Quality Design and Control
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Lecture – 34
Acceptance Sampling-I (Contd.)

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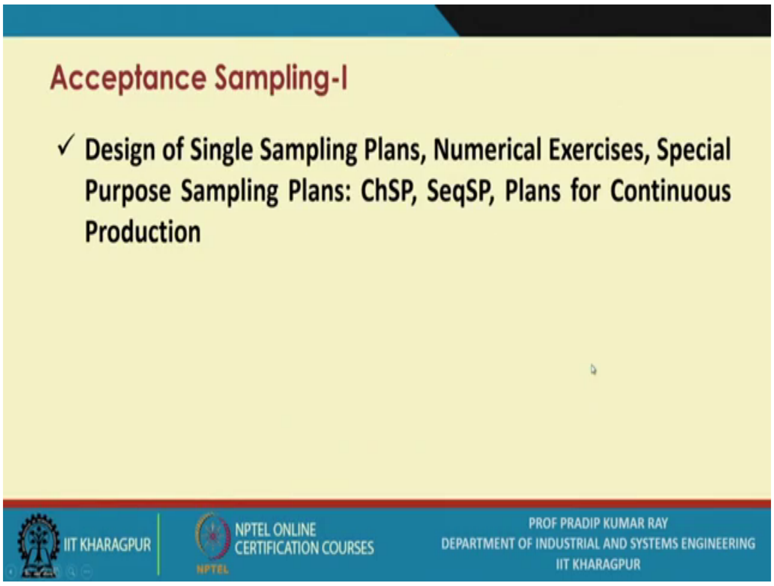

Now, I am going to discuss under acceptance sampling a part 1 an important topic called the design of sampling plans and with numerical exercises and as I have already told you that there are the 2 kinds of sampling plans you come across one is the general purpose the sampling plans we have already referred to like single sampling plan double sampling plan multiple sampling plan, but you need to use you know, but the different the special purpose the sampling plans under the special conditions.

So, we will be discussing certain the special purpose sampling plans in specific terms will be referring to change sampling plan, sequential sampling plan as well as the plans for the continuous production.

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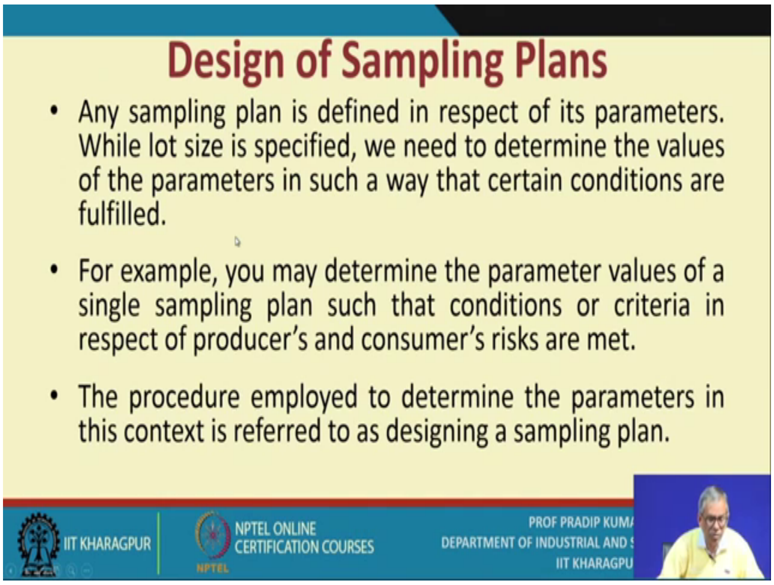

So, this will be our coverage in this particular the lecture session now the design of sampling plan is an very important issue whenever you try to use acceptance sampling the techniques in your work place; obviously, now you have to the select appropriate sampling plan and while you select an appropriate sampling plan you also must know as an expert as a learner.

The design procedure of a sampling plan; that means, how to design a sampling plan you must know and then only if the design process is known to you then only it is most likely that the selection of an appropriate sampling plan is based on scientific logic and the selection is proper. So, any sampling plan is defined in respect of it is parameters we have already pointed out while lot size is specified it is pre specified whether it is 2000 or 5000 or 10000 capital N we need to determine the values of the parameters in such a way that the certain conditions are fulfilled.

So, any design exercise when you carry out; obviously, you know these design exercise is carried out to meet certain goals or to meet certain objectives for example, you may determine the parameter values of a single sampling plan such that the conditions or the criteria in respect of producers and consumer discs are met is it, we have already pointed out that the there will be producers risk, there will be consumer risk, whatever may be you know the design quality of a sampling plan. So, what you need to know; that means, you specify the acceptable values of alpha and acceptable value of the beta and then you need to design or even need to recommend a sampling plan.

So, these there could be many other the such a criteria you need to use or need to consider while you design a sampling plan the procedure employed to determine the parameters in this context is referred to as designing a sampling plan is it clear.

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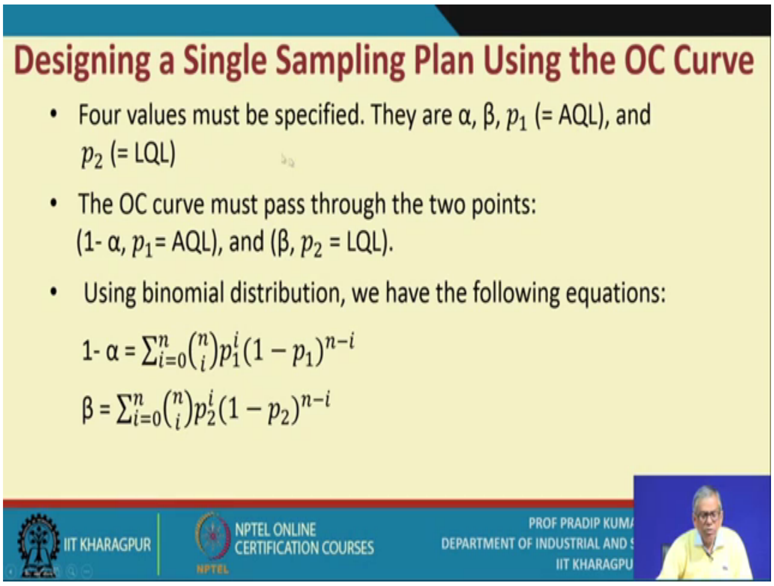

4 values must be specified as already pointed out right the alpha, beta, what is alpha, is the producers risk, what is beta, is a consumer risk, what is p 1 ; that means, p 1 is considered to be a very good quality. So, it may be conceive considered as AQL acceptable quality level and p 2 may be considered could be a bad quality or the poor quality and this may be referred to as LQL limiting quality level.

The OC curve must pass through the 2 points; that means, suppose you specify all these 4 values and you design a sampling plan against a sampling plan you need to construct the OC curve and these OC curve must pass through all these 2 points that is 1 minus alpha p 1 and beta p 2 is it. So, this point already we have elaborated when we were discussing that the OC curve. Now how to determine the values of the decision variables using binomial distribution; that means, you are considering a series of lots we have the following equations; that means, what is 1 minus alpha; that means, when the probability. So, this is i equals to 1 to c and; that means, the c is the acceptance number and the value of say for the non conforming in a particular sample may be 0 or may be 1 up to the acceptance number that is c.

So, nci p to the p 1 to the power i into 1 minus p 1 to the power n minus I, similarly if it is a beta; that means, this is sigma i equals to 1 to c and i varies from 0 and c is the acceptance number nci p to the power p 2 to the power i into 1 minus p 2 to the power n minus i; that means, these are the 2 equations you have and how many unknowns you have, you have the unknowns of c and unknowns of n is it so; that means, what are the parameters, the parameters are the sample size n and the acceptance number c.

So, you have 2 equations and the 2 unknowns.

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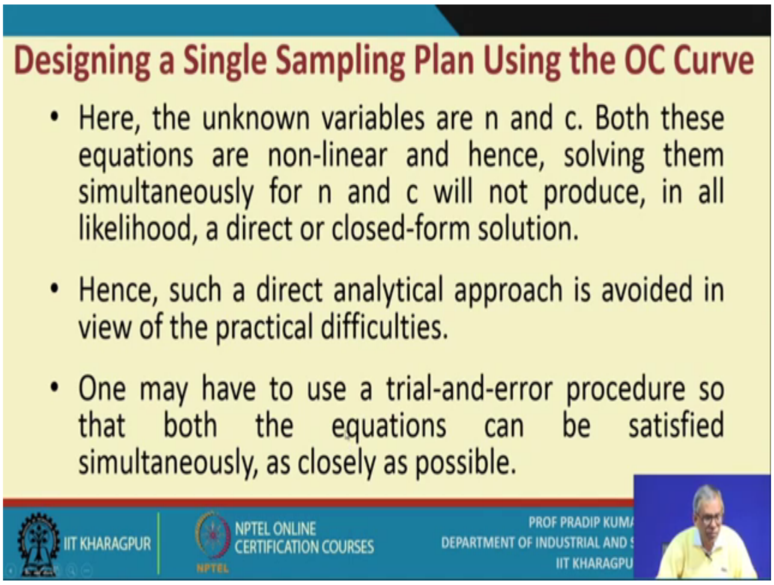

Now, the unknown variables are n and c, both these equations are non-linear and hence solving them simultaneously for n and c will not produce, in all likelihood a direct or a closed form solution, this is a high chance that will not be getting a closed form solution. Hence such a direct analytical approach or analytical approach is always preferred, but in this case what you see or what you observe is that, that the analytical approach may not provide or may not the lead to a closed form solution.

So, hence in this particular context a direct analytical approach is avoided in view of the practical difficulties is it. So, one may have to use a trial and error procedure so, that both the equations can be satisfied simultaneously as closely as possible.

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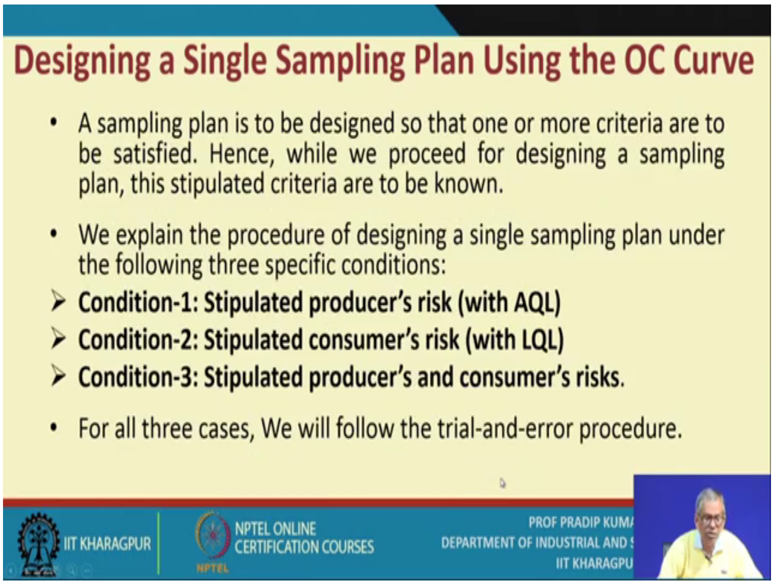

So, while you would design a sampling plan you will find that we will be adopting at the trial and error approach instead of adopting analytical approach I think the reason is very clearly understood that why we are preferring a adopting a trial and error approach, a sampling plan is to be designed. So, that one or more criteria are to be satisfied is it like say criteria like alpha, a criteria like say the beta.

Hence while we proceed for designing a sampling plan these stipulated criteria are to be known; that means, what are those stipulated criteria you must know, we explain the procedure of designing a single sampling plan under the following 3 specific conditions is it say the condition 1: stipulated producers risk with AQL that means, the designer wants to design a sampling plan in such a way that the producers risk condition is satisfied as stipulated, condition 2 : is you are bothering about the consumer risk you are not bothering about the producers risk.

So, you design the sampling plan in such a way that the stipulated consumer risk condition is satisfied so; obviously, when you define consumers risk you refer to LQL it must be defined with respect to the LQL similarly you may face a situation called face the condition 3; that means, the stipulated producers and consumer risk. So, 3 cases we will be referring to and we will give you the solution approach or the design approach for all these 3 cases we will follow the trial and error procedure.

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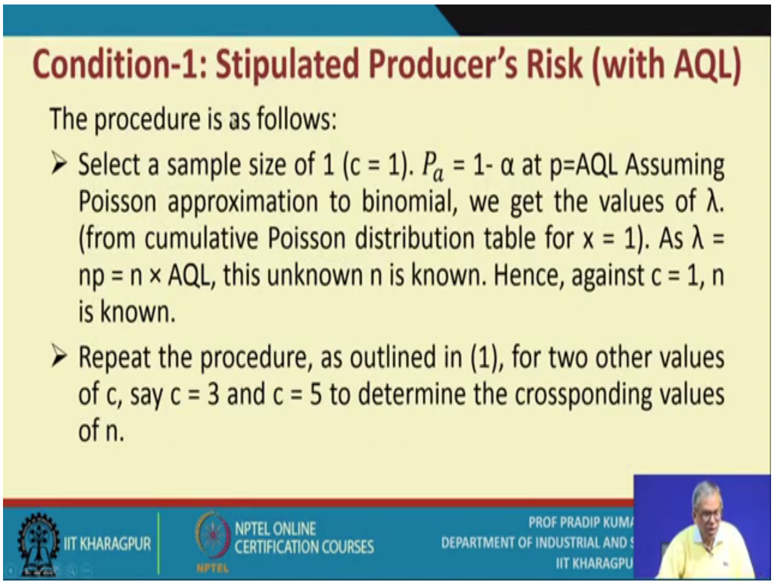

The procedure is as follows select a sample size of 1 c equals to 1 pa is equals to 1 minus alpha for p equals to AQL assuming poisson approximation to binomial we get the values of lambda, lambda is equals to n into p is it.

From cumulative poisson distribution table for x equals to 1 because c is 1; that means, x is equals to 1 if you refer to the poisson distribution cumulative poisson distribution table, as lambda equals to np equals to n into AQL this unknown n will be known hence against c equals to 1 n is known the value of n will be specified repeat the procedure as outlined in 1 for 2 other values of c says c equals to 3 and c equals to 5 to determine the corresponding values of n is it right.

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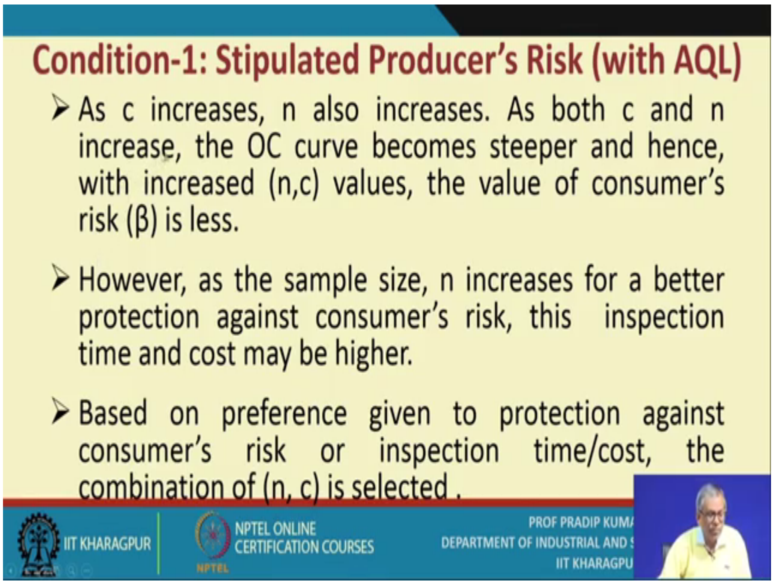

So, as c increases n also increases as both c and n increase the OC curve becomes steeper and hence with increased n, c values the value of consumers risk is less is it. That means if you have you know the stiffer OC curve what you will find that the consumer risk, at a particular value of LQL will is expected to be very very less; however, as the sample size n increases for a better protection against consumer risk these in the inspection time and cost may be higher is it. So, that is why we always prefer; that means, whether we make a decisions whether you will opt for a higher values of n or r say the lower values of a lower value of n.

So, based on preference given to protection against consumer risk the protection against a consumer risk will be very very high if the sample size is more, but against if the sample size is more the inspection time or the inspection cost may be higher. So, that is why you have to make a decision that, which one we will ought for and accordingly you decide that what is the best combination of n and c is.

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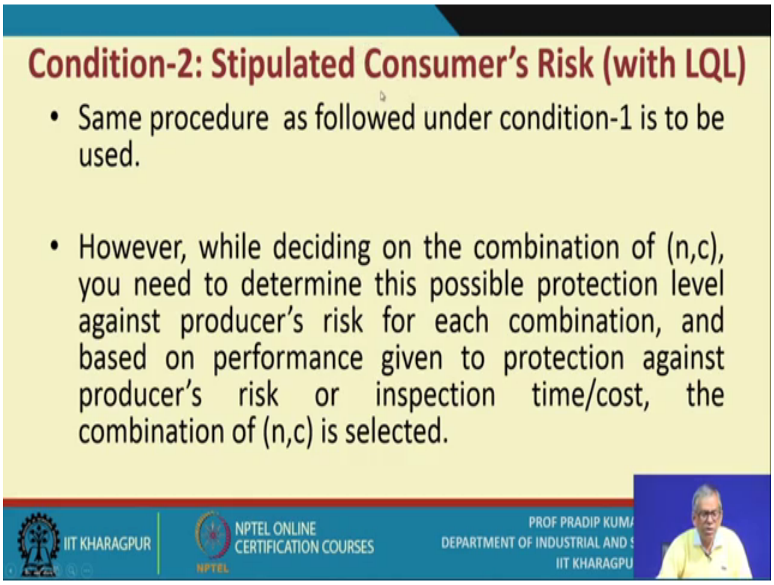

In the condition 2 that is stipulated consumer risk with a LQL same procedure is followed under condition one is to be used; however, while deciding on the combination of n and c you need to determine the possible protection level against producers risk is it.

For each combination and based on performance given to protection against a producers risk or inspection time or cost the combination of n c is selected is it. So, this is the same thing you repeat, but only thing here means the consumer risk a criterion say that you fulfill, but you check that as the sample size increases what might happen that the producers risk is come down, but, but then the if the sample size is more the inspection time and the cost could be higher and that may not be acceptable to you.

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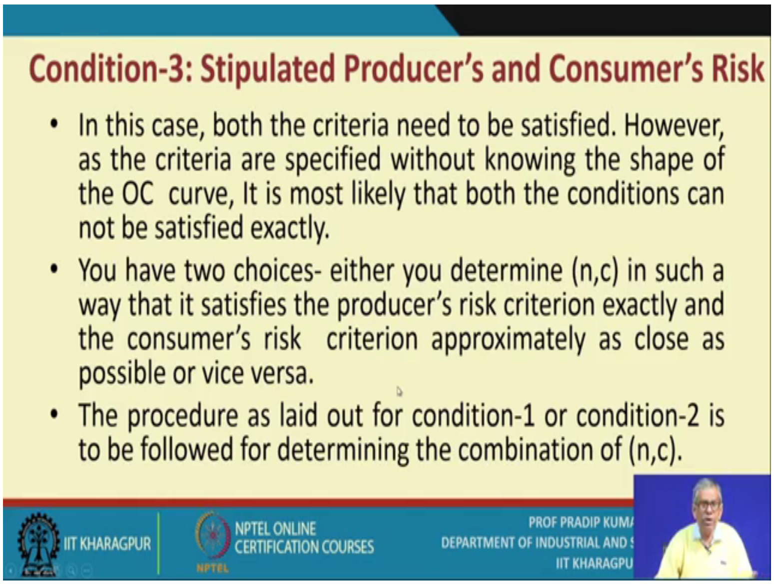

So, the condition 3 is the both producers and consumer risks you have to mate. So, in this case both the criteria need to be satisfied; however, as the criteria are specified without knowing the shape of the OC curve it is most likely that both the conditions cannot be satisfied exactly. So, this is the point to be noted you have 2 choices either you determine n, c in such a way that it satisfies the producers risk criterion exactly and the consumer risk criterion approximately as close as possible or vice versa.

So, the choice is yours. So, you have 2 choices you have to adapt just one of these 2 choices the procedure as laid out for condition o1 or condition 2 is to be followed for determining the combination of n, c is it.

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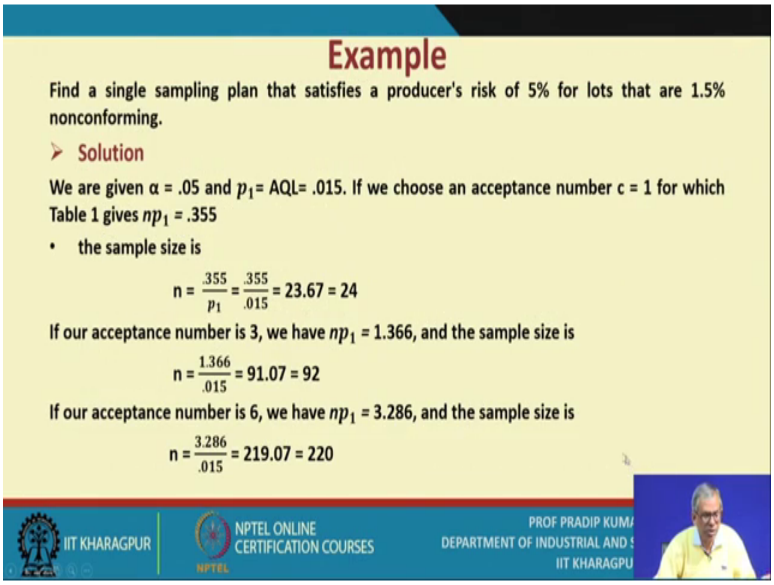

So, please go through this example and this example is related to finding a single sampling plan that satisfies the producer's risk of 5 percent for lots that are 1.5 percent nonconforming. So, what is the solution, here alpha is 0.05 p 1 that is AQL is 0.015, if we choose an acceptable number c equals to 1 for which table 1 gives np1 is equals to 0.355 the sample size is this is it; that means, this value you get from the cumulative poisson means the n value you get that is the lambda is the0.355 and this is the p 1 that is 0.15 that is 23.67 that is 24 is it.

It is approximated with 24 round it up for our acceptance if we are acceptance number is 3 we have n p 1 is equals to this one and the sample size is n equals to this; that means, corresponding lambda values right and it is 91.07. So, how do you get these values; that means, here it is 95 percent; that means, when the if you refer to the poisson the cumulative poisson distribution table against a particular value of say the probability of acceptance and a particular value of say x, x is already given.

So, that is c equals to 3 the corresponding value of lambda you can read from the table and that value is 1.366 is it, similarly when the acceptance number is changed to 6; that means, x equals to 6 probability of acceptance is 0.9 5. So, if you refer to the cumulative poisson distribution table you can get the value of lambda and that value of lambda is 3 0.286, if c is 6 n is 220 is it.

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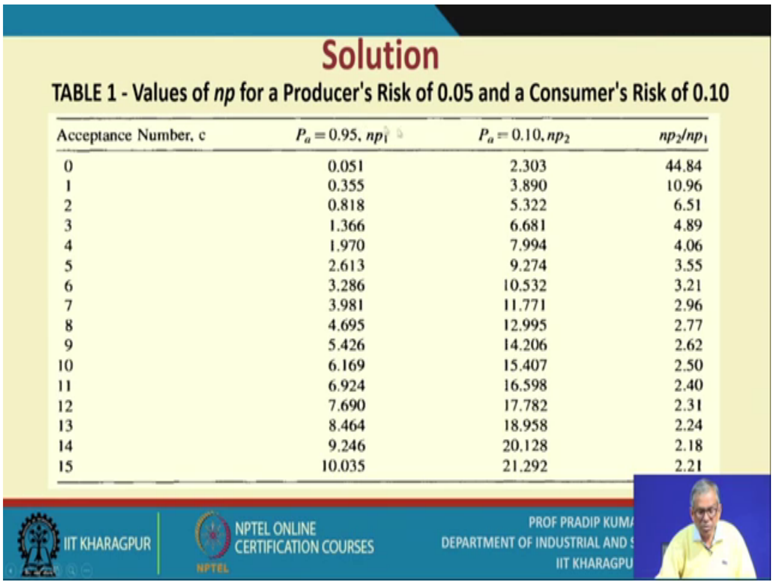

TABLE 1 - Values of *np* for a Producer's Risk of 0.05 and a Consumer's Risk of 0.10

Acceptance Number, c	$P_a = 0.95, np_1$	$P_a = 0.10, np_2$	np_2/np_1
0	0.051	2.303	44.84
1	0.355	3.890	10.96
2	0.818	5.322	6.51
3	1.366	6.681	4.89
4	1.970	7.994	4.06
5	2.613	9.274	3.55
6	3.286	10.532	3.21
7	3.981	11.771	2.96
8	4.695	12.995	2.77
9	5.426	14.206	2.62
10	6.169	15.407	2.50
11	6.924	16.598	2.40
12	7.690	17.782	2.31
13	8.464	18.958	2.24
14	9.246	20.128	2.18
15	10.035	21.292	2.21

So, these are the possible values and, when pa is 0.95 np 1 corresponding values pa is 0.10 and p 2 that is related to the consumer risk and np 2 by np 1 these possible values you compute is it.

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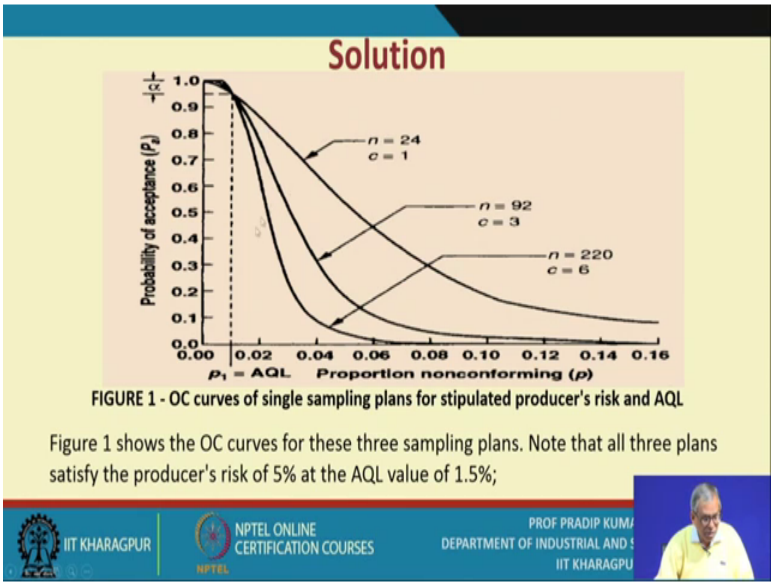

And then the OC curve. So, a single sampling plans for stipulated producers risk and AQL. So, this is a one example we are provided. So, these figure shows the OC curves for the 3 sampling plans note that all 3 plans satisfy the producers is a 5 percent at the AQL value of 1 .5 percent is it.

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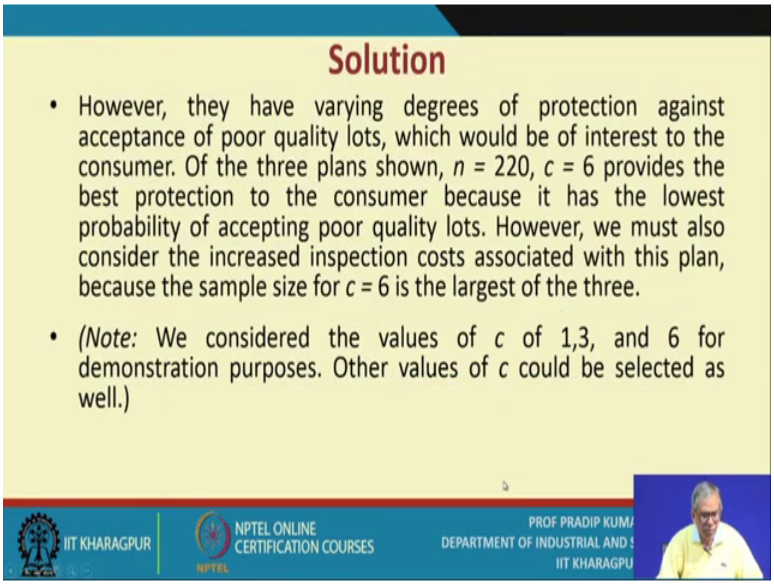

So, you just follow these examples later on I will give you several you know the numerical exercises related to this and when you follow all these steps your understanding will be very good that and you will know that how to design a single sampling plan what is the procedures you have to follow.

So, here this point is that they have varying degrees of protection against acceptance of poor quality lots which would be of interest to the consumer now of the 3 plan shown n equals to 220, c equals to 6 provides the best protection to the consumer this point we have already elaborated as the sample size increases. So, you will have better protection against consumer risk; however, it has the lowest probability of the accepted poor quality lots we must also consider the increased inspection cost associated with this plan because the sample size of what c equals to 6 is the largest of the 3.

So, you have to make a trade off. So, this is the procedures we follow.

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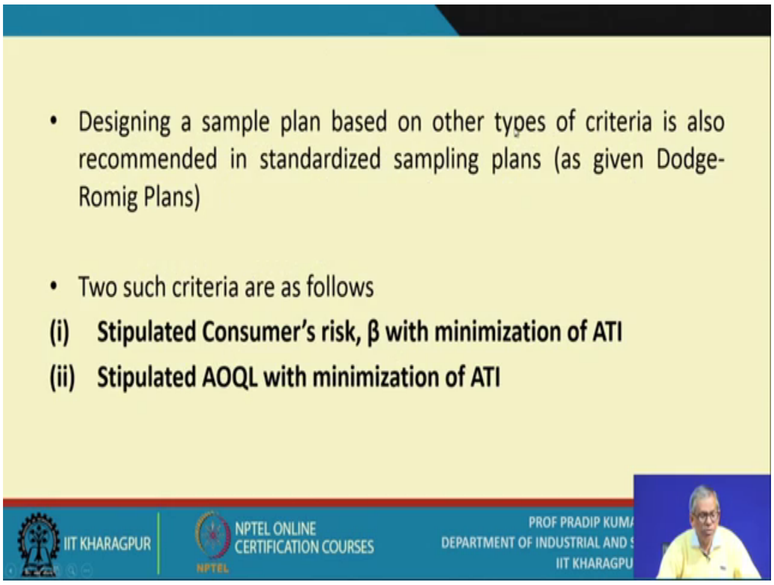

And what we are saying that a grater you select the values of c in such a way that they are feasible designing a sample sampling plan based on other types of criteria is also recommended in standardized sampling plans as given by as given in draw the Romig plans 2 such criteria are as follows stipulated consumer risk beta with minimizations of ATI stipulated AOQL.

We have already explained, what is AOQL with minimizations of ATI. So, ATI already we have explained and similarly you know what is the consumer risk and the stipulated AOQL. So, these 2 you know the sets of criteria also we have the considered while the proposed you know the sampling plans with rectifying inspection.

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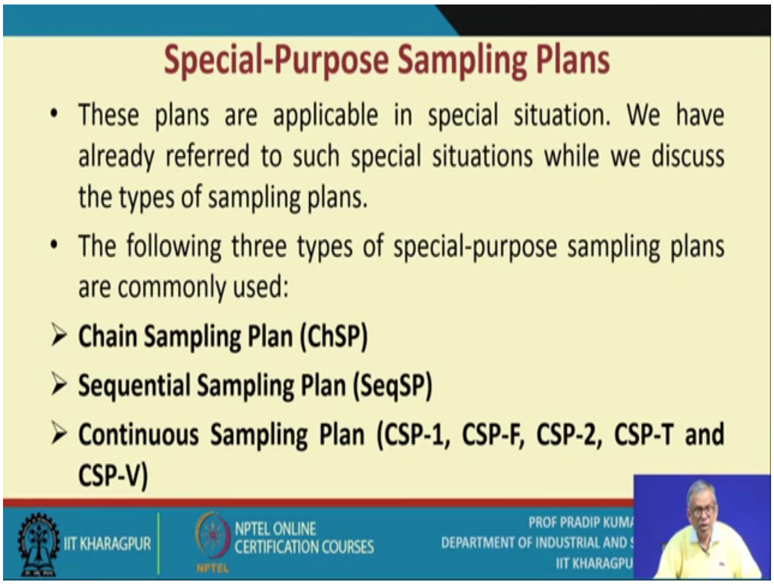

Now let us the discuss the special purpose sampling plans there are many the different types of say the special purpose sampling plans already developed by the several researchers several practitioners as well as the several organizations. So, out of all these special purpose sampling plans we will be referring to just 3 these are all important. In fact, you must learn all these 3 types of a special purpose sampling plans, first one is the chain sampling plan, next one is the sequential sampling plan and the third one is the continuous sampling plan under continuous sampling plan you have these you know by the 5 varieties as per the standards that is CSP -1, CSP -F, CSP - 2, CSP-T, and CSP -V.

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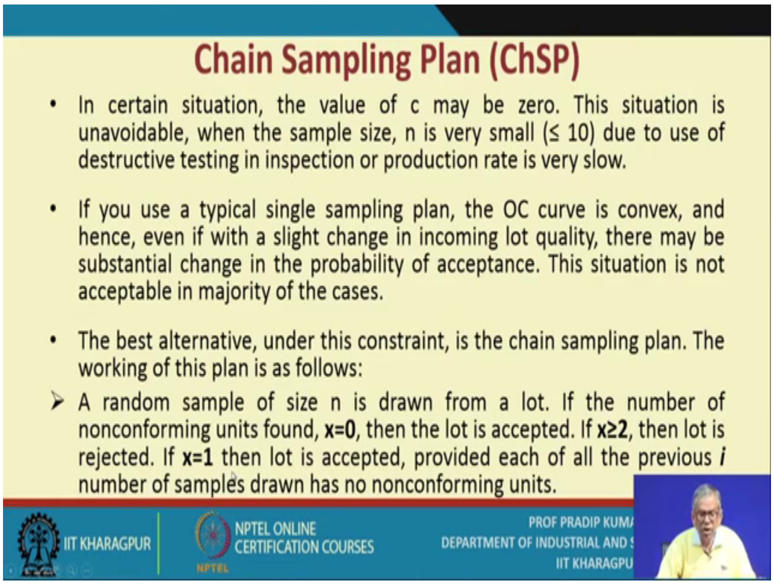

So, briefly I will explain all these special purpose sampling plans now the chain sampling plan is recommended when the value of c is 0 now this the value of c may be 0 when the sample size n is very small less than equals to 10 due to the use of destructive testing inspection or the production rate is very slow. So, if the sample size is less than equals to 10 say 8 or 7 in all likelihood you will find that you suggest that the acceptance number must be 0.

If you use a typical single sampling plan the OC curve is convex and hence even if with a slight change in incoming lot quality there may be substantial change in the probability of acceptance this point already we have elaborated the situation is not acceptable in majority of the cases. So, the best alternative under these constraint is the chain sampling plan the working of these plan is as follows, a random sample of size n is drawn from a lot and these the sample size is very very less, less than equals to 10 if the number of non conforming units found that is x, x is basically a random variable x equals to 0 then the lot is accepted.

If x is greater than equals to 2 then the lot is rejected if x equals to 1 then the lot is accepted provided each of all the previous i number of samples drawn has no non conforming units is it.

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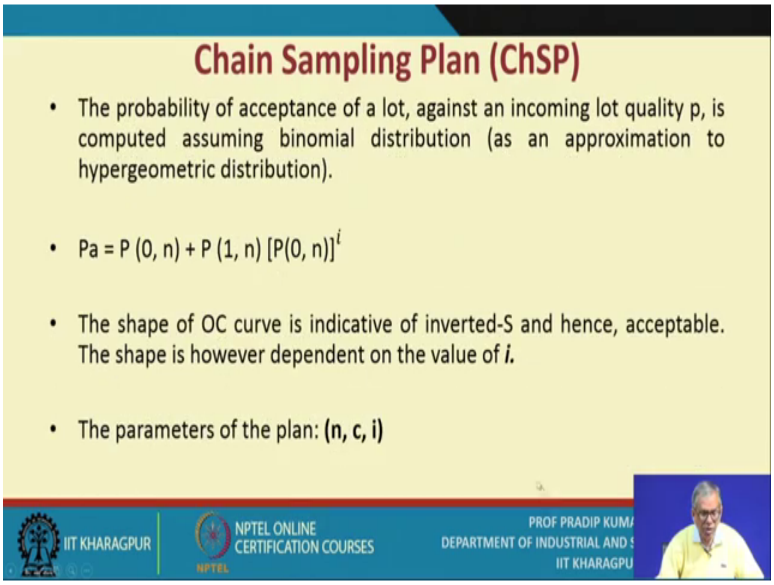

So, it is conditional. So, how do you compute the probability of acceptance of a lot. So, when the working of the chain sampling plan is as explained that is the probability of acceptance is a probability that there will be 0 non conforming in n number of units plus probability that there will be 1 n confirming unit in n number of units that is a sample size provided that the previous i number of samples all are having 0 non conforming you know 0 non conforming in the sample.

So, this is the condition and you must have this condition and with this condition even if in the current sample you have one non conforming unit you are going to accept it, this is the shape of the OC curve is indicative of inverted S and hence acceptable the shape is; however, dependent on the value of i. The parameters of the plan is sample size the acceptance number that is 0 and you have to specify the value of i whether it is 1 or whether it is 5 that you have to specify.

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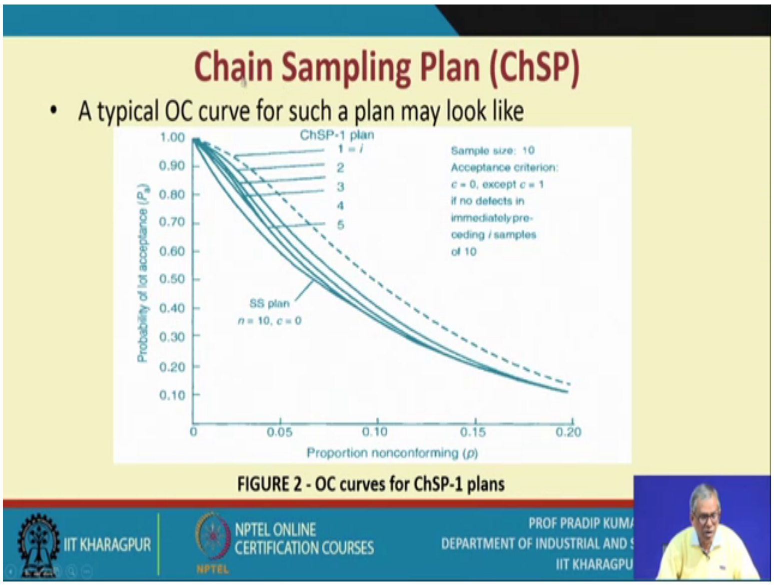

So, here is just an example what do you find that this is a typical single sampling plan with n equals to 10 and c equals to 0. So, you have this curve OC curve that is convex. So, this is not acceptable what you do, you go for change sampling plan. So, sample size is 10 and the rules you follow for acceptance and you just vary the value of i. So, when I equals to 1 you will find that the shape of the those OC curve is like this whereas, if you go for a say i equals to 2 or 3 4 or 5 as you increase the value of i you will find with the increased value of i the shape takes the inverted S form and that is why it is accepted.

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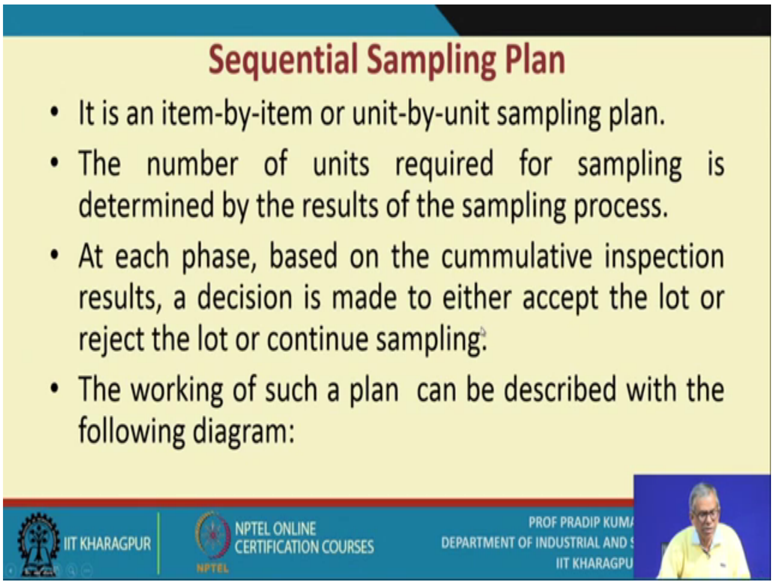

So, it is now, what is the sequential sampling plan, it is an item by item or unit by unit sampling plan is it till now we have considered the lot by lot sampling plan. So, when you refer to the sequential sampling plan this is that unit per unit sampling plan the number of units required for sampling is determined by the results of the sampling process. So, at each phase based on the cumulative inspection results a decision is made to either accept the lot or reject the lot or continue sampling the working of such a plan can be described with the following diagram.

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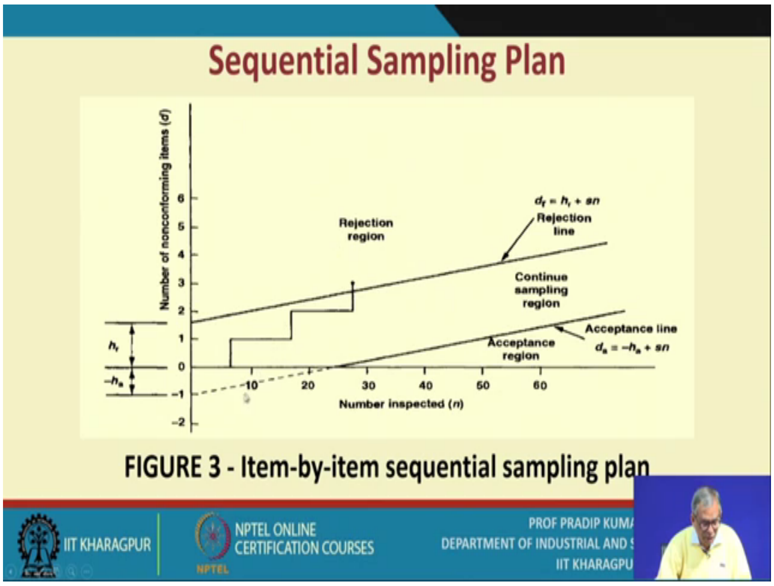

So, this is the diagram you have; that means, on the x axis you get the number of items inspected and on the y axis you just get the value of number of non conforming items or the units is it. So, you have these acceptance line and you have the rejection line and. So, this is the acceptance region and this is the rejection region. So, you have these equations for the rejection line, you have these equations for the rejection lines. So, this is your intercept minus and this is the intercept for the rejection line that is hr. So, these are the notations we used n is the number of units you inspect and what do you try to plot that is the cumulative the number of nonconforming items.

So, you here all these cumulative number you know this is the continuous sampling region and as soon as you reaches a rejection region. So, you have maybe you have say inspected around say the 28 units and you find that the 3 units as the non conforming units, but already you have reached the rejection region. So, you say that I will reject the lot.

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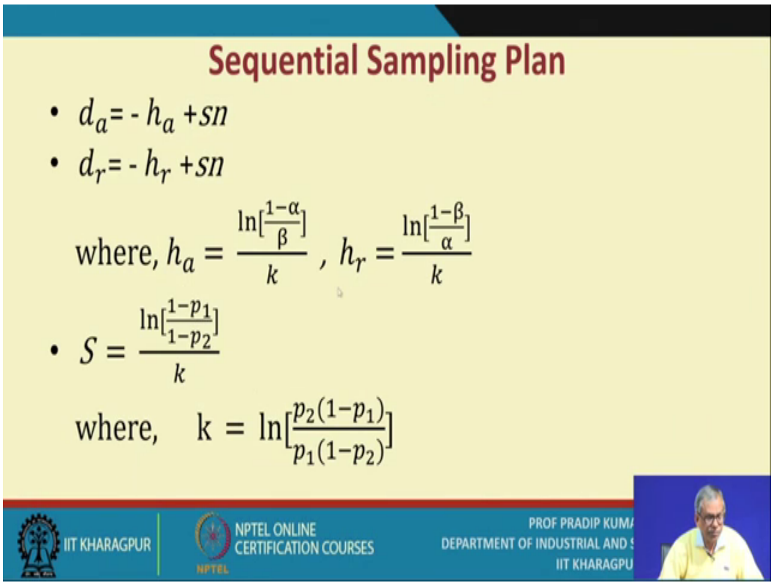

So, these are the equations you have please go through all these equations, this is the equation for the acceptance line this is the equation for the rejection line what is S, S is basically the slope and what you need to do; that means, you need to specify the producers risk that is alpha along with the value of p 1 and good quality and similarly you have to specify the value of beta along with p 2 that is LQL and then you apply all these the formula and you get the expressions for say the rejection line acceptance, line and the slope this is the expression for slow. So, all these details you will come to know.

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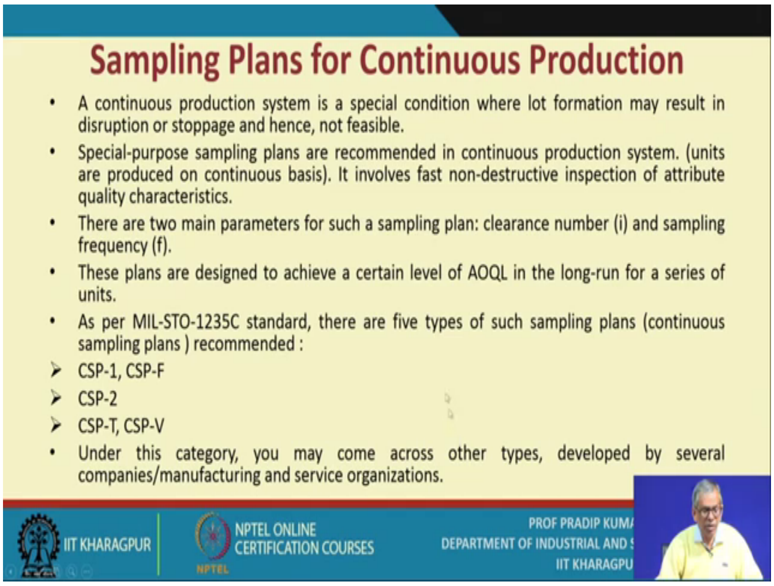

And you can define the sequential sampling plan now for a continuous say the production you know the standard lot by lot the sampling plan is not acceptable because in a continuous production scenario you cannot form the lot if you form the lot what happens that there could be the desorption in the production system or you know there could be the stoppage in the production system.

The productivity gets lost and you will not be getting a acceptable performance. So, this is not acceptable. So, what do you try to do; that means, for the continuous production if you want to use the sampling plan, you go by unit by unit sampling plan and what you try to do; that means, you apply at the different or you use a different kinds of sampling plans. So, there are 2 main parameters for such a sampling plan one is the clearance number and the second one is the sampling frequency.

So, these plans are designed to achieve a certain level of AOQL in the long run for a series of units. So, as per a military standard 1 2 3 5 c there are 5 types of such sampling plans under continuous say the production scenario and these are referred to as the continuous sampling plans. So, CSP 1, CSP F, CSP 2 and CSP T and CSP V under this category you may come across other types developed by several companies and manufacturing and service organizations.

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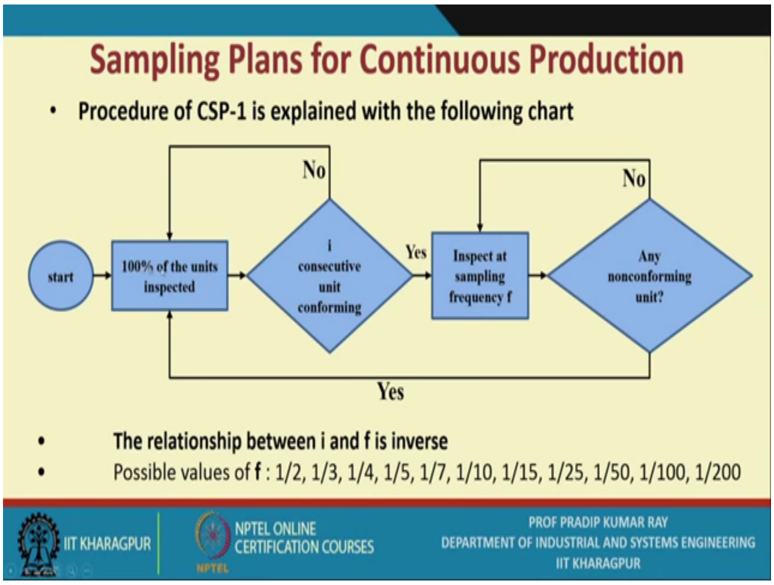

So, this is a typical the CSP 1 you start you go for 100 percent inspection of the units one by one and then you check whether the I consecutive units conforming or not. If you achieve this condition then what you do; that means, a condition of consistency is reached. So, instead of going for 100 percent inspection now you go for the sampling inspection with a sampling frequency of f is now during this phase if you find any non conforming unit is it, you will immediately any non conforming unit. So, you immediately you go for 100 percent inspection. So, if you go for any 100 percent inspection, but. So, long you do not get any non forming unit under sampling inspection you continue with a inspection at a sampling frequency f.

So, this is a sampling procedures we follow so; obviously, there are 2 parameters one is i this is called the clearance number and f is the sampling frequency now; obviously, if i is more the sampling frequency is less. So, the relationship between i and f is inverse and what are the possible values of f as given in the standards that is it could be half, it could be 1 third, it could be 1 fourth, it could be 1 fifth, if it is 1 fifth means out of 5 units you come across you just select 1 unit for inspection and this selection is a must be a random selection.

So, 1 upon 7, 1 upon 10, 1 upon 15 and it may go even 1 upon 200; that means, may be say i value you have considered that is say 5000. So, what do you find that all the 5000 consecutive units 500 nonconforming so; obviously, the sampling frequency could be very very less.

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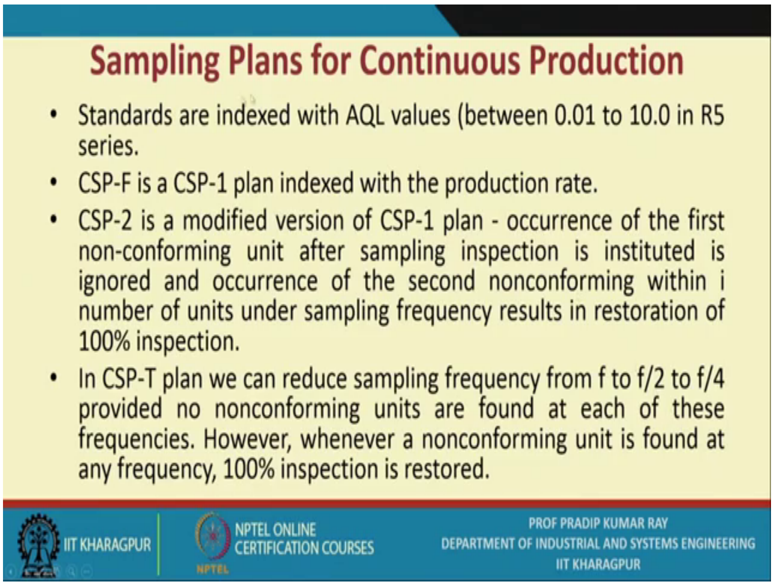

So, now there is a variation of CSP 1 now when the production rate is less what you try to do; that means, you ought for CSP -F is basically CSP 1 plan, but it is indexed with the production rate, you go for CSP 2; that means, in the CSP 2 what you do; that means, when you in it is basically CSP 1, but the first time under sampling frequency when you get a non conforming unit you ignore it is it.

But if you get the second a non conforming unit under sampling frequency definitely you go back for 100 percent inspection. So, that is the main difference between the CSP 2 and CSP 1. Under CSP T plan we can reduce sampling frequency from f to f by 2 to f by 4 provided no non conforming units are found at each of these frequencies; however, whenever a non conforming unit is found at any frequency 100 percent inspection is restored.

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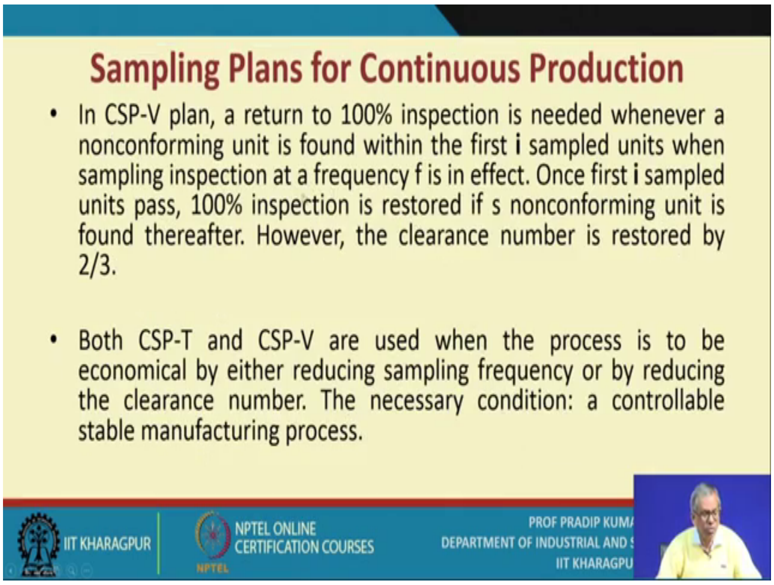

In CSP V plan a return to 100 percent inspection is needed whenever a non conforming unit is found within the first i sample units when sampling inspection is at a frequency f. Once first i sample units pass 100 percent inspection is restored if S non conforming units is found thereafter; however, the clearance number is restored by 2 third is it; that means, both CSP T and CSP V are used when the process is to be economical by either reducing sampling frequency or by reducing the clearance number so, the necessary condition a controllable stable manufacturing process.

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So, all these details, please you know refer to all these special types of a say sampling plans there are 3 types we have explained and the related to all these the sampling plans will have in the numerical exercises later on as a part of your assignment later on.

So, we are concentrating on 3 special types that is one is the chain sampling plan, the second one is the sequential sampling plan and the third one is the varieties of a continuous sampling plans, mainly the CSP 1 we have we have discussed and once the CSP 1 is known under the several other conditions you may ought for other varieties of continuous sampling plan or CSP 2 or CSP V or CSP T or CSP F.

So, we conclude our discussions on the first part of the acceptance sampling in the next week we are going to when they discuss the sampling plans of a for. So, the variables data; that means, there are many cases related to particular quality characteristics you are now collecting the variables data. So, how to say the design or how to use sampling plans, when you collect a variables data, this part we will be discussing in the next week.