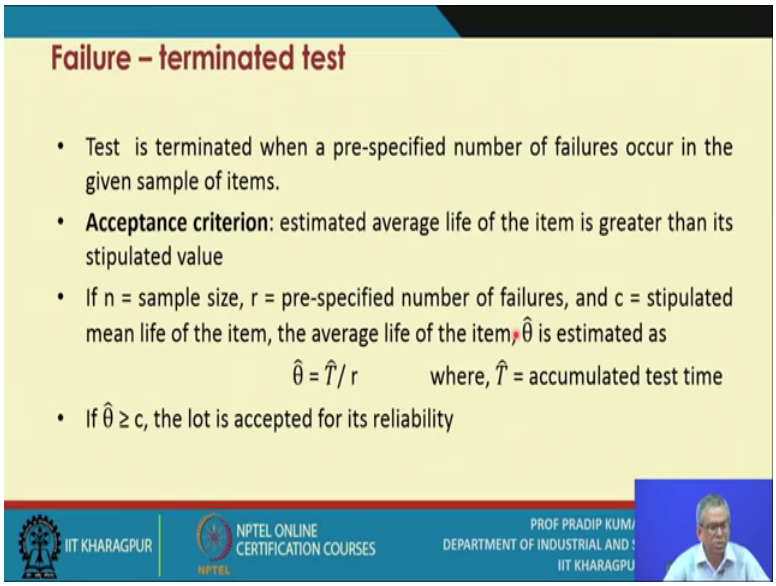

So, what is this failure terminated test. So, let me elaborate on this the test is terminated when a pre specified number of failures occur in the given sample of items I already mentioned; that means, sample size is n.

Now, all these n n number of items are subject to the test as we took it even there the tests will be carried out under simulated conditions on all the components simultaneously, then the test is terminated when a pre specified number of failures occur acceptance criteria, how do you accept this sample and then the lot is it ok. So, it is basically in acceptance you know the sampling plan ok.

Estimated average life of the item is greater than its stipulated value; that means, what you try to do; that means, you have to collect you have to you will be collecting the data and after analyzing the data you will compute the average life of the item; that means, estimated average life of the item and then this average life of the item is compared with the stipulated value ok.

So, what is the stipulated value you must know suppose you say the estimated average life is say 500 hours, whereas, the stipulated value you say you know by the 400 hours; so; obviously, you are going to accept the sample and as we are going to accept the sample; obviously, you are going to accept the lot, is it ok.

So, the based on the tests you carry out on the on the sample. So, you will be taking a decisions on the lot or the population. So, now, I will elaborate with the notations like if n is equals to sample size, r is equals to small r is equals is equal to the pre specified number of failures and c equals to the stipulated mean life of the item, is it ok, stipulated the average life of the item theta hat is estimated as T hat capital T hat divided by r what is T hat; T hat is accumulated test time.

Now, how to accumulate the test time that we will be we will be taking up one example and we will come to know that how do you compute this accumulated test time, is it clear, right. So, if theta hat is greater than equals to c the lot is accepted for its reliability, is it ok, the lot ultimately you are taking a decision whether you will go for lot acceptance or you will go for lot rejection, is it ok. So, this is a sampling plan.

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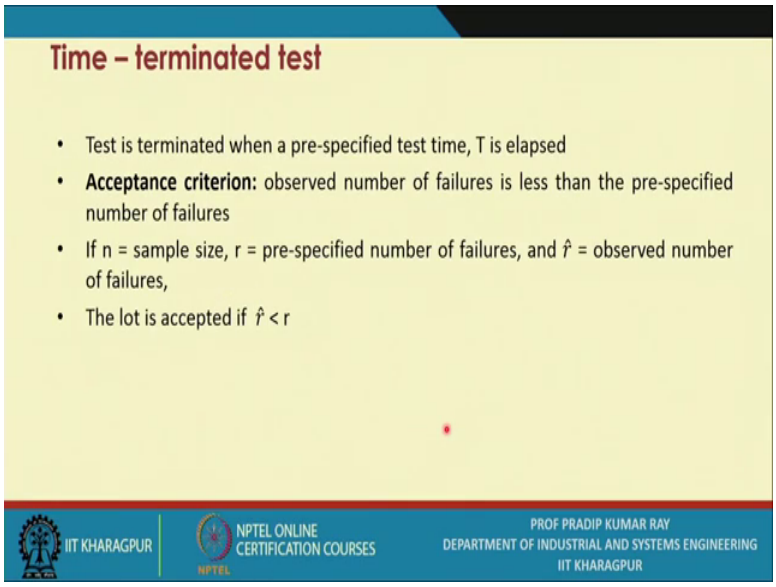

So, this is one alternative, what is the second alternative second alternative is time terminated test supposing due to some reasons, is it ok, you have to identify that what could be the possible reasons, is it ok, possible reasons and if those reasons exist you cannot go for failure terminated test say to think of alternative. So, what is the alternative that is the time terminated test whenever we opt for a particular test, we are assuming that this test is feasible, is it ok; that means, there will be no problems in carrying out such a test is terminated when a pre specified test time is elapsed, I have already mentioned, is it ok. So, that is the pre specified test time say 1000 hours.

So, what is the acceptance criteria observed number of failures is less than the pre specified number of failures; that means, suppose the test time is one thousand hours; that means, the test is conducted on n number of items for 1000 hours and you observe the number of failures suppose the number of failures is 6 whereas, the pre specified number of failures when that is that you can tolerate that is suppose 10, is it ok.

So; obviously, so, the observed number of failures is less than the pre specified number of failures and that is why you are going to accept the lot. So, this is the simple rule you specify. So, if n equals to the sample size r is equal to the pre specified number of failures and r hat is equal to the observed number of failures the lot is accepted if observed number of failures is less than the stipulated number of failures or pre specified number of failures that is small r. So, the rule is very very simple.

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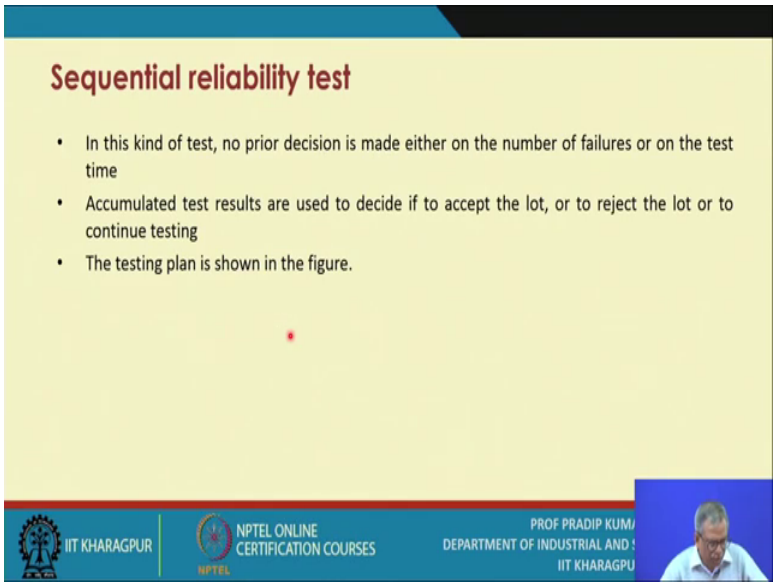

Now, what is the next one next one is sequential reliability test, is it ok. So, how it is different from the other two tests in this kind of test no prior decision is made either on the number of failures or on the test time; that means, this is the decision is based on what is the current result; that means, what sort of result you get, is it ok, one specific aspects definitely at a particular point in time when the test is being carried out. So, no prior decision is made either on the number of failures or on the test time.

Accumulated test results are used to decide if to accept the lot or to reject the lot at a particular point in time or to continue testing; that means, at any point in time is it there

could be three kinds of decisions you may say that I have decided to accept the lot or you might say that I have decided that I will reject the lot or I will I have decided to continue testing, is it ok. So, that is why it is referred to as a sequential reliability test.

The testing plan is shown with a figure.

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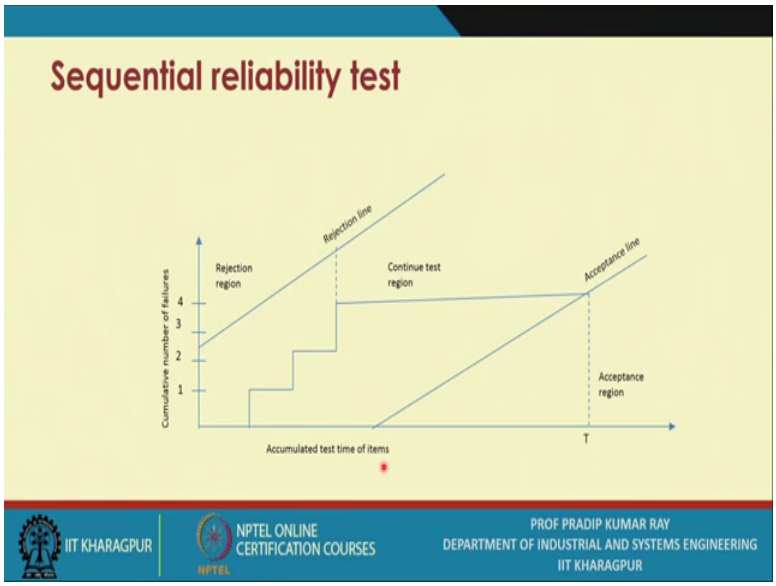

So, this is a typical you know what the testing plan and that the testing plan is sequential you know the reliability testing is explained with this figure, what do you have basically the x axis represents the accumulated test time of items that is x, I have already explained; what is the accumulated test time; that means, the total time you spent on all the components on testing at a particular point in time, is it ok.

So, suppose you have the 5 items 100 test and suppose hundred hours you have already spent on testing for each, is it ok. So, what will be the accumulated test time; obviously, 5 into 5 that is 500 test time and this is referred to as the accumulated test times, is it ok.

So, as the test time continues right. So, accumulated test time also will be increasing, is it ok. So, this; so, x axis represents the accumulated test time of the items and the y axis represents the cumulative number of failures the as the test you carry out, is it ok, on the number of items in the sample, what you try to do; that means, the cumulative number of failures, is it ok, the cumulative the number of failures you note down, is it and those values will be plotted like say this is the first one at this accumulated test time.

Next when the accumulated test time is this much; that means, the second item second failure has occurred when you your accumulated test time is this; that means, the third failure occurs third or fourth failure occurs, this is whatever it is the third or fourth failure occurs and then you constantly you are testing the items accumulated test time is increasing, but the number of for the cumulative number of failures remains constant till it touches the acceptance line, is it ok.

So, what do you do; that means, as soon as the accumulated test time is capital T you stop the test and you say yes I am going to accept the lot is it clear. So, ah; so, there is an acceptance line and the area beyond this acceptance line is referred to as the acceptance region, is it ok; that means, is it is heading towards the acceptance region as soon as it touches the acceptance line you say that yes my testing is over and I have decided to accept the lot it could be the other way around; that means, you may find that when the testing time is this one the number of failures the cumulative number of failures is this much and it is already touching the rejection line.

So, what you what you say that my testing is over and I say that my decision is rejection; that means, I am going to reject the lot why I am I have decided to reject the lot because the this cumulative number of failures because this value is touching the rejection line. So, as you have the acceptance line you must have a rejection line and the area beyond this rejection line this is referred to as the rejection region.

So, now, what you need to do; that means, in order to get the equation for the acceptance line as well as the rejection line.

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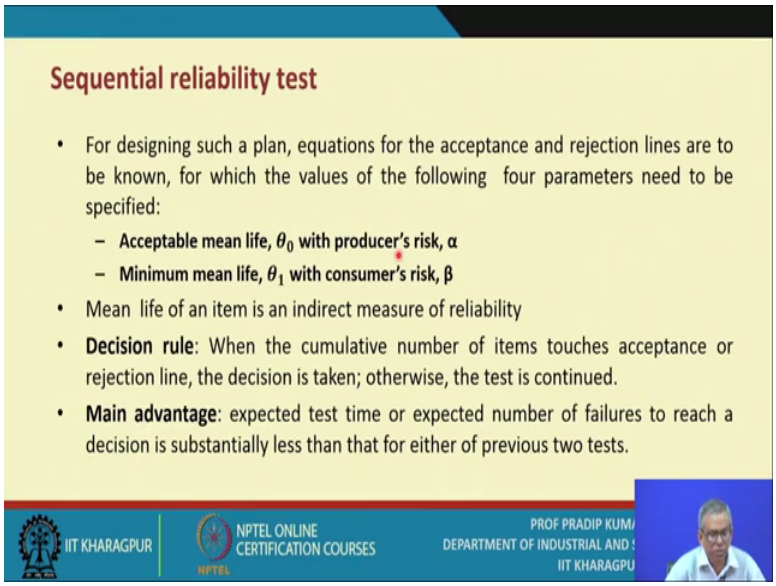

Now, the four conditions you specified; that means, you want to design this sort of sampling plan; that means, is a sequential reliability testing for designing such a plan equations for the acceptance and the rejections line are to be known is it because I am showing to you a figure. So, that the acceptance line is there similarly rejection line. So, it is a straight line; obviously, there will be intercept and there will be in the slope. So, you must have an equation for the acceptance line and parallel to the acceptance line you must have a rejection line and similarly the rejection line will have an intercept and slope.

So, how to get these equations; so, what you need to do; that means, you specify the values of the four parameters what are those four parameters acceptable mean life theta 0 with producers risk alpha; that means, here we are discussing reliability. So, you know to a layperson how do you how do you say that the reliability is very high or the reliability is very low ok.

So, how do you say so; obviously, you know if you start explaining the concept of reliability in terms of the probability he or she may not understand, but the basic you know so, the idea he must know; that means, I will say that if the mean life of the component is very high I may assume that the component reliability is very high in the mean life of the component is very is less, is it ok, it is not 10000, it is just 1000. So, I

may conclude that the reliability of this component is less, is it because essentially the reliability you know the refers to the survival time of a component or a system.

So, now what you try to do; that means, this is the acceptable one with the producers risk; that means, it is a sampling plan. So, in any sampling plan you use there are two types of risk; that means, even if the quality is very good there is a possibility of rejection. So, that is basically the producers risk here instead of saying say the quality, we are referring to the reliability and the reliability is indirectly measured with the main life. So, that is theta 0. So, theta 0 with the producers risk alpha say 0.01 or 0.05.

Similarly, the minimum leave mean life; that means, even if it is just say 500 hours mean life it is considered to be very very less, but still as you are applying the concept of sampling, there is a possibility of it is acceptance. So, that is basically the consumer risk this beta. So, these four values must be specified while you propose or you propose the equations for the acceptance line as well as the rejection line.

Mean life of an item mean life of an item is an indirect measure of reliability this point we have been we have been saying. So, what is the decision rule when the cumulative number of items touches acceptance or the reaction line the decision is taken otherwise the test is continued.

What is the main advantage expected test time or expected number of failures to reach a decision is substantially less than that for either of the previous two tests ok. So, this point should be clear; that means, in other words, it means that very quickly you can take a decision.

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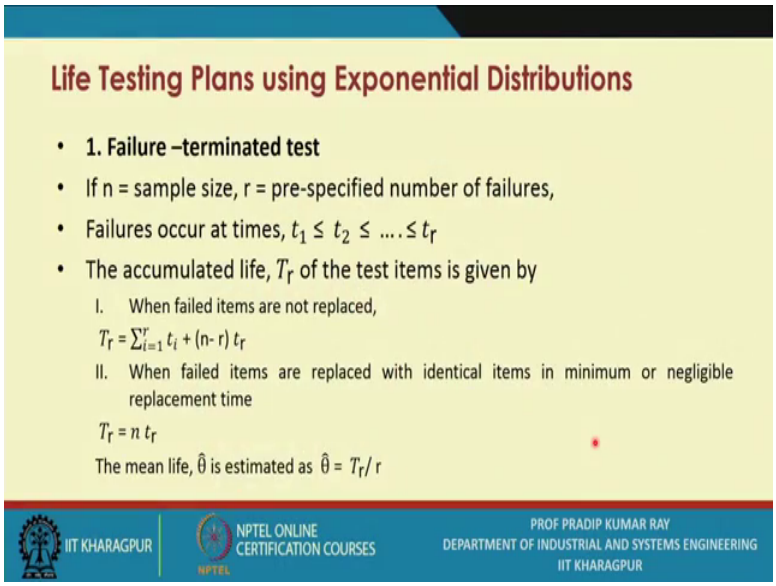

Now, so, now, I will explain that how do you get the data and how do you take a decision, is it ok, whether you will get you will whether you will accept the lot or you will reject the lot suppose you opt for failure terminated test and we are assuming that the time to failure is exponentially distributed if n is the sample size, r is the pre specified number of failures and the failures occurred at times T 1 less than equals to T 2, if it is equal to T 2, it means that at the same point in time there are two failures, is it ok, it may so happen that all the odd number of r number of failures may occur at the same point in time then only the equality condition holds.

So, the accumulated life T r of the test times is given by accumulated test life when failed items are not replaced there are two conditions as soon as there is a failure they replace the item. So, if the or you are not replacing the item with an identical component of the item. So, if the failed items are not replaced then what is the accumulated test time that is i equals to 1 to r sigma T i plus n minus r into T r because this number you know of the items there survived for T r time periods, is it ok, T r time periods.

When the filled items are replaced with identical items identical in the sense that when you replace with another item that item must have the same time to failure the distribution as well as the same parameter value in minimum or negligible replacement time; that means, you are replaced with identical items in minimum or negligible replacement time; that means, we are assuming that the repair time or the replacement

time is minimum and assumed to be almost 0, then T r is equals to n t r; that means, all the items are basically are surviving.

So, the mean time mean life theta is estimated as theta hat equal to T r by T ok.

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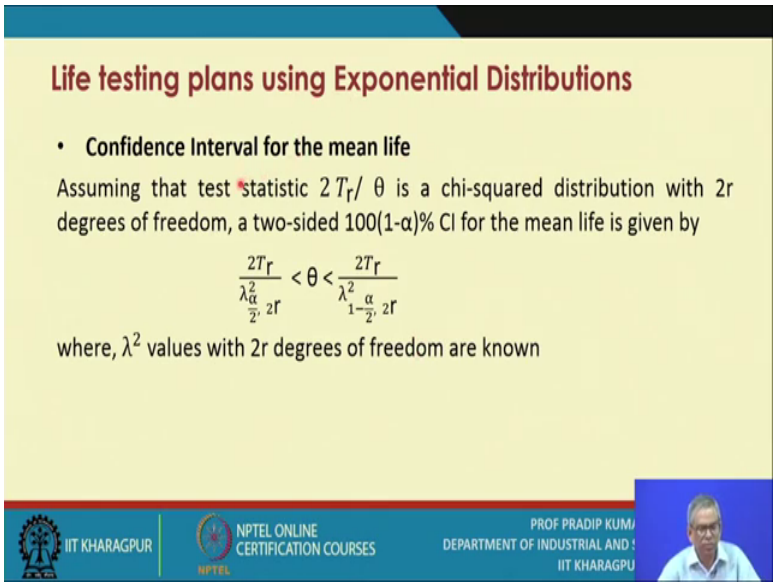

So, this is the point estimate now you go for the interval estimate assuming that the test statistics 2 T r by theta is a chi square distribution with T r degrees of freedom that has already been tested a 2 sided 100 into 1 minus alpha percentage confidence interval for the mean life is given by this one; that means, 2 T r divided by chi square alpha 2 with 2 r degrees freedom less than equals to theta less than equals to 2 T r divided by chi square 1 minus alpha by 2 significance with 2 r degrees of freedom. So, the chi square values with T r degrees of freedom are known; that means, you are you will be referring to corresponding tool of the chi square distribution you will get the values.

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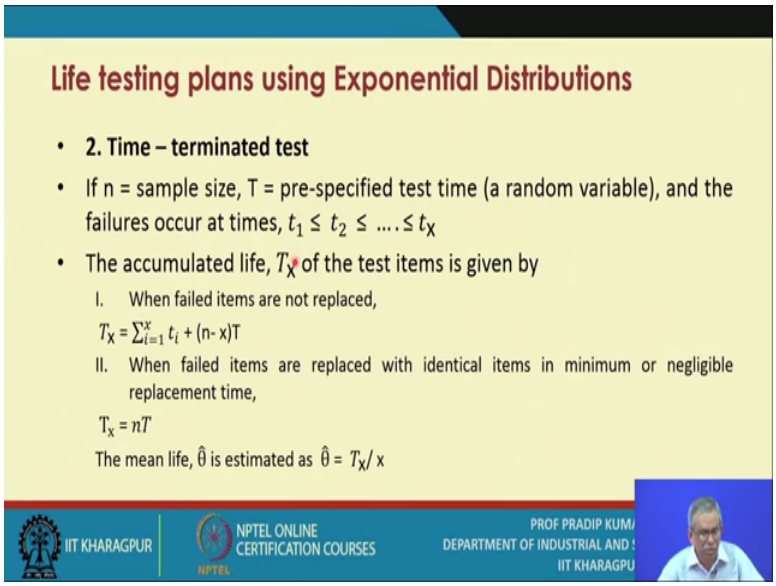

If it is a time terminated test what you try to do; that means, same sample size T is a pre specified say the test time and this is. So, the number of the failures occurred at times T 1 T 2 less than T x and; obviously, this number x is a random variable this is so random variable will be the x; that means, x maybe 2 x maybe 3 ok. So, x is a random variable.

So, what is the accumulated test time when x number of failures occur. So, when the failed items are not replaced. So, you have this expression so; that means, sigma I equals to one to x T i plus n minus x into T and when the failed items are replaced with the same conditions; that means, T x equals to n into capital t; that means, all the items have survived for capital T time period and similarly you in the same way you calculate the theta hat that is the estimated mean life that is T x by x.

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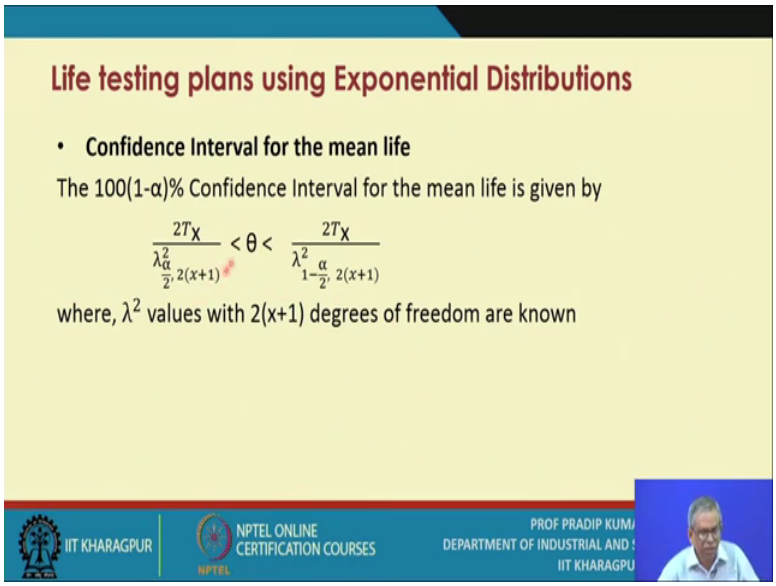

And then the confidence interval from the point estimate you go for you know interval estimate.

So, the confidence interval you determine; that means, hundred into 1 minus alpha percentage confidence interval that is suppose alpha is 5 percent, it means 0.05; that means, it is 95 percent confidence interval for the mean life is given by 2 T x by a chi square alpha by 2 2 x plus 1 degrees of freedom and less than equals to theta less than equals to 2 T x by chi square 1 minus alpha by 2 2 x plus 1 degrees of freedom, what is x x is the number of failures occurring within the test time that is capital T and; obviously, x is a random variable.

So, where chi square values with two x plus 1 degrees of freedom are known, is it ok. So, so, these are the tests you carry out and the both the point estimate as well as the interval estimate you compute and; obviously, you know the interval estimates are more reliable than the point estimate, is it ok.

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So, these are the procedures, later on we will take of many more numerical problems on these issues, is it ok.