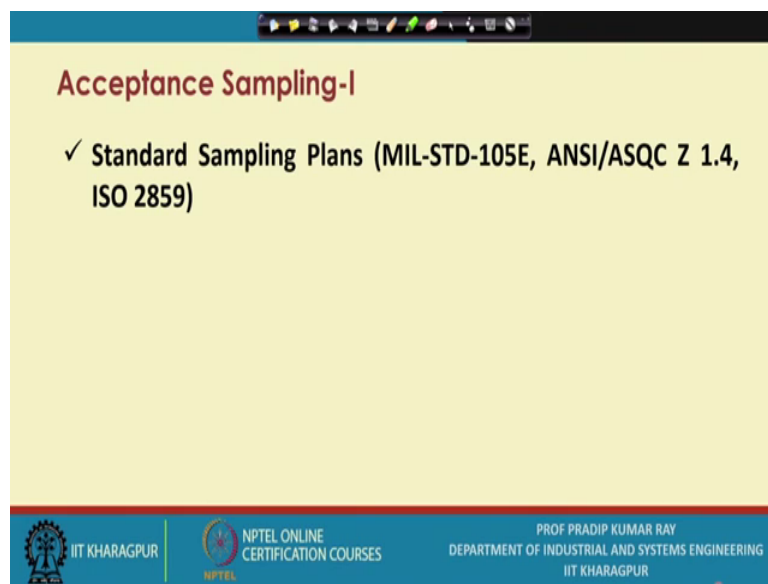**Quality Design and Control**
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Lecture – 35
Acceptance Sampling – I (Contd.)

So, during this lecture session on the acceptance sampling, I will be discussing now, the standard sampling plans.
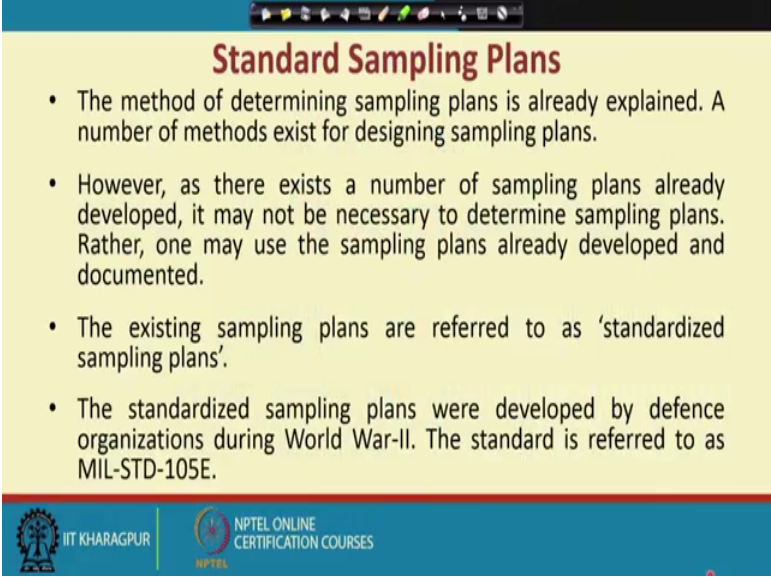
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By this time you have come to know how to design a sampling plan under the different situations particularly you know when deal with the attributes data.

Now, once the sampling plan the designing is known; that means, you are aware of that what kind of steps you have to follow to determine the values of you know the sampling plan parameters in order to satisfy certain conditions like we refer to the stipulated producers risk, stipulated consumer risks or you know the stipulated like say AOQL well or say the stimulated say the minimization of ATI. So, there could be the different stipulations and against each set of stipulation you can design the sampling plan.

Now, the question is that you will be getting different kinds of situations. So, it may not be feasible for you to design the sampling plan every time.

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And what has happened over the years that the researchers the practitioners the several organizations they have already design the different kinds of sampling plans and the question remains that why do not we use some you know the standard sampling plans.

So; obviously, you know the, these sampling plans were introduced during the Second World War days and the main issue was the quality control of say you know say a military hardware components. So, for quality controlling; obviously, you know the sampling acceptance sampling procedures they adopted.

So, and later on you know that particular the standard initially developed for say the military hardware components now those standards with certain modifications those standards were adopted for the civilian products. So, I will just give you a brief overview of all these standards.
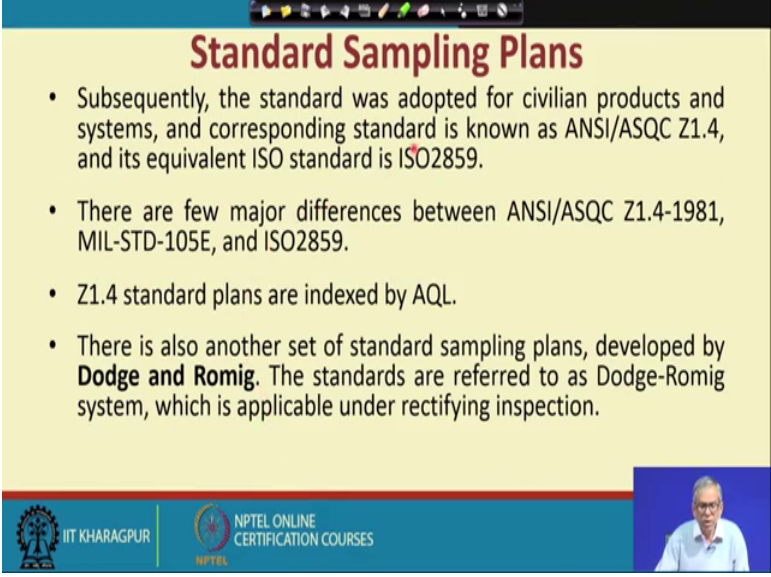
Now, certain comments are made like say method of determining sampling plans is already explained; that means, already is known to you the number of methods exist for designing sampling plans; that means, there could be different methods depending on the what sort of the criteria you need to satisfy.

However as there exists a number of sampling plans already developed it may not be necessary to determine sampling plans rather one may use the sampling plans already developed and documented, the existing sampling plans are referred to as the

standardized sampling plans. So, in many a time to in order to reduce the time and effort what you can do; that means, you may select the suitable sampling plans from already given sampling plans in the standardized sampling plans.

The standardized sampling plans were developed by the defense organizations during world war 2 this point I have already mentioned and the standard is referred to as military standard 105E; that means, around the 1950 this was proposed as military standard 105 E that is the a version in 1950 subsequently there are the lot of the changes had taken place in the standards and this latest version is MIL- STD -105 E.
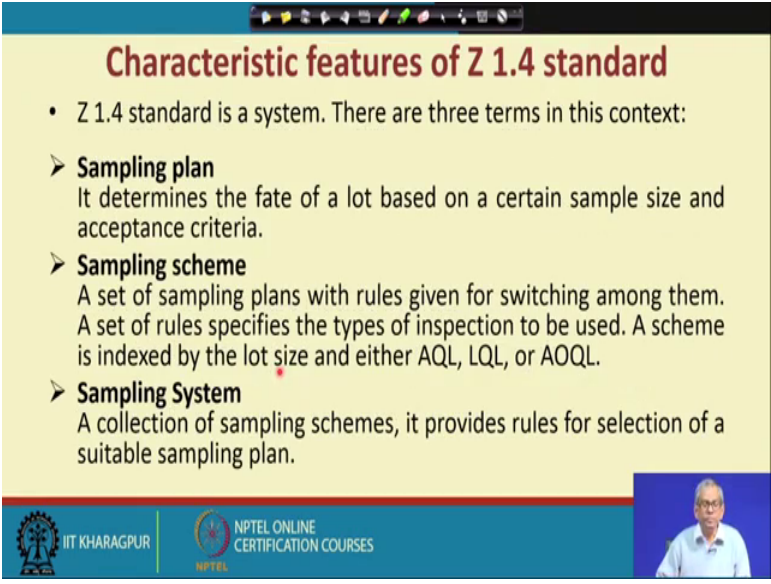
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Subsequently, the standard was adopted for civilian products and the systems and the corresponding standard is known as ANSI ASQC Z 1.4 standards in these are the 2 organizations American National Standards Institute and American Society for Quality Control these 2 organizations they formed a committee and this committee was constituted to adopt other military standards or the civilian product. So, certain changes we are made and so, this these standards related to acceptance sampling for civilian products is referred to ANSI ASQC Z 1.4 standards and subsequently during 1970's the international standards organizations with certain changes is they adopted these ANSI ASQC standards and these standard is ISO 2859 is it. So, during these sessions will be discussing some you know the characteristic features of this particular standard.

The point to be noted is there are a few major differences between ANSI ASQC Z 1.4 standards 1981 and military standards 105 E and ISO standard 2859 there are definitely there are certain differences, but these differences are very few Z 1.4 standard plans are indexed by AQL in short these ANSI ASQC Z 1.4 standard in short this is referred to as the Z 1.4 standard.

Now, these the standard sampling plans are indexed with respect to AQL; that means, you need to specify the value of AQL we have already explained what is acceptable the quality level. There is also another set of standard sampling plans developed by Dodge and Romig in 1950's, Dodge and Romig they proposed different kinds of sampling plans and these standards and ultimately those they are the end of the proposals were accepted as the standards and the standards are referred to as dodge Romig system which is applicable under rectifying inspections.

Whereas when you use Z 1.4 standards; that means, it is a normal situation that is; that means, there is no rectifying inspection whereas, whenever you use a rectifying inspection you cannot use Z 1.4 standards, but you have to use the Dodge Romig system.

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Now, let me explain in brief during this session what are the characteristic features of Z 1.4 standard, now the Z 1.4 standard is a system and we use different kinds of terms and terminologies related to acceptance sampling and these terms and terminologies are well explained well defined in these standards. So, we will be referring to all the important

terms and terminologies and then only you will come to know that how to use this particular standard in a given situation.
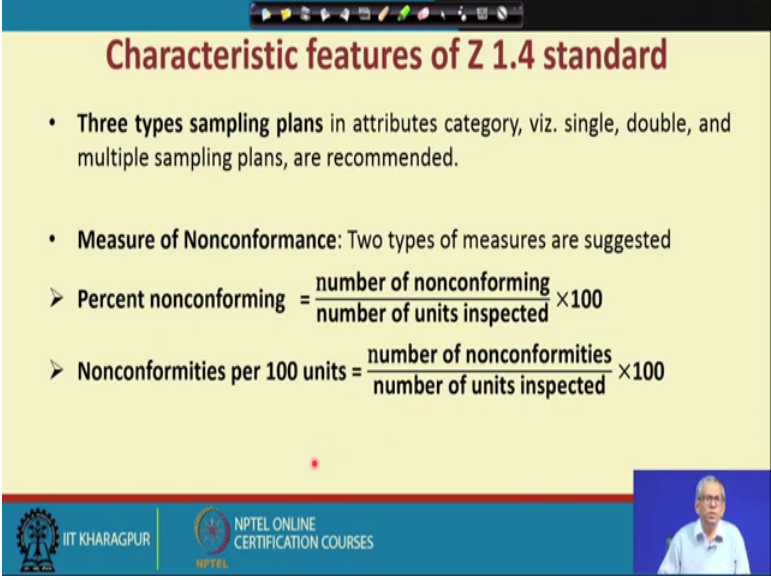
Now, there are terms in this context; that means, when you refer Z 1. 4 to standard as a system first thing is the sampling plan has been defined. So, now, what is the sampling plan as you may be knowing it determines the fate of a lot based on a certain sample size and acceptance criteria like say acceptance number and the sample size these 2 are specified and if you use a single sampling plan. So, how do you take a decision whether you will go for lot acceptance or rejection that is referred to as a sampling plan.

Next the term that is used that is sampling scheme, now what is the sampling scheme is said sampling plans with rules given for switching among them now there are switching rules provided later on we will explain what are these switching rules and you know in a given in a given situation there could be different types of inspection and in the under sampling scheme, what is stated is that if you need to change from one type of inspection to another, under which kind of say the conditions you are required to switch over from one type of inspection to another.

So, these the set of rules specifies the types of inspection to be used later on you will come to know that what are these types of inspection a scheme is indexed by the lot size; that means, the capital N you must be able to specify and either AQL or LQL or average outgoing quality limit these 3 either one of these 3 values you must be able to specify.

Now, what is the sampling system, the sampling system is basically a collection of the sampling scheme. So, when you refer to the standards when you start reading those standards we will find that we refer to different kinds of sampling schemes and in totality all these schemes actually constitute the sampling system. So, it provides rules for selection of a suitable sampling plan. So, the 3 terms we have used sampling plan the sampling scheme and sampling system.
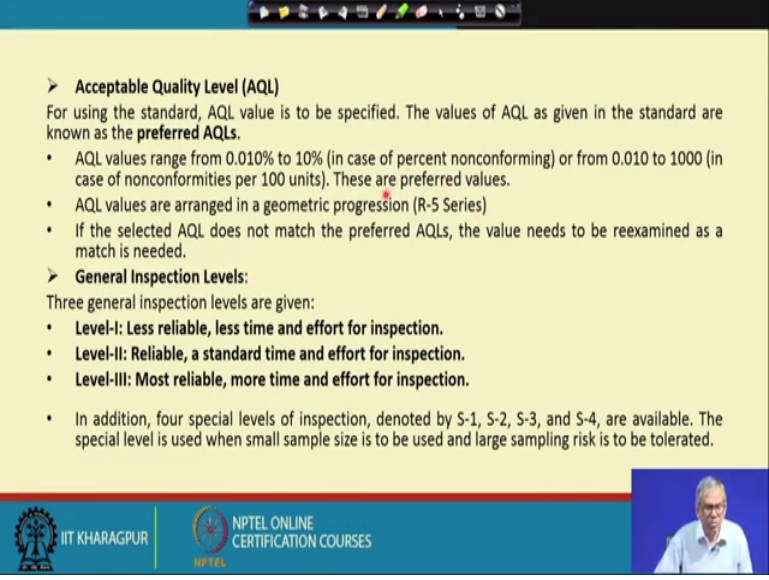
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Now the next important aspect is whenever the you use a sampling plan you deal with the level of nonconformance now in this particular the standard there are 3 types of sampling plans you may use and these sampling plans are in attributes category, then the they are basically is a single sampling plan either you can use or you may use double sampling plan or in certain cases you also may opt for multiple sampling plans and here the multiple sampling plans in Z 1. 4 standards just you make a note that you can go up to the 7 th level; that means, for making a decision in certain cases; that means, you are allowed to say the draw a maximum number of 7 samples, and whenever you are allowed to more than 2 number of samples to make a decision; obviously, that sampling plan is referred to as the multiple sampling plan.

Now, this is a standard that specifies the measure of nonconformance and the 2 types of measures are suggested now here you know whenever you say the nonconformance now there could be 2 types of nonconformance, one is related to say are the nonconforming output and another one is related to the number of say the nonconformities. So, the nonconformities are nothing, but the defects whereas, a nonconforming means the defective, this point already we have explained.

Now, there are 2 types of measures one is the percent nonconforming that is the number of nonconforming divided by the number of units inspected into 100 as it is a percent from conforming. So, this could be one measure you can select or whenever you are

dealing with nonconformities or the defects; that means, corresponding measure of nonconformance is nonconformities per 100 units or the 100 items. So, number of this is defined as the number of nonconformities divided by the number of units inspected into 100 is clear.

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Now the next one is we have already defined the acceptable quality level AQL now for using the standard AQL value is to be specified that is why we say that Z 1. 4 standard is indexed with respect to AQL. Now the values of AQL as the driven in the standard are known as the preferred AQLs; that means, when you refer to this particular standard you will find that certain values of AQLs are stated and these values are referred to as a preferred AQL values.

So, the AQL values range from 0.010 percentage to 10 percent. So, maximum is 10 percent; that means, in case of percent on conforming right whereas, in case of nonconformities per 100 units that is the measure of nonconformance this you know the AQL ranges from 0.010 to 1000; that means, 1000 number of nonconformities per 100 units or 100 items, these are the preferred values.

Now when you look at these preferred values as given in the standard you will find that these AQL values are arranged in a geometric progression and this is R - 5 series is it; that means, say the geometric the ratio is 10 to the power 10 upon 5. So, the between the 2 values; that means, between 1 and 10 there will be say the 5 values excluding 1

similarly between 0.1 and 1 there could be 5 values in R - 5 series excluding 0.1 and so on .

If the selected AQL does not match the preferred AQL then what you have to do as the value needs to be reexamined as a match is needed because what is given actually the sampling plans are given against a particular AQL value; that means, over all listed values now if your actual value is different from say the preferred AQL so; obviously, you have to make a compromise is it.

Now, next important term we use that is the inspection level and it is very clearly defined now there could be 2 types of inspection levels, either it is general inspection levels or it could be the special inspection levels. Now let me explain that what do you mean by the general inspection levels, now the 3 general inspections level are given in the standard the first one is the level 1, the second one is the level 2, and the third one is the level 3.

Now, whenever; that means, the essentially what you do inspection level means you know the certain the standard you prescribed. So, it is like say if you are asked to inspects a 100 units now if you the specify the standard like say the 2 hours will be given.

Now, if you and suppose the 2 hours is the standard and then you inspect 100 units of a specific product or the component then you say the level 2 is my inspection level; that means, level 2 is the norms; that means, it is reliable a standard time is given for doing inspection and effort is also very standard; that means, you are not overworking or you are not under working. So, this is considered to be the standard. So, you start with the level 2 inspection level.

In certain cases because of many reasons suppose the less time is given; that means, instead of giving 2 hours you know the standard time you are given 1 hour so; that means, you are moving from level 2 to level 1. So, if you spend less time to inspect the same number of items what you know you say you may conclude that the entire inspection system may not be that reliable in the sense that the data which you are getting they may not be reliable and as the less time and effort for inspection given, that is level 1.

What is level 3; that means, here what you are doing that we need instead of giving 2 hours you are giving 4 hours is it. So, you take more time. So, the entire inspection system becomes more reliable more time and effort for inspection is given. So, certain times when you know the time is not a problem is not a constant and the corresponding the components which you are dealing with for acceptance sampling there is a very very critical components. So, you may opt for level 3, there are 3 levels. So, these are referred to as general inspection levels.

Then in addition to the general inspection levels 4 special levels of inspection are also given in the standards and these are denoted by S-1, S-2, S-3 and S-4, The special level is used when small sample size is to be used because of many reasons and the large sampling risk is to be tolerated, sampling risk you know what are those sampling risk mostly alpha and beta risk. So, this is the effect of general inspection level on the OC curve, now OC curve as one of the performance measures.

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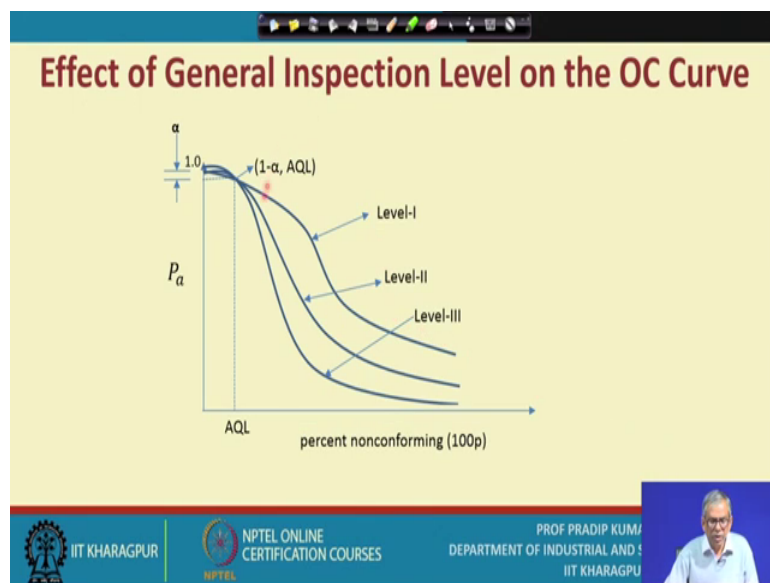
So, this is you know x axis is percent in nonconforming that is 100 into p and you specify the AQL and corresponding you know the producers risk is alpha this is already known to you and. So, this value; that means, all the if you have the level 1; that means, this curve the OC curve becomes flat whereas, if you opt for level 3 you know the OC curve becomes very very stiff and the level 2 is the norms.

So, that means, all the 3 curves must pass through 1.0 that is 1 minus alpha AQL. So, this is the effect; obviously, you know. So, if you opt for level 3, it is the most to discriminatory right.

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Now, as I have already mentioned when we refer to the switching rules in the sampling scheme while we define the sampling scheme we have referred to the types of inspection. Now, under this the Z 1.4 standards there are 3 types of inspection first one is the normal inspection. So, what is normal inspection; that means, the inspection is used at the start of the inspection; that means, when you start being inspection, you start with the normal inspection quality level is at AQL or better so, that is your objective normal inspection.

What is reduced inspection used when products quality history is excellent; that means, most of the time we will find that the lot is accepted and so, what you can do, you can relax your inspection norms and that is referred to as the reduced inspection; that means, instead of a say collecting a sample of size 50 if the quality history is excellent. So, why say that I do not need to say inspect 50 units I can just inspect 25 units is it.

So, and I know that the lot quality in coming lot quality is very very good. So, when you offer reduced inspection it uses the smaller sample sizes is it, but then again if the quality history is extremely poor what you can try to do; that means, now you enforce the tighter control and you opt for the tightened inspection, now this type of inspection is used when recent quality history showing deterioration is it there is no improvement even with
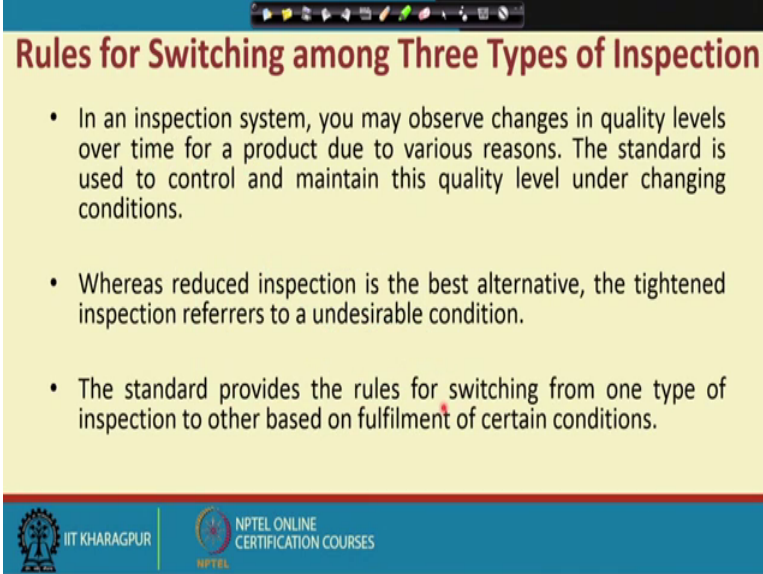
repeated trials even with repeated attempts. So, the quality must be at least AQL is it. So, there are 3 types of inspection normal inspection is the norms, but in certain cases you may opt for reduced inspection and certain other cases you have to go for tightened inspection.

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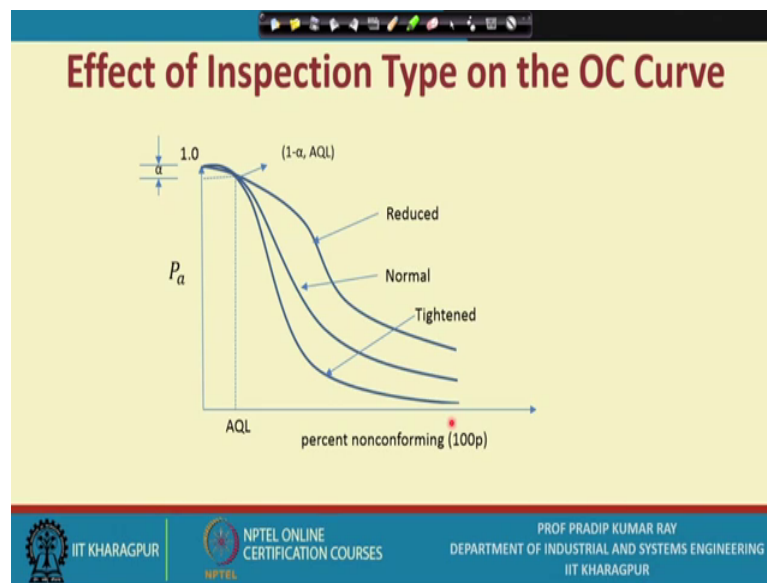
So, the effect of inspection time on the OC curve you will find that again you know this is AQL indexed. So, all the 3 OC curves are passing through that AQL 1 minus alpha point is it. So, the alpha value must be specified as well as the AQL. So, if you are for reduced inspection; that means, discriminatory power of the OC curve is poor whereas, if you opt for the tightened inspection; that means, the discriminatory power how the OC curve is very high whereas, if you opt for the normal inspection; that means, the shape of the curve is well acceptable and it is neither very discriminatory or less discriminatory, it is a normal situation.

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Now the standard provides the rules for switching among 3 types of inspection. So, in an inspection system you may observe changes in quality levels over time for a product due to various reasons. So, this point you please note it down the standard is used to control and maintain this quality level under changing conditions. So, acceptance sampling procedure is adopted or is used not for quality improvement purpose, but essentially for quality control purpose.

Whereas, reduced inspection is the best alternative the tightened inspection referrers to an undesirable condition is it this point already I have mentioned when we defined the types of inspection, the standard provides the rules for switching from one type of inspection to other based on fulfillment of certain conditions is it.

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Figure 3- Switching Process for Normal, Tightened and Reduced Inspection
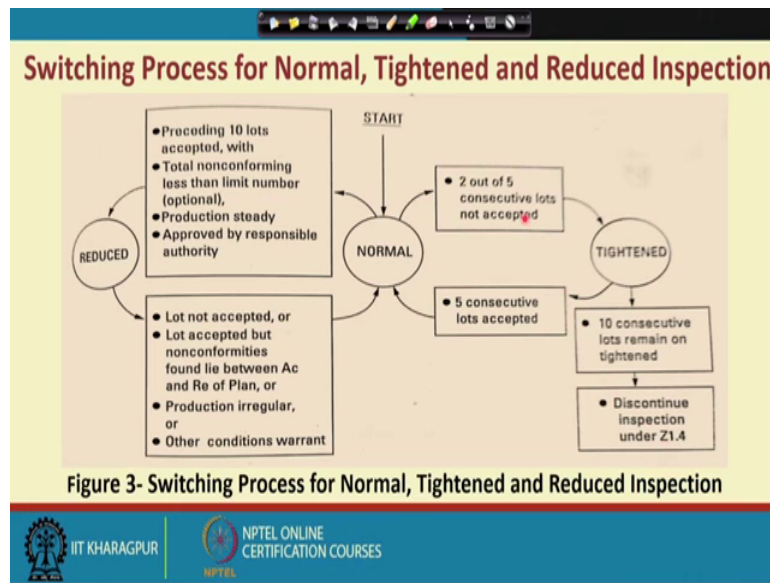
So, what is this, the switching process, let me explain it like say suppose your starting point is the normal inspection; that means, what you expect that you can achieve AQL or the higher values of AQL right. Now when you are in the normal inspection you find that the 2 out of 5 consecutive lots not accepted; that means, the 40 percent of the lots is it are not acceptable.

So, you go for tightened inspection, but while you are tightened inspection you find that there are 5 consecutive lots accepted again you go back to the normal inspection, but under tightened inspection if you find that the 10 consecutive lots remain on tightened inspection then; obviously, you find that there is a certain you know the quality control problem which cannot be rectified by implement accepting sampling is it. So, you discontinue inspection under Z 1.4 standards that means, the problem may be very very deep rooted.
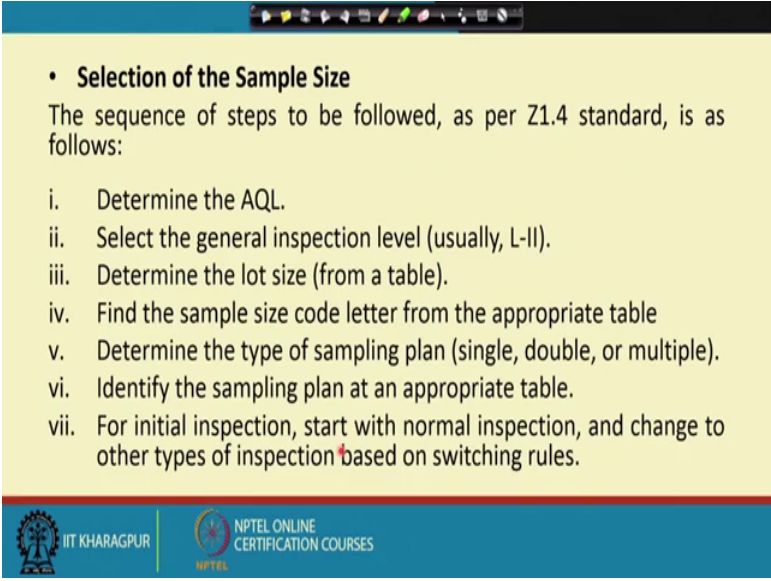
Now when under certain conditions; that means, these 4 conditions if you fulfill then; obviously, you may opt for say reduced inspection from the normal inspection. So, what are these 4 and conditions first one is the preceding 10 lots accepted with total nonconforming less than the limit number that there is a limit number table; that means, in order to say accepting the lot how many you know the numbers of how many nonconforming units you are on an average you are inspecting. So and whether it is this number is causing the limit number or not.

So, what do you find that the total number of nonconforming the units inspected is less than the limit number that is the second condition plus you find that the production is at in the steady state and the and it is approved by the responsible authority. So, if these 4 conditions all these 4 conditions are met you may offer reduced inspection, but when you are in the reduced inspection suppose one single lot not accepted immediately you go back to normal inspections or lot accepted, but nonconformities found lie between acceptance and rejection number of plan when you refer to you know the acceptance sampling plans under reduced inspection this could be the cases; that means, the acceptance number and the rejection number difference between these 2 may be more than 1 is it.

So, now suppose the actual number is lying between acceptance and rejection numbers. So, that particular so, the lot is accept, but from the next lot onwards you go back 2 normal inspection, third condition could be; that means, the production has become irregular. So, you do not want to take a risk you go back to the normal inspection or other conditions warrant this is not specified; that means, depending on the situations you take a decision there could be many conditions you may face and you say if you go for reduced inspection it becomes very very risky, I do not to go back to normal inspection.

So, what is the selection norms of the sample size, because are the sample size you have to select.
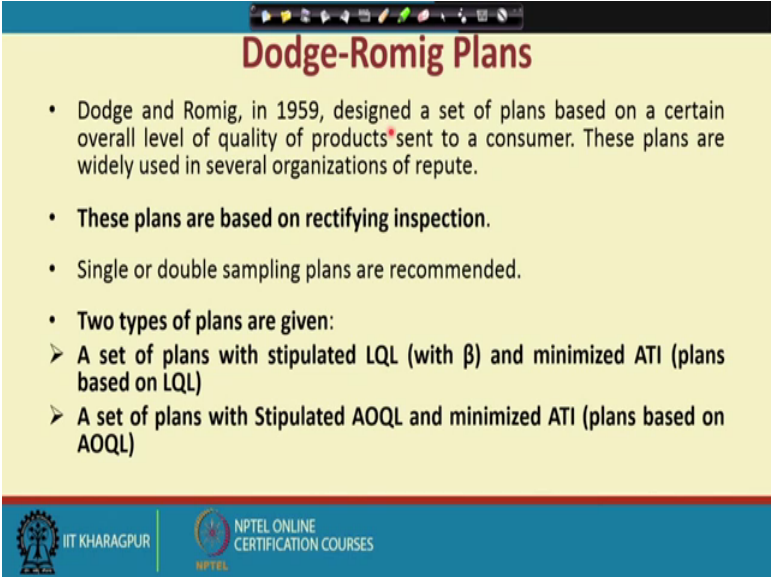
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- **Selection of the Sample Size**
The sequence of steps to be followed, as per Z1.4 standard, is as follows:

i.   Determine the AQL.
ii.   Select the general inspection level (usually, L-II).
iii. Determine the lot size (from a table).
iv.   Find the sample size code letter from the appropriate table
v.   Determine the type of sampling plan (single, double, or multiple).
vi.   Identify the sampling plan at an appropriate table.
vii. For initial inspection, start with normal inspection, and change to other types of inspection based on switching rules.

So, you are referring to the standards. So, there are certain steps, you have to follow as per the standards. So, I am just you know the referring to these steps like that first you need to determine the AQL value, select the general inspection level that is usually L- 2 is the norm; that means, general inspection level 2, determine the lot size from a table the table is given in the standard, find the sample size code later from the appropriate table is it.

So, first you get the lot size and from the left side you get the sample size coat later, then determine the type of sampling plan; that means, the single sampling plan or double sampling plan or the multiple sampling plan which one will opt for the choice is yours, identify the sampling plan at an appropriate table from an appropriate table there are different types of tables given. So, please refer to in your textbook all these the tables in any textbooks on quality you will find that these standards are given and you refer to all these tables you study those tables and for initial inspection start with normal inspection as I have already pointed out and change to other types of inspection based on the switching rules.

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Now just I will just refer to the Dodge Romig plans the Dodge Romig in 1959 designed a set of plans based on certain over a level of quality of products sent to a consumer is it. So, these plans are widely used in several organizations of repute over the years. So, these plans are based on rectifying inspection I have already mentioned and single or

double sampling plans are recommended not the multiple sampling plans as you find in Z 1.4 standards.

There are 2 types of plans given in this particular system called Dodge and Romig system a set of plans which stipulated LQL they have developed LQL with beta; that means, the consumer risk and the minimized ATI that is plans based on LQL. So, plans based through LQL you refer to and you get those tables and you select either the single sampling plan or the double sampling plan or in the next set of plans you will find where AOQL you stipulated and when minimized ATI plans based on AOQL average outgoing quality limits. So, this particular term already we have explained when we refer to say ATI curves as well as you know the AOQ curve.

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Reference

✓ Amitava Mitra, Fundamentals of Quality Control and Improvement, John Wiley.
✓ Jerry Banks, Principles of Quality Control, John Wiley.

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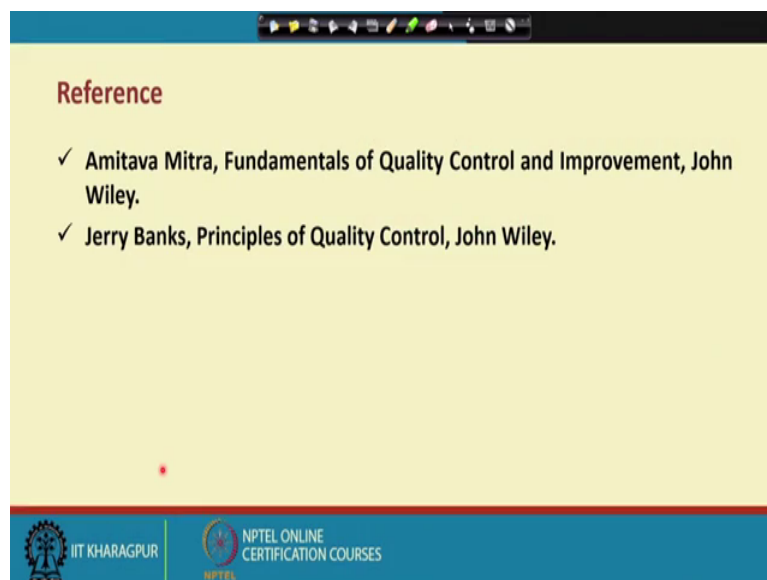
So, this is the coverage. So, I hope that you will be studying this 2 types of standards mainly Z 1.4 standards and you will check and what is the most important thing is when you refer to a particular sampling plan and you select a sampling plan with respect to AQL or say with respect to AOQL or LQL you know that what are the steps to be followed because already you know what is it is how to design a sampling plan. So, I conclude this part and we will be discussing other aspects of you know the acceptance sampling during the sessions in the next week.