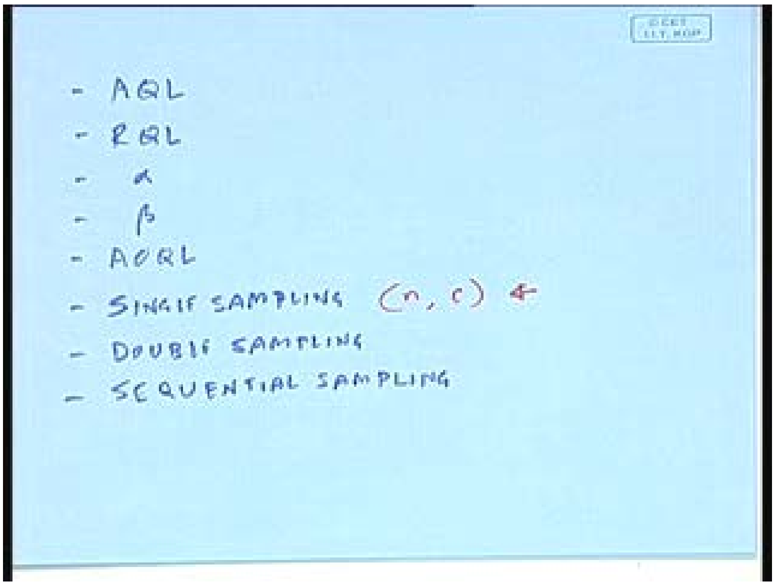
Six Sigma

Prof Dr T P Bagchi
Department of Management
Indian Institute of Technology, Kharagpur

Lecture No. #20

MIL-STD-105E Sampling Plan

(Refer Slide Time: 00:31)

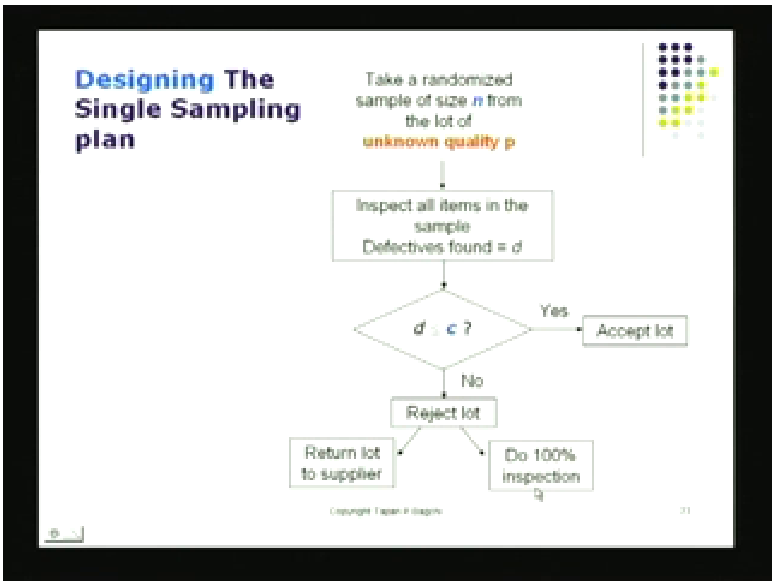


Good afternoon, we resume our lecture again. What we have done so far I have it on a sheet here, you can see we discussed something called AQL, that is acceptable quality level as far as the user or the prime or the consumer is concerned. Then, we had something called RQL that is rejection quality level. Then we had something called alpha, alpha is actually the risk for the producer. And then, we looked at something called beta, beta is the risk of the consumer. We looked at something called AOQL, which is the worst quality level that is any kind of sampling plan, we will deliver to the user.

And then we looked at couple of procedures, one was called single sampling when you draw one sample only. And I come up with quantities called n and c, n is the number of items that you pick fromed a lot - lot is generally of size n, big n. And c is the control limit which should not be exceeded if you want to accept the lot. Then we looked at double sampling, we looked at sequential sampling, and these are these are all going to guarantee the same alpha beta protection to the user and to the producer. At the same time, we are as we are going from single to double to sequential sampling, we are also trying to cut down at the total amount of effort that is required in trying to do the inspection in doing this plan.

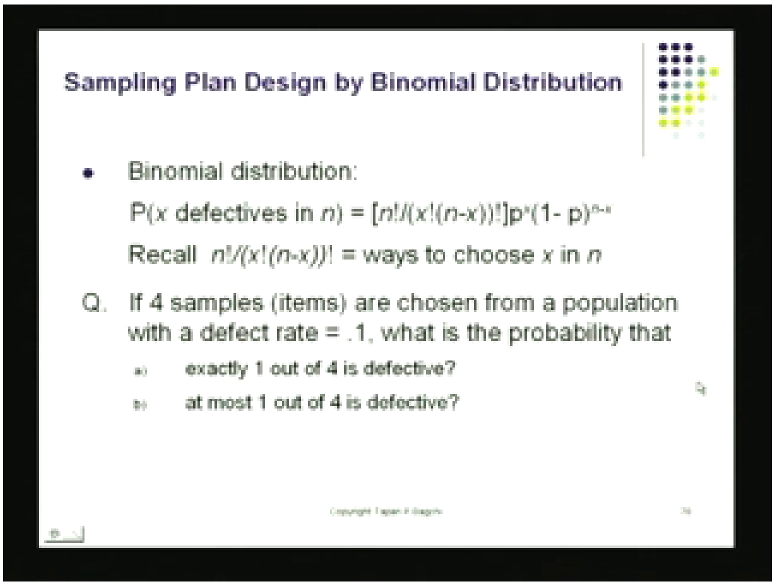
Now, here what we are going to be focusing on, is to how to determine this n and c this is what we would like to focus on how exactly do you go about finding n and finding c. That is going to be the prime goal for this session, this third session. The plan must protect both the consumer, the buyer and the supplier, both of these guys, these parties have to be protected.

(Refer Slide Time: 02:16)



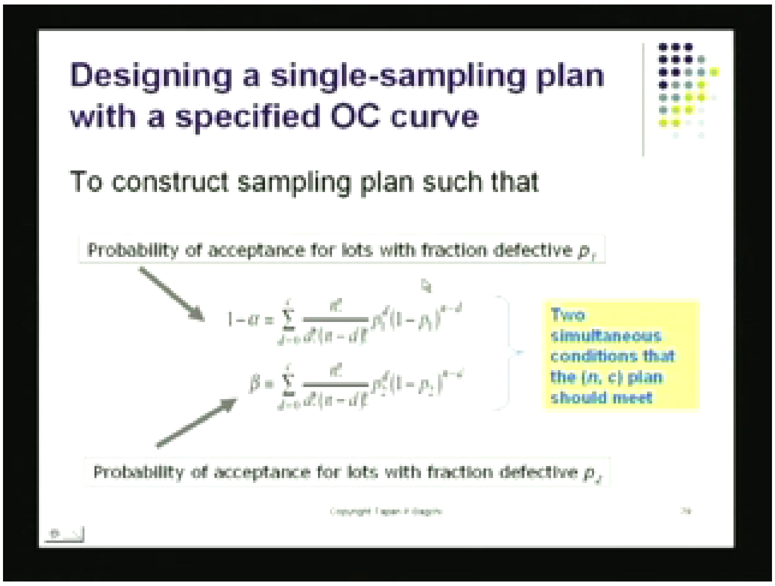
Then if you look into the single sampling plan itself it is a pretty straight forward thing. Take and randomize samples from there and the lot quality is unknown that is p. Number of defectives found by your inspection is little d. If little d is less than equal to c, c is the control limit there you accept the lot otherwise reject the lot, either you do and then you return it to the supplier or do 100 percent inspection to rectify inspection and then take it on. But, how do I find this n and c that is going to be the goal for the designer.

(Refer Slide Time: 02:54)



Remember we could, we had the exact formula given by the binomial distribution with the help of which we could really do this. And there is a little problem here given as 4 samples, 4 items are chosen from a population that has got a defect rate of 10 percent. what is the probability that exactly 1 out of 4 would be defective. Now, I trust you can do this is going to be basically 4 choose 1, p is going to be this 0.1 0.1 raise to the power 1, and 1 minus 0.1 which is going to be 0.9 raised to the power 4 minus 1, which is going to be 3 that is going to be exactly this. And I could write this formula out for you or we could do that so, thing can be done the moment. We assume our distribution to be binomial.

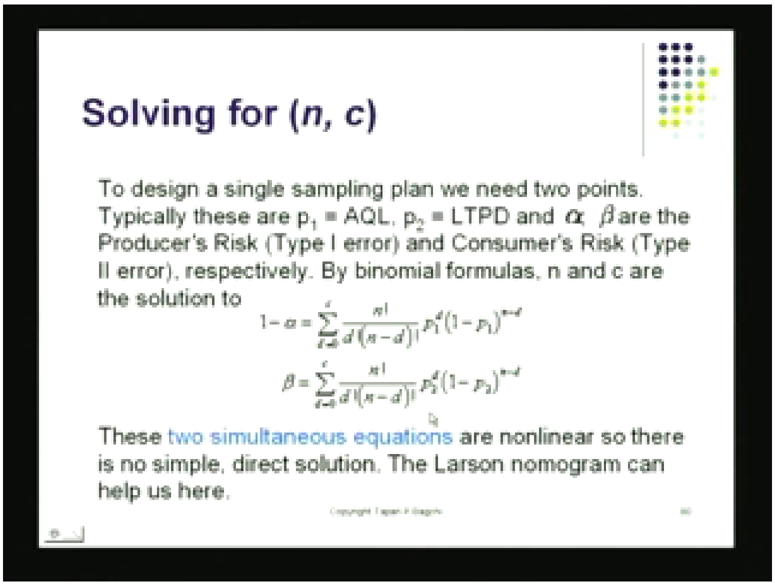
(Refer Slide Time: 03:47)



We could do it other ways also, I have used the same formula here and I put down here 2 P a values. 1 P a value is at the level of quality which is p 1, p 1 is very close to your AQL, p 1 is the same as your AQL. And p 2 is the same as RQL in the previous lecture there. Beta is the probability of accepting the lot which is at RQL level or p 2 level. And again this would mean that defectable sustain only up to c. Both of these are probability of acceptance so, I got to have this limit there d going from 0 to c and d again going from 0 to c and I could do that.

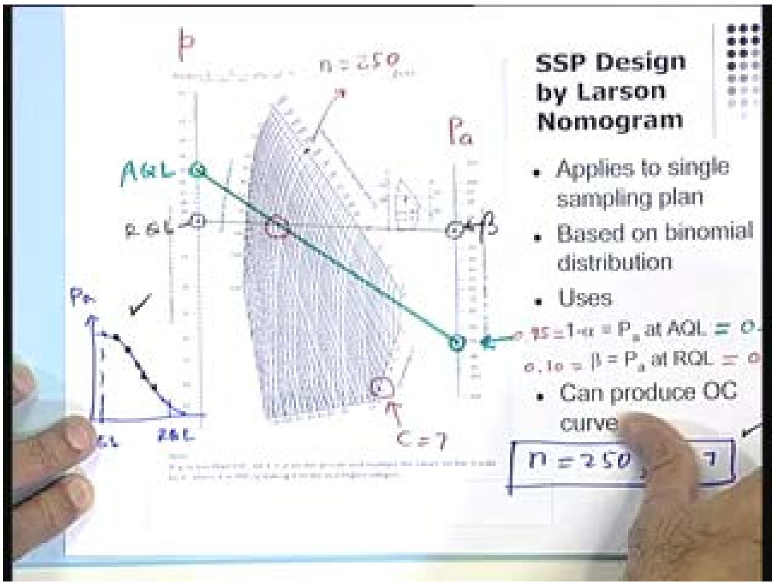
So, these two expressions these are now two simultaneous conditions that your n c plan, you take your plan, remember your single sampling will require two parameters one is going to be sample size n, the other is going to be your control limit c, control quantity c. Both of those basically will determine together, these two conditions which I have given here and condition one is this condition two is this.

(Refer Slide Time: 04:59)



Let us see how we bring them together? We could of course, solve these two equations for the values of n and values of values of c we could probably do that. But, as you probably know solving these two simultaneous equations which are non-linear, it is not going to easy, it is going to be hit and trial basically if you try to do it. There are practical methods for doing this one is of course, to convert this into a Poisson distribution and use the Poisson formula to be able to work this out.

(Refer Slide Time: 05:28)



And I am going to show you another method, which is like the remember the old method that we used in thermodynamics. Many times we ended up using what we called a nomogram. A nomogram is basically the graphic representation of a number of equations. And number of equations can be boiled down to what we call a nomogram that is what you have shown here. This nomogram basically is a relationship between what we call p and P a. On this side I have got P a on the right hand scale, I have got P a on the left hand scale, I have got p is your lot quality.

Now, what are the two conditions given to me? My P a should be 1 minus alpha. Remember now, if you remember the OC curve, this is to the left of the OC curve, this is near the peak of the OC curve and that value of P a there should be equal to 1 minus alpha. Alpha is the risk of the who is this risk for it is for the producer he should not get good lots to turn to them and this has to be done at the AQL levels so, this is one condition. One condition is just that the other condition is the condition of beta and beta is shown right here. Beta is P a at RQL level, beta is the straight probability of acceptance of the lot.

Now, together of course, we can produce the OC curve, we can produce all kinds of things. Let us see how we determine n and c, given these two conditions? I have the same graph here, I have got the same graph here on a piece of paper, and I am just going to write on this so that you will remember what these are. I am going to write the two quantities one is going to be P a and the other is going to be p. Those are the two scales, I have got the p scale and the P a scale. And the two conditions I have to meet, one of them is this condition here 1 minus alpha equal to P a at AQL. So, what I do is?

I will have to assume some value of alpha and I will have to assume some value of AQL, I am just going to do that for you because, I have to work this out. And I could do the same thing for beta, I could assume some value of beta and I could be assume some value of RQL. Let us start putting down some of these values here, let us make AQL equal to 5 percent 0.0 5. And let us make the value of RQL to be equal to 10 percent, this is equal to 0.1 0. And let us put these two risks, alpha is going to be let us make it 5 percent therefore, 1 minus alpha is going to be now let us call if 0.95. And the value of beta let us make it 10 percent so this is going t be 0.1 0.

So, I have quantities now which are specific, all I have to do is I have to draw two lines here that will take care of the two conditions which I showed you earlier. One is going to be true at AQL level, the other is going to be true at RQL level. So, for AQL, what do I have to do? I have to look at the value of P a that is 0.95. And that 0.95 is going to come, I am going to put a small circle there, 0.95 is right there. And let us make it green there, that is 1 point there that is 0.95 right there, and that is the value of P a.

And what is the value of AQL that corresponds to this 5 percent? 5 percent again I could put a point there and put it like this. And then what I do? I do my magic, I have a pencil and I have a ruler and I join these 2 points and I will just hope that my lead is not going to break and my line is going to be this one this is going to be my line. I drew a line and if it is too light for you, let me use the green line. So, I am going to use the green line and I am going to give you that line there this is one line, now that line takes care of one of those conditions.

That condition is what? 1 minus alpha is P a at AQL, AQL is here so let me write AQL there, AQL, and on this side I have got 1 minus alpha so that is going to be this quantity there 1 minus alpha. Then I have got the other equation also and what is the other equation? 0.1. 0.1 is going to be my P a so 0.1 I have to find on this so 0.1 is right over here I have got 0.1 there, and this is true for RQL at. RQL is the same as p remember lot quality so RQL is going to be 0.1 so 0.1 is going to be over there somewhere.

If I join these two lines, I will be taking care of this second condition so let me join them like this and they are joined, (No audio from 11:14 to 11:19) And I have got the other line now. Remember now the first which is the green line will take care of my protecting the producer or the supplier. The black line is going to be protecting now the user or the consumer. At this point which I am going to mark with I think a good color will be, oh let us put red, at this point both conditions are satisfied. I satisfy the condition for the this guy, who is this guy? He is the user and this is the producer, at this point both are satisfied. All I have to do now is on this nomogram there are markings for n and there are markings for c.

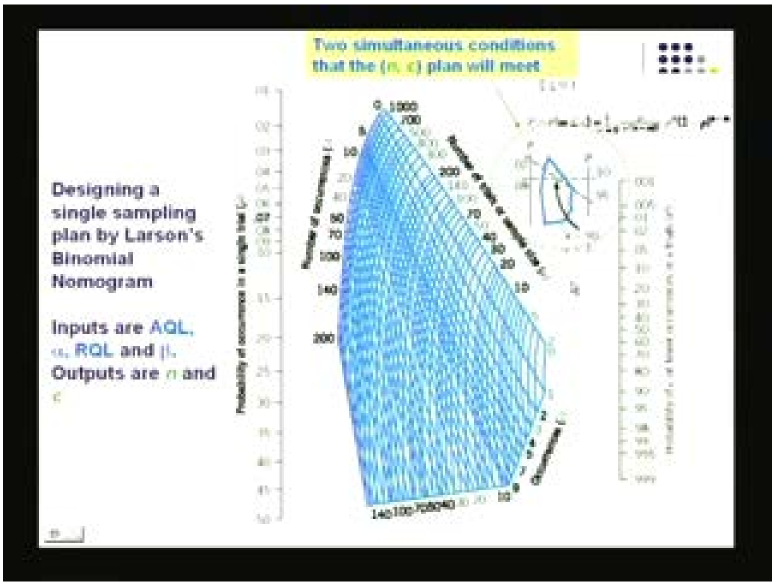
S o, let me read the value of n, n turns out to be in this case, somewhere here which is 250, n equal to 250. And the value of how did I find n? I just climbed up the curve that is all. And I climb down the curve this way and I will end up with a, let me do it carefully. I end up with here somewhere and this turns out to be my value of c, this is the value of c, c equal to 7. Now, what is the result of doing all this? I have got my sampling plan designed. And the sampling plan will be going like this, I have here n equal to 250, c equal to 7 and that is my single sampling plan. And the design is now complete. Now, if I wish I can construct the OC curve for it. And there is a very easy way to construct the OC curve, once you got this thing there. Remember the OC curve it kind of you know comes down like this and for that what I have to do is?

I have to rotate my little scale there and I have got to rotate it between AQL and RQL. I did not put my RQL there, let us put my RQL there, this is my RQL and this of course, is your beta, beta is this value there. So, I have got I took care of alpha in AQL and I took care of beta in RQL. And to find the OC curve all I have to do is put it here and rotate it and keep looking at values of p and the corresponding values of P a. Values of p and P a, if I keep doing that, if I keep looking at those pairs of readings I will be able to construct my OC curve. And the OC curve will let me just you know spoil this chart here, the OC curve will look like this.

It will start at some point which is like AQL and it will end at some point which is RQL and on this side I will have P a. And to you just make sure that you are able to see it, there is my OC curve and I found these points. How did I find these points? All I did was I pivoted that is my sampling plan, right in the middle and that red circle is a sampling plan. I pivoted my scale so, I kept reading little p and P a pairs, I kept find them, I kept finding these points, these points I kept finding for the OC curves then of course, I joined them, I end up with my OC curve also.

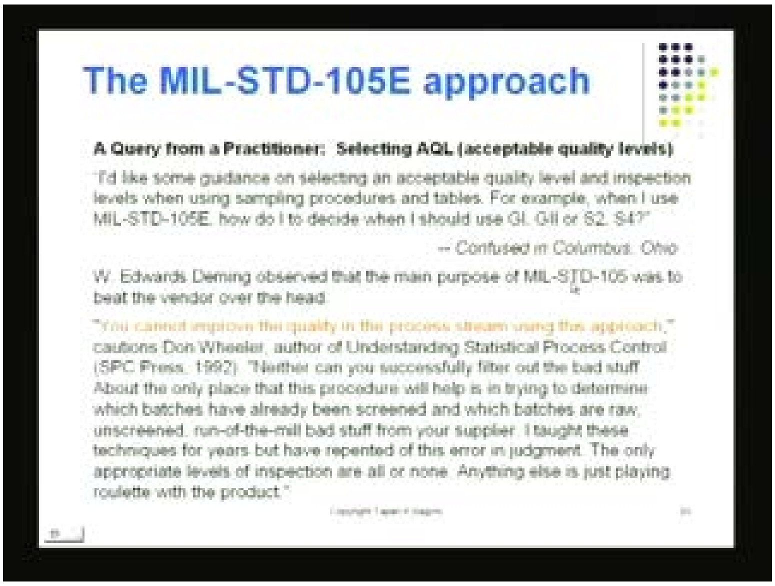
And once I have the n c plan, I have this one and I have this one, my sampling plan is completely designed so it is like a great way to get your quick and dirty plan, this nomogram is called the Larson nomogram. It is the Larson nomogram, it is a pretty famous nomogram and this gives you the exact design of the single sampling plan. No such easy method is available for the double sampling plan or the sequential sampling plan. Generally, speaking there you have to look up some tables or you may have to actually use a computer. And calculate all the OC curves and everything else those you should be able to do, once you have written your software routines and so on so forth that you should be able to do. Well this nomogram shown here is the exact method for designing what we call the single sampling plan the SSP.

(Refer Slide Time: 16:21)



Let us look at some other procedures also, we go back to the screen here. This is exactly the same thing that I showed you earlier, I gave you another example and here again. They have done, they have designed an OC plan and in that red circle there notice the red circle there. They show you how to do the manipulation, how to draw up the alpha, beta AQL RQL and so on so forth and they show right there. So, that is just a illustration of what we done before.

(Refer Slide Time: 16:45)

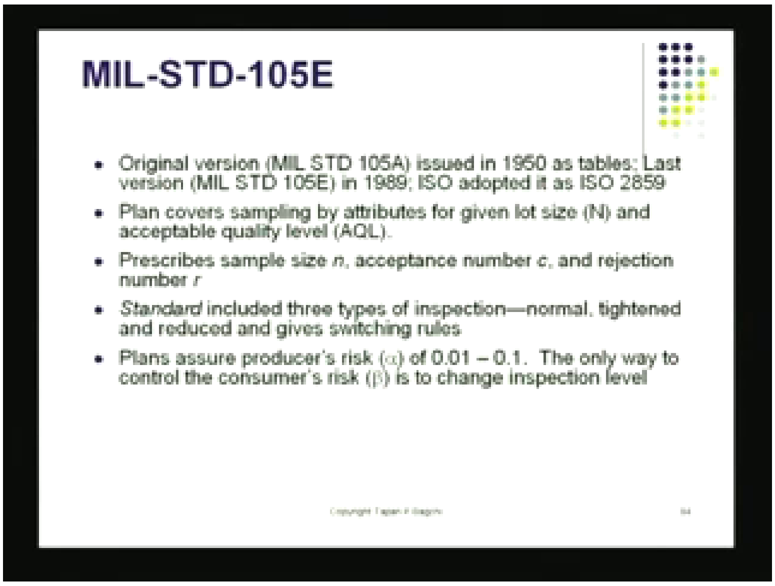


Now here is another approach, the military of course, I do not know really I do not know if the military ends up with a curve like this. I do not know they might be doing it for you know projectile estimation stuff like that, they might be doing that or they might be doing it. Inside an airplane they might be using some nomograms for navigation stuff like that those they might be doing target setting and so on. But, as far as a device like this is concerned, this is best used in the office, it cannot be used really out in the field somewhere. Where there is a there are trucks arriving and with boots and bullets and everything else. And there you got to do some quick sampling to accept or reject what has been received there.

So what you would like to do is? You would like to have a quick and dirty way to come up with a sampling plan. And that is done by ML-STD-1O5E this is a standard method that is been around for almost like 60 years now or even more than 60 years. This was designed by experts at the Columbia university and there were some resistance of course. And people have spoken up against this, they have said that the movement you are going the acceptance sampling route, you are throwing away your idea of your philosophy of 0 defect and so on so forth. Which is actually true, but in it turns out in many cases defect levels have, not yet come down to the level of six sigma, they have not yet come down to the level of you. Know few fractions in a thousand or million or something like that they have not reached that level.

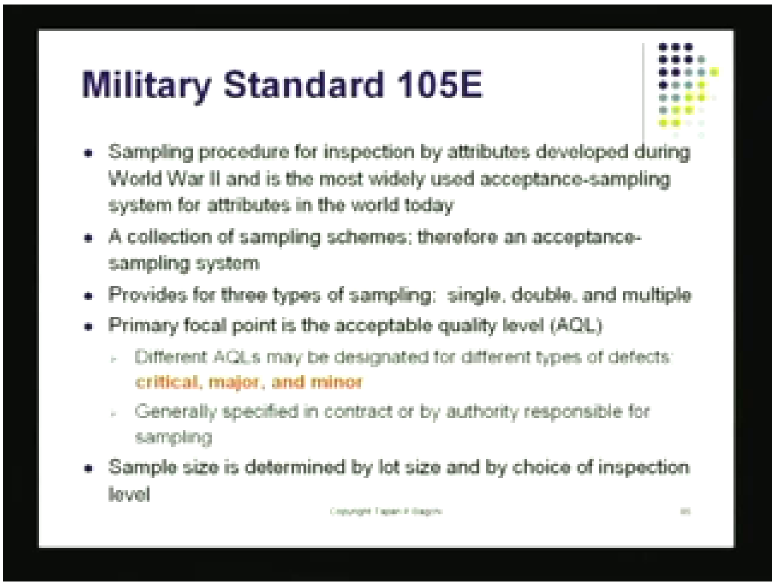
Defect I will (( )) you at percent level, we find many many parts and items which are still at that level there, which is like c p or c p k less than one. Which we will discuss in another session, that is like something where six sigma is trying to go, , but because not many people are at the six sigma level. People are saying we got to have some method that we can use here and now today with the kind of supplier that we have. Our suppliers are not at six sigma level so we need some method and one such method is this, the MIL-STD-1O5E approach.

(Refer Slide Time: 18:47)



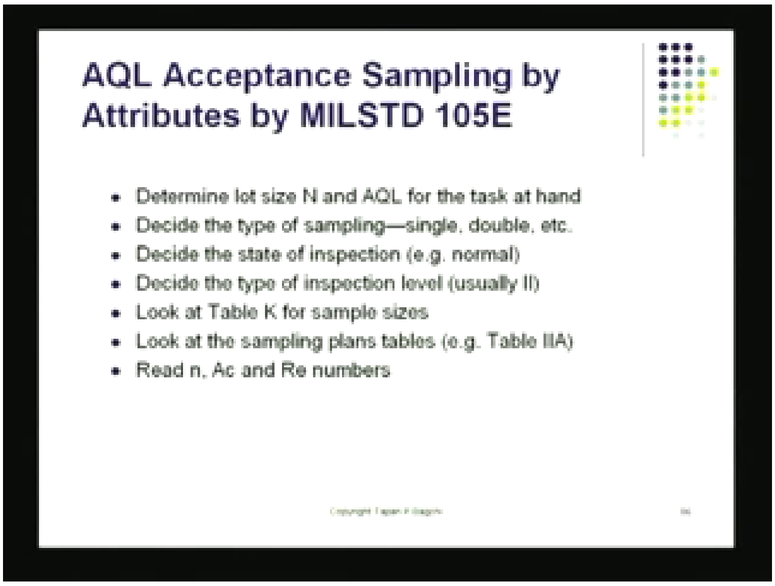
Let us see how it actually works? There is a bit of history, it came from world war 2, came around, it was built around world war 2.

(Refer Slide Time: 18:55)



And these are standard methods and they are a bit of a cook book type. They say you find this plug in here, look up some number there, then again move up to another table, look up something there, and you keep doing these things you will end up with n c plan. Eventually, the goal is still to get the n c number that we found using our, you know friendy nomogram. We could do this without too much trouble at all , but the same thing is done now using some tables. And let us see how they do it?

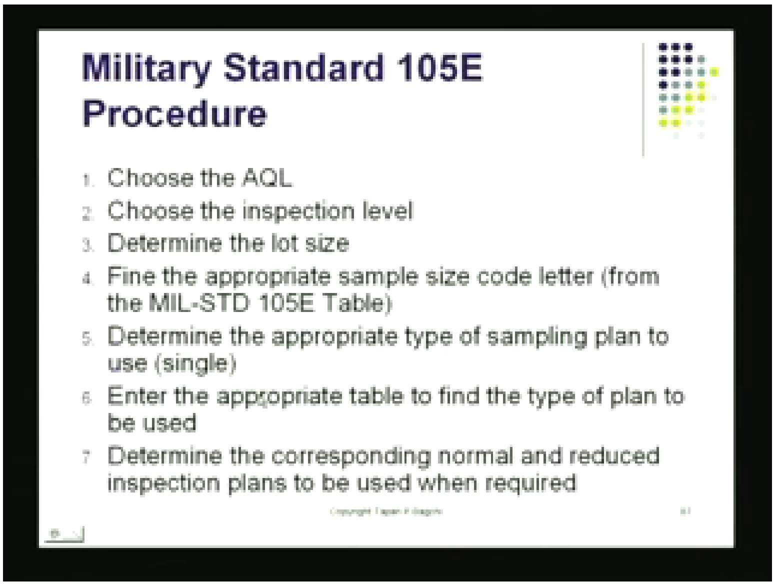
(Refer Slide Time: 19:24)



So, take a look at the process, the process is this determine the lot size, determine what lot size, what is the size of the truck that you have received, so, what is the size of the truck? Once you know the size of that, you ask him how many items have he brought? He says I have got two thousand items there. Now, you have got to come up with your plan to be able to do that. So, the first thing is determine your lot size and what AQL would you like to operate with? You ask these two questions of course, you ask the users for this, you ask the supplier for n, you ask the user for AQL.

Then you try to decide which kind plan I am going to use, it is going to be single sampling, double sampling or what. What state of inspection would you like to be using? Would it be a very stringent or would it be normal inspection or will it be relax inspection, what would it be like? Then you follow through a certain procedure, you look up something called the table k, then you go out to some other table and so on and so forth and then you read of the numbers of n and c and so on and so forth.

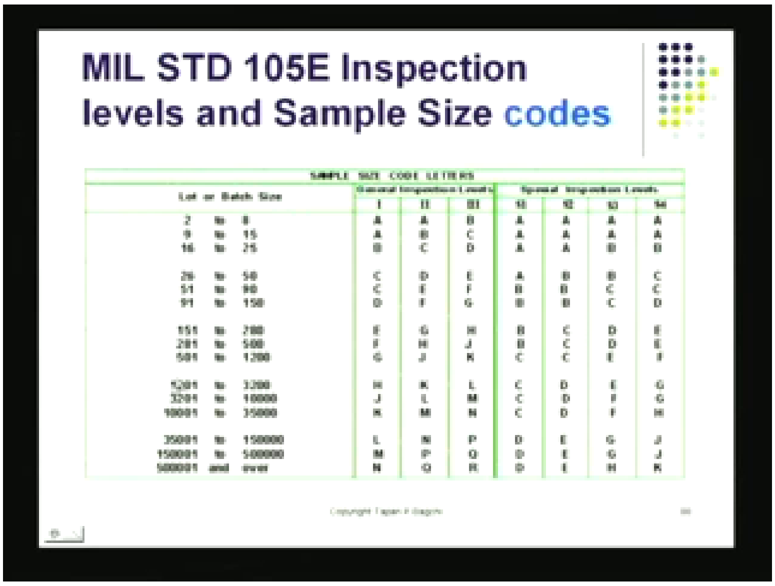
(Refer Slide Time: 20:28)



Let us see let us try to walk this walk this path, choose the AQL and determining AQL of course, depends on the use that you have. Now, the if you look at quality if there is a certain part there you can you can probably tolerate a few percent defectives. You might just say well as far as pens are concerned probably 5 percent defectives are ok in the lot. But, as far as may be the scales are concerned not more than one percent should be defective. And as far as this mouse is concerned probably not more than 1 in 10,000 should be defective.

So, you determine your AQL level by looking at basically what you would like to do be able to do? Once you have done that you have got at least one item taking care of which is like your AQL. After you chosen AQL, decide on inspection level, there are certain procedures given for it. Then you determine lot size, lot size is found by finding the size of the truck or how many items it is carrying. Then you would like to go to what we call the mil tables and one of the mil tables is going to be the MIL-STD-1O5E table, it is a standard table that is given to us. You decide on the kind of sampling you would like to use, single sampling this is what we would be using there. And when you find the appropriate table that will be to used now. And in conjunction with the single sampling decision that you have made, then you go out and work out the procedures.

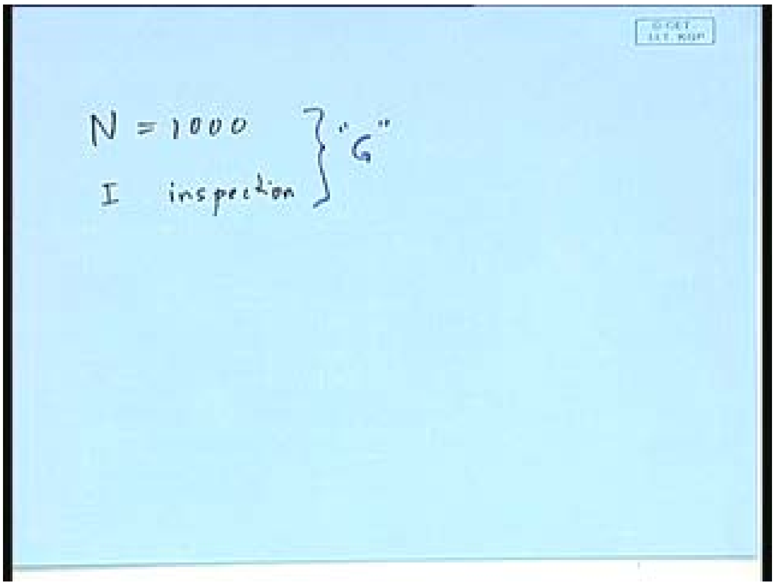
(Refer Slide Time: 21:53)



SAMPLE SIZE CODE LETTERS	General Inspection Levels			Special Inspection Levels			
Lot or Batch Size	I	II	III	S1	S2	S3	S4
2 to 8	A	A	B	A	A	A	A
9 to 15	A	B	C	A	A	A	A
16 to 25	B	C	D	A	A	B	B
26 to 50	C	D	E	A	B	B	C
51 to 90	C	E	F	B	B	C	C
91 to 150	D	F	G	B	B	C	D
151 to 280	E	G	H	B	C	D	E
281 to 500	F	H	J	B	C	D	E
501 to 1200	G	J	K	C	C	E	F
1201 to 3200	H	K	L	C	D	E	G
3201 to 10000	J	L	M	C	D	F	G
10001 to 35000	K	M	N	C	D	F	H
35001 to 150000	L	N	P	D	E	G	J
150001 to 500000	M	P	Q	D	E	G	J
500001 and over	N	Q	R	D	E	H	K

Let us take a look at some of these sample size codes. Let us say my lot size was 1,000 so I am just going to be writing some numbers here lot size was 1,000, n equal to 1000 that is given to me. And of course, you then ask me to decide on inspection level. So, inspection level, what a inspection level? Let us take the easiest one we will say, we will be using a general inspection level category one so, category one inspection.

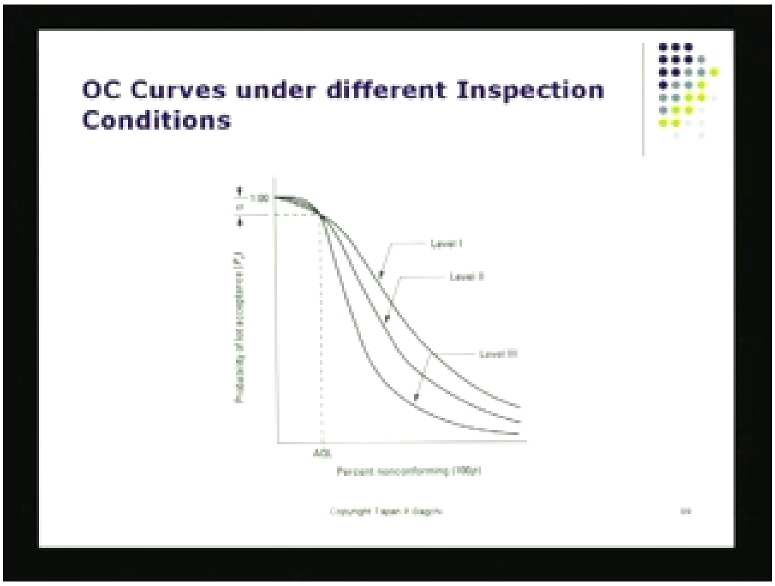
(Refer Slide Time: 22:24)



Just for illustration so, I will be using inspection 1, this is what we would be doing. So, you got 1,000 there, I there and if I do that, I and if I take this plan, if I take this plan

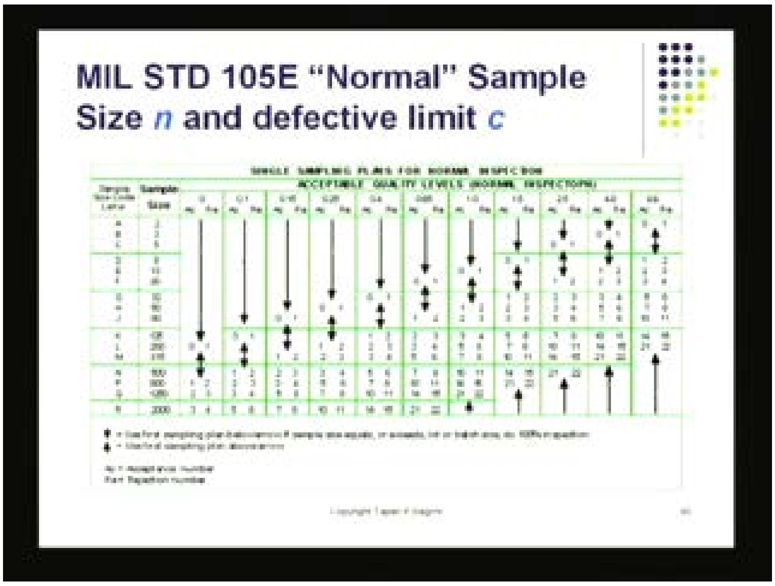
1,000 will fall in this range there and general inspection will give me a code G. So, these two things together they give me a letter called G, G is a letter that I end up with. This G is to be used subsequently; G is to be used in another table. So, what I do is? I have got this G there.

(Refer Slide Time: 23:06)



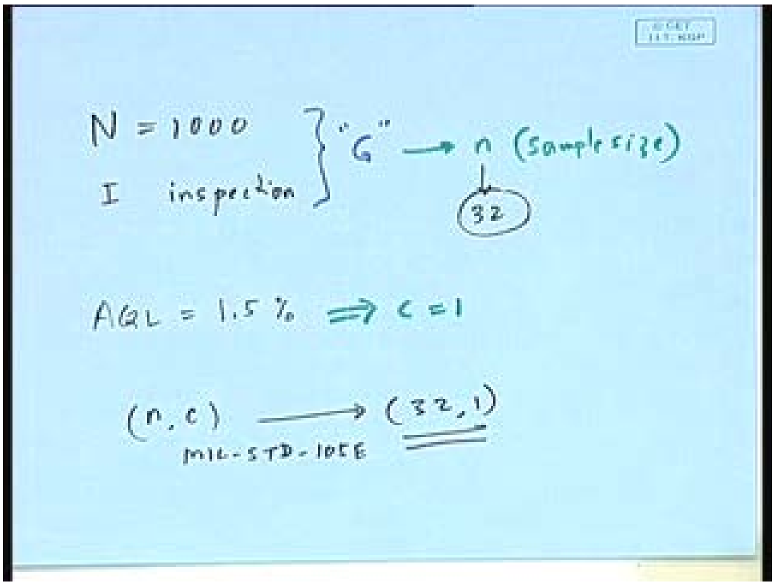
And then I go on and I have already decide about the inspection level. So, there we are at level one that we have decided already.

(Refer Slide Time: 23:12)



Then we have to really see what we could do with our G? Remember G is now going to be giving me an idea of sample size. So, G will lead to n, G will lead to sample size n, G will lead to sample size. And how is this to be done? You go to the normal sample size and you go to the mil table normal sample size. And there, what you find? You have got G there, it is got a sample size of 32.

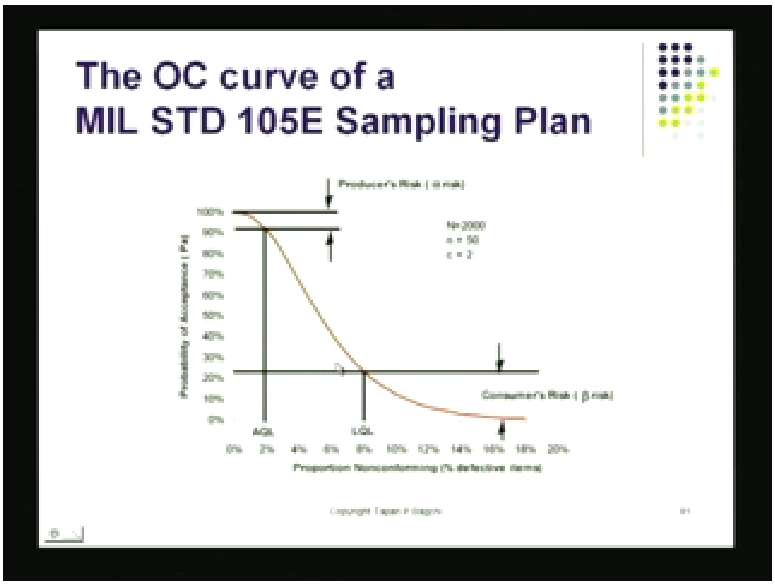
(Refer Slide Time: 24:03)



So right away, I get my sample size n to be equal to 32. 32 is 1 number that I found in my, for my single sampling plan. Then what I do now I ask the question, what about AQL, what AQL are we talking about? And let us take an AQL; I am going to just pretend that I am going to be taking an AQL of 1.5 percent. Let us decide AQL requirement to be 1.5 percent, let us say this is our requirement. What I then do is? I locate 1.5 percent on AQL, I locate that on the columns, in the columns I locate my 1.5. And from this G I draw a straight line there and I come down to this and I end up with 2 numbers there one is one, number 1, and the other is two.

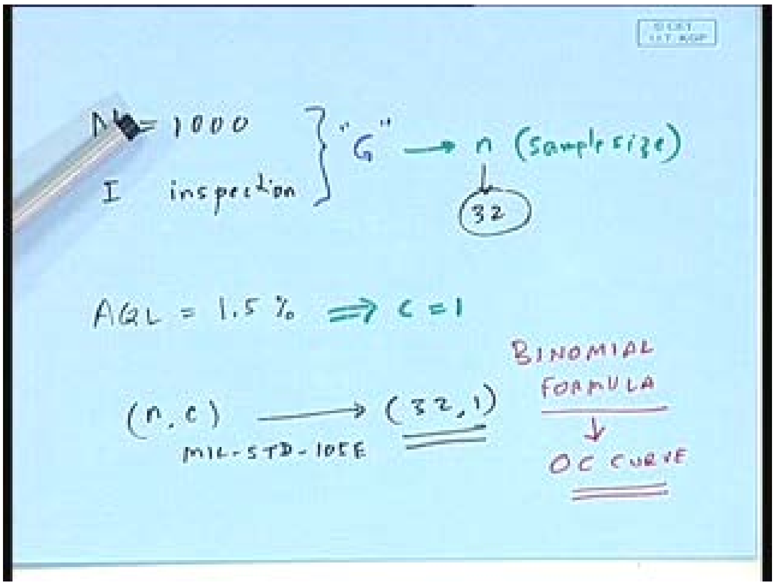
No here it turns out, this gives me c equal to one because, that is the acceptance quality number, number here acceptance level. These many defects I can allow in 32 items, out of 32 items I will allow at most one defect to remain. 0 or one would pass the lot, 2 or more out of 32 defectives, 2 or more defectives out of 32 would fail the lot that means I will have to return the lot. So, now I have got a plan completely with me and the n c plan by mil STD 1O5E turns out to be 32 comma 1 that is my, this is my final plan, that is my single sampling plan. And you could see how easy it is. All I did was, I went through a couple of tables and I was able to get to this final table and here I was able to get my n and c, very very easy.

(Refer Slide Time: 26:16)



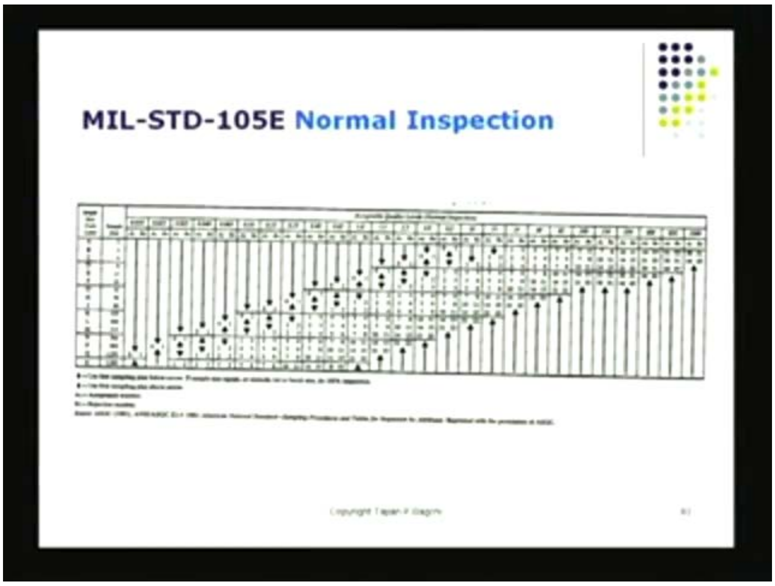
And of course, I can if I wish I could use the old nomogram or some other calculation. If this is a finite lot, I will have to use probably the hyper geometric formula. But, if you assume this to be quite large as compared to the, to my sample size here I could assume this to be more or less infinity. Therefore, the formula that I could use here would be the binomial formula.

(Refer Slide Time: 26:44)



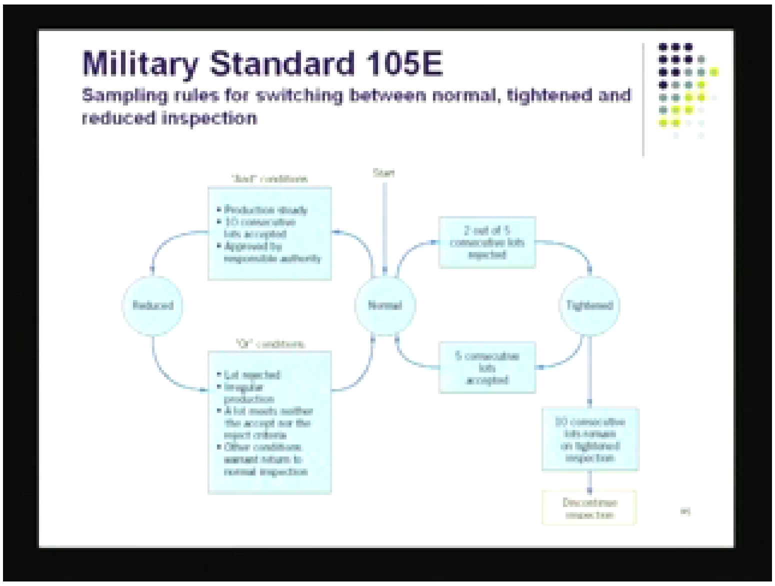
And I could, once the binomial formula could be used (No audio from 26:43 to 26:51) I could this use this to construct the OC curve. Why do I need the OC curve? Because, I would like to get some feel, if this plan is going to be sufficiently discriminating for me to tell between good and bad.

(Refer Slide Time: 27:11)



Now, let us review a couple of things here, then there is the there is something called the normal inspection plan. Then there is the reduced inspection plan those tables are there and if you wish you could do that.

(Refer Slide Time: 27:21)



And there are some switching rules also depending on the quality of supply that you are getting, there are some switching rules also. And I will leave this on the screen for you as I do my talking here so keep that in front of you all do some talking to you. There are certain things which are actually not possible to do with the mil STD plan. One of which is let us say you go some beta that you would like to impose. Beta, what is beta? Beta is a risk, beta is the risk of the user. The consumer ending up with lots which are at RQL level.

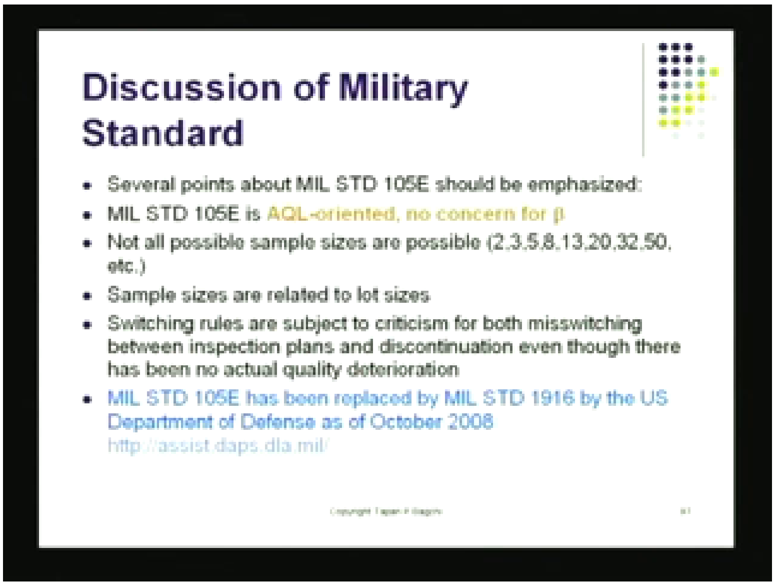
Notice here all we did, all we did was we looked at lot size, if you go back to the diagram here, we looked at lot size inspection level AQL that is all nothing else I used and I ended up with my n c. What about beta, what about the risk to the producer, what about the risk to the consumer? None of those things are really quantified here. For that you have to construct, go to the binomial distribution, work out the formulas and so on, so forth. We will have to do it so, the mil STD plan does not actually tell you the exact risk; it does not tell you that.

But, by doing the switching, they have a switching method here, by which what they try to do is if are receiving bad lots one after the other. Then what it does is? It tries to protect you by making your sample size, larger. Which is like increase n or reduce c both of which are then going affect your alpha and beta? If you increase n, your curve is going to come down sharply, if you reduce your c again the curve is going to go down very sharply. And therefore, what you are doing is? You are trying to move toward, gradually toward that ideal curve.

The ideal curve comes right down then it goes flat like that this is what you would like be able to do now. It does not do that in any scientific or quantitative way, it does not do that. It basically gives you the switching plans, which is what I have got on the screen here. These switching plans will generally give you deductional support to reduce your alpha and to reduce your beta. But, the mil STD plan directly by itself it does not give you any indication at all as to what sort of risk you are exposing yourself to that is very unfortunate.

There are people of course, who have used these mil plans and they have worked out those things. And you got parkers for the mil plan and you got of other things for the mil plan, you got the OC curves plotted for the mil plan. But, these have been done afterwards in the original mil plan, these are not there.

(Refer Slide Time: 30:02)



Mil plans by the way they have gone through some revisions and it turns out in the latest version. In October 2008, look at this last blue line here, the mil STD 1O5E has been replaced by mil STD 1960 by the us department of defense as of October 2008. And I have given you a particular thing and I do not want to click here because, I am not really sure, if the network is connected. If the network were connected we possibly could see what all plans they bring out. And they give you completely different set of instructions and so on and so forth.

Now, if you were to choose what would you do? If you are in a factory and if you do not have access to engineers, if you do not have access to good nice statistical hand books and so on, so forth, if you do not have a book on quality control and so on. In that case it might be easier for you to find either they aware of Indian standard plan or a mil STD plan and use that plan to come up with your n c b e r schemes.

It is also possible that you would in this case if there is a large amount of production to be affected by poor quality parts. What you would like to do is? You would like to put some effort and understand this sort of stuff and you try to come up with basically. What you would like to be able to do is? You would try to come up with an exact plan. So, the OC curve is known and the protection is more everything else is known, this is the exact way to do your job your sampling plan design. Couple of other things are also important, it is very important for us to realize. It is very very important for us to realize that AQL RQL these are quantities that should not be determinant arbitrarily, they should not be found arbitrarily.

For example, AQL is the level at which your factory can operate comfortably. And depending on your own effort in quality assurance and quality management and so on you might like to reduce that AQL very close to 0. For example, suppose you are doing j i t. If you are doing j i t then input to your system should be perfect and there is no question of using sampling, if you are doing j i t absolutely no question of using sampling. Because, sampling will allow a few defective items to go in because, you are not doing a 100 percent inspection. The only way you can do that, if you do 100 percent inspection of the lots that have arrived and then you release them one after the other on your j i t line, , but there in you are not really doing j i t.

You are really doing a lot of work that should have been done by doing much better process control; this is something you got to remember. Same thing goes for RQL, RQL also has to be lated to the cost of production stoppage because, RQL kind of assumes if a few defectives came along and suppose these were the pens. These were the pens that we purchased from a market and who did we supply these pens to? We gave them to a drafting class and they had a test and they were using the same pens. And suppose these pens were at a high level of defects, suppose the 10 percent were defective that means every tenth pen had some defect or what about that tenth by who ends up with that tenth pen there and he is not able do to his job?

He is going to suffer as far as his grades are concerned, the exam is going to be incomplete and everything has. And think of the same thing happening in a factory. Suppose, a defective part gets into a machine it stops the machine, you got to dismantle the whole thing, you have to take it all apart and so on and so forth perhaps it has broken a few things and so on and so forth. So, if you got defective parts coming in and messing up your system you better make sure nothing of that sort comes in. How do you justify that, how do you ask for a higher quality? You work out in economics, you work out the down time caused by a change that is required because a defective item came in.

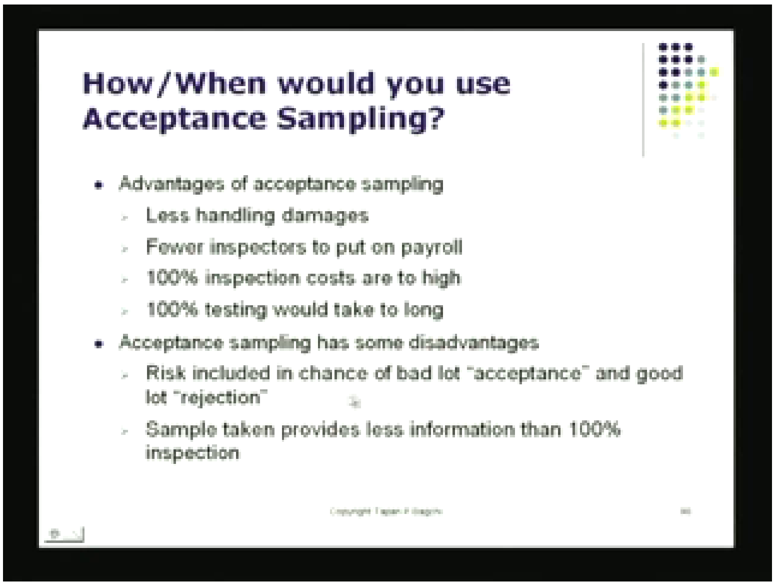
A defective item got into your system and that impacted your production system and it caused some major you know disaster. And there it stopped the machine broken tool or did something like that and it just caused down time and this has happened so much. When I worked in a factory there were so many occasions, I was in a, I at 1 point I was operating a can filling machine and this cans, you know the cans were lot like this bottles there and those cans they were made of cardboard. And sometimes the crimping that is done to make sure that the seal is there, that seal was not very good and cans after they were filled they started leaking.

And this would happen probably once in 200 or 300 , but every time one of those cans got stuck in the machine, there was oil all over the place and we had to stop, we had to clean up and so on and so forth. We would rather pay double the price for the cans just to make sure we got good seals around in the bottom. Now, this is a kind of economics you have to work out. And you should do it well ahead of time and you should sit with the supplier and make sure he understands your cause. Just as he is interested in not being returned, you know the good lots should not being returned back to him that is like something that he should know. But, he should also understand that we it is not just that the pen is defective so I throw a pen I pick up another pen.

What about the consequence of some kid who is not able to write his exam? Because, the pen is defective or he ends up getting a bad you know bad, he ends up with bad grades.

Because, the pen smurged or the ink ran or did something very funny and that is not really going to be funny for him as far as his performance is concerned.

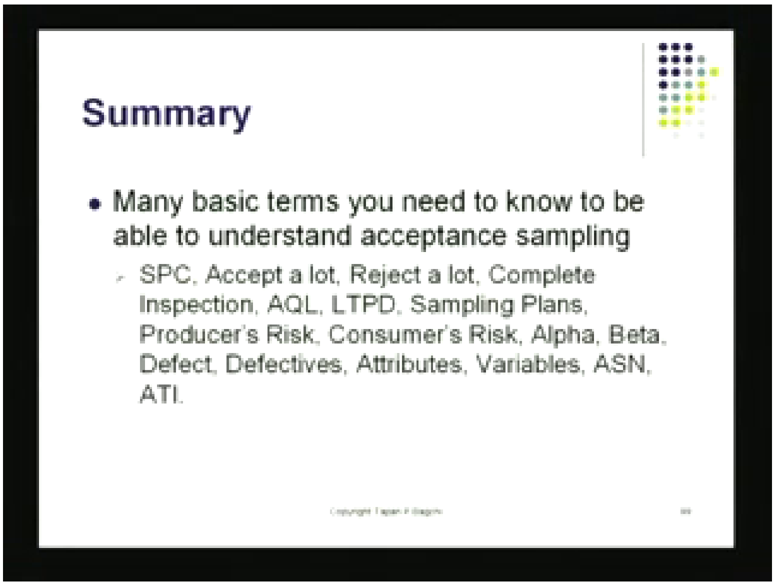
(Refer Slide Time: 35:38)



When would you use acceptance sampling? There are certain occasions when you got to do this. When you do auditing for example, you might do some sampling there or when 100 percent inspection is too high you might like to do some sampling there. Those are like occasions you would like to do this 100 percent inspection may also take a long time that you would like to avoid. Of course, when you do acceptance sampling you are exposing yourself to certain types of risks.

So, you remember the moment you step into the world of acceptance sampling your alpha and beta are both going to be greater than 0, they are not going to be 0. Therefore, you will end up with a few bad parts in your system as a user or you will end up returning some good lots back to the supplier. Because, again you are not doing 100 percent inspection and a few bad parts may affect the results one way or the other because this is statistical sampling.

(Refer Slide Time: 36:31)



So, what is the summary of all this? Let us take a look at let us take a quick look at some of these terms. Many basic terms that you need to know before you go into this SPC is statistical process control. Which means control of the real process that is producing these parts? So, I am pretty sure hopefully the machines for producing these pens are so good that they do not have to do basically what we call SPC. We will look at SPC in another session , but SPC is something that is really not required when you are doing routine mass production. In today's day and age, SPC should not really be a concern your c p k should be 1.6 or 2 or somewhere there.

If it is there, of course, then you are a reliable supplier. That is like something where you know there is a shift taking place industry wide, there is a shift taking place. Remember that path that I showed you we are on a uphill climb, we are climbing up and up and up. We did everything based on inspection, which is what acceptance sampling does. Then we did process control we did SPC, then we would do D O E design of experiment, then we would do Taguchi methods, then we would bring in t q m, then we bring in six sigma and so on so forth. And the march is on and on and it this will keep going till we reach perfection, till we reach complete satisfaction it will be there.

There were certain reasons when we would accept the lots. There were certain reasons when we would reject the lot these conditions were given in the acceptance sampling plan as that little letter c, c was the control quantity. Complete inspection could be justified if the item was such that the defect could be critical, it could cause loss of property or loss of a life. For example, you would like to do 100 percent inspection there. AQL is the average quality level that you would like to live with that you could live with quite easily. LTPD is lot tolerance percent defective this is the same as RQL. This is something even if one lot of this kind gets into a shop, it is like hawk, it is like nightmare.

Various types sampling plans are available and you know certainly you got sample plans we are talking about. You got the double sampling plan, you got the single sampling plan, you got the sequential sampling plan and there are many other plans that we have not discussed. There of course, are the Dorgen roaming plan and the whole set of variable sampling plan they are also there. These are methods that can be picked up very easily if you got a book on statistics or statistical process control they will tell you about all these plans.

You have just got a window open for you, now this window of some sampling has been opened for you. Now, what you have to do is? Get deeper into this, pickup the basics, the basics you get from these lectures there. Then you get in there and you try sort of see do I understand it all, can I apply it, can I design a sampling plan. For example, you must try. I am certainly not kidding; you must try to see if you could given AQL RQL and basically your alpha beta. Can I come up with my n c, can I come up with that sort of plan that could be a big you know booster as far as your conference goes. So, you have got then producers risk, we have got consumers risk, we have got alpha beta, these are the probabilities and all that.

Now, the difference between defect and defectives, a defect is something which is which happens in a product, a defect is there for example. If the clip does not close properly, see if I put into my pocket for example, suppose the pen goes flying that means there is a defect in the clip or suppose the cap falls off I have the thing in my pocket and somehow I was running around bouncing and so on. And the pen fell off somewhere that also is not such a good it is a defect in the design. And there are could be other defects, it could be for example, the tip could be defective. Now, defective is something that has got the property, that is a some quality criterion, it is not being met then it is said defective item. An item is defective and what it has is a defect that is what it does.

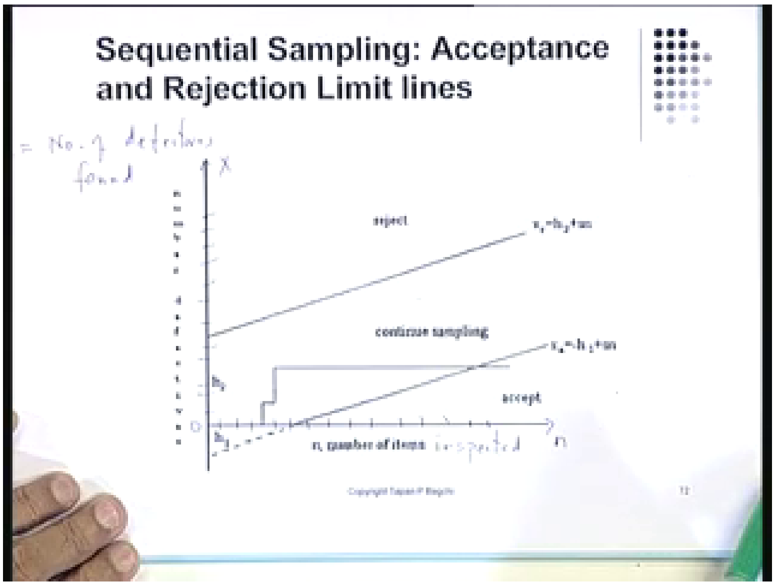
Then you got something called attributes. Attributes have those quality characteristics that I can categorize between good and bad that is like something I could do quite easily. And I generally use a go, no go test for doing that. Now, in mechanical objects when I have got mechanical objects there is usually something like a horseshoe. And you bring in your item and you try to see does it fit in or does it not fit into that finger.

If it does not fit in it is a no go and if it goes in then it is there and there could be multiple set of these go no goal gauges. That eventually determine whether this is acceptable or not that is one way. The other way to do is to apply some sort of a gauge, you take some gauge and you try to measure the item against that gauge and you try to measure it is length or diameter or whatever it is. So, there I am doing variables measurement that is like another way I could just quality, I could assess quality and that could be another way to try to come up with the sampling plan. There are sampling plans that are based on variables measurement those are also there.

We have then of course, something called the average sampling number, it turns out that the single sampling plan requires you on the average to take the largest number of items to sample. Whereas, if you look at the sequential sampling plan it takes this smallest number of items that you require on the average to sentence the lot that has arrived. But, there are some issues here, one issue is this that the sequential sampling plan is a little difficult to explain to somebody else.

And remember those curves that I showed you, I showed you a couple of curves going you know from one end to the other, I showed you curves those curves. I believe, I can find those curves for your again just one second, I will find those curves for you. And it is important for us to realize that there are many instances when those curves become very very handy for us. And they can help us stop the process of inspection very very quickly, one curve is right here.

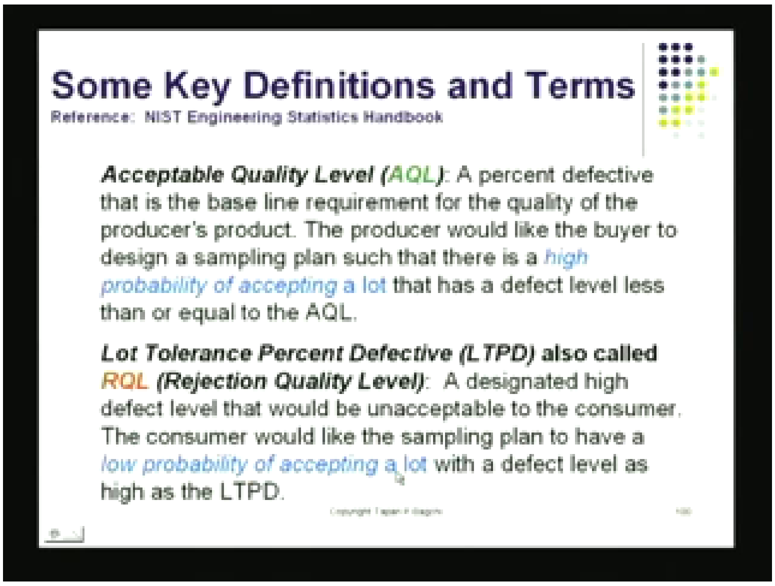
(Refer Slide Time: 42:46)



It is important for us to realize these are decision curves and I may start my sampling. With my single sampling plan what will I do? I will right away take like these many items and I will take may be, like I said in that case we ended up with 80- 90 items there somewhere. And that is a very large number item to sample all at once and before unless you inspect them all you cannot really make a decision. Whereas in the sequential sampling plan you can sample one item at a time. And then if you hit this line you accept the lot or if you end up going this way you reject the lot.

And the chances are almost 0, this is there is a theoretical result that shows that chance is almost 0 that you will end up going this way and never really end going this way. This is a small chance of doing that , but that probability is almost 0. So, it is very important for us to realize that the sequential sampling plan is going to give you the smallest number of items to sample, that is something. That is also important for us to realize when I am selecting between good and bad and so on, so forth. Then of course, we have got the average total number inspected.

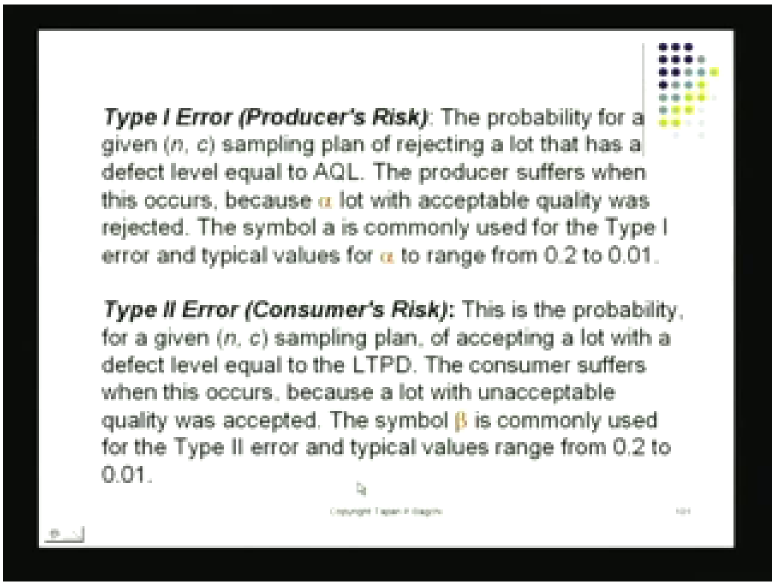
(Refer Slide Time: 43:54)



What I have done is? I have attached to this, I have attached a couple of other sheets which really define this concept of AQL. A percent defective that is the baseline requirement for the quality of the product or the producers product. The producers would like the buyer to design the buyer is now the consumer. The producer who is the who is supplying the parts or the or the pens and so on and so forth. He would like the buyer to design a sampling plan such that there is a high probability of accepting a lot which is coming in at AQL level. Because, there really is no reason for us to reject a lot which is already at AQL level now, this is, this being high means alpha should be low.

On the other hand, I have got this quantity called RQL lot tolerance percent defective, this is the rejection quality level. And this is of concern to the user to the buyer this is of high concern to the buyer. And of course, the buyer would like to make sure that there is a very low probability of accepting a lot which is at RQL level that means here beta should be low. This is also a something that we should try to remember.

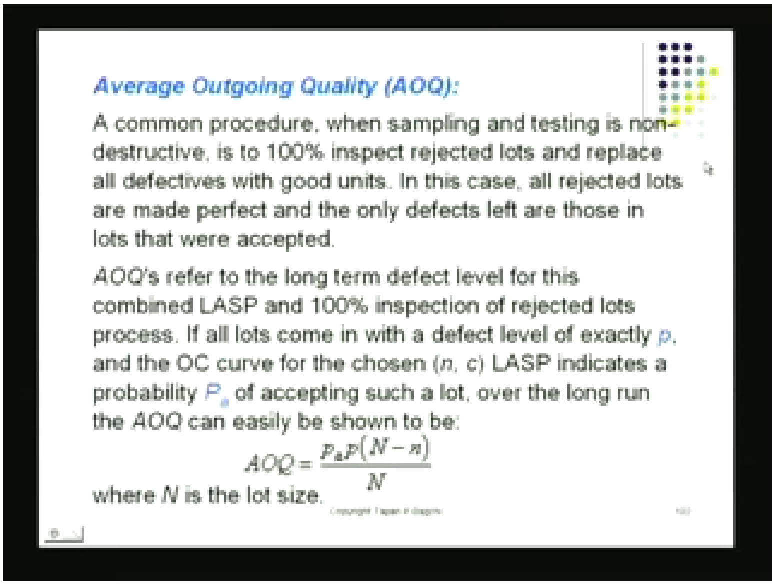
(Refer Slide Time: 45:03)



There are two risks involved, these are the two likelihoods therefore, there are two risks involved. One of which is called the alpha risk, which is the type one error or the producer's risk. What is this risk? The producer may actually have a lot that is otherwise fine it is actually at AQL level , but it is turned down, it is rejected by the sampling plan. Because, again sampling is not , but the moment you using sampling and knowing you are not doing a 100 percent inspection. Therefore that is something that we would like to make sure we do not turned into too off. Then of course, we have got something called type two error which is actually is the consumer's risk.

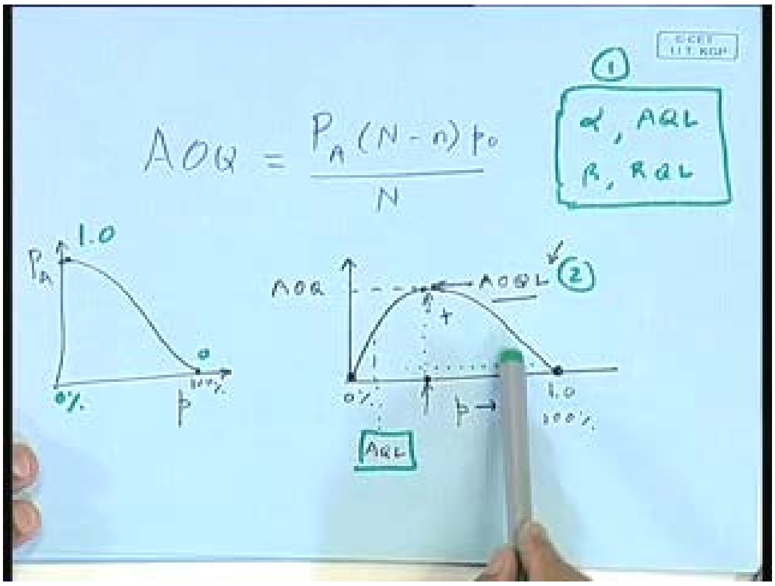
This is now the buyer or the user, his risk is that he should have almost no lots got into his shop that is at RQL level or the LTPD level. Therefore, he would like to have that beta to be as small as possible. A sampling plan is very powerful when it is able to reject most of the lots that are somewhat away from AQL so it approaches the ideal curve. In fact the effort should be by increasing your n or by reducing c. The effort should be, you should try to approach as closely as you can the ideal curve. If I can approach the ideal OC curve you are doing the best that is possible.

(Refer Slide Time: 46:29)



The average outgoing quality like I have mentioned to you it is very important for us to realize that there is something called the average outgoing quality.

(Refer Slide Time: 46:38)

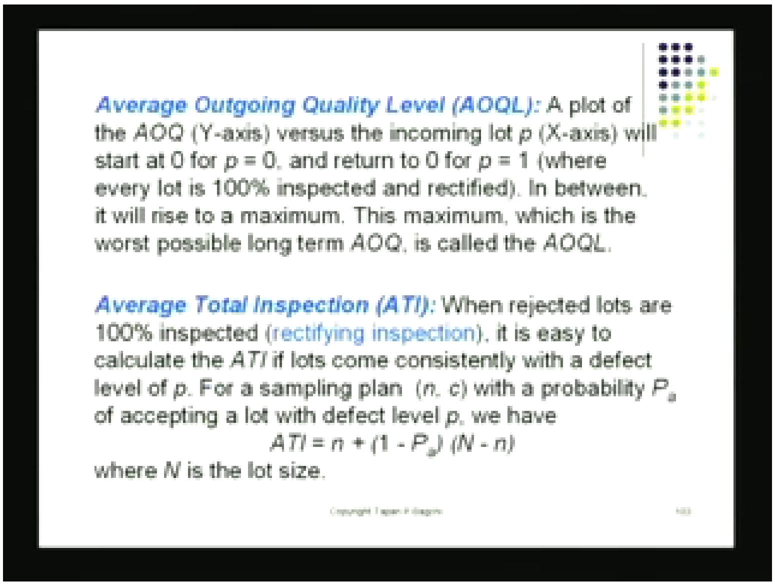


And looked at this thing, no matter of what sampling plan you are using. Your P A is going to be pretty high when your quality level is pretty good. So, if you got 0 percent defective your P A should be pretty close to 1. This is near 1.0 and your P A should be very close to 0 when your defect levels are really really high. If you use this principle and if you work out this is the expression for AOQ. AOQ is coming out of your rectified inspection. When you look at rejected lots, , but you what you basically do is? You remove all the defects from the rejected lots and then you pass the lots.

If you are doing that you are AQL curve is going to look like this. And there is going to be a certain point somewhat mid way where there is going to be a the worst level of quality that this sampling plan will basically try to pass on the average.This again is on the average not for a specific application of the application of the sampling plan. No not for that, , but you apply the same sampling plan same n c number again and again to the various different trucks that are arriving, various different lots that are arriving. You will end up with an average worst level and many times customers could not like to tell you about the AQL, RQL and so on.

They would just say well there is a number I do not want to exceed that number. I do not want the incoming lot quality to be worse than this. There of course, you will be using this plan there and there are sampling plans that are based on this. This can be estimated quite easily from this and this is what is shown here when we do the basically when we work out the details of the plan. We should work out this AOQ if possible we should also try to work out the AOQL.

(Refer Slide Time: 48:31)



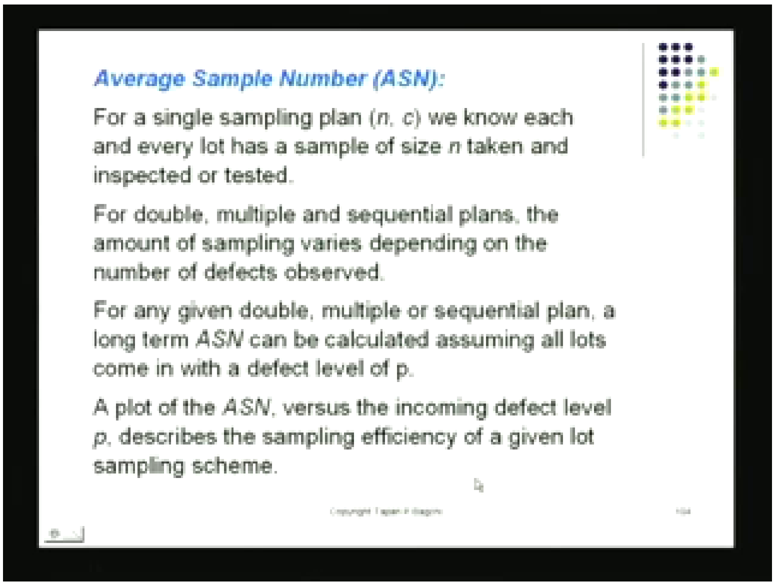
And that AOQL that actually is a pretty decent indication of how good or bad you are your plan is? Now, good or bad is in the sense of discriminating or being able to act as a screen. What also is a concern many times is the amount of inspection. You have to do to keep the your inspection system going and that gets in into something that we call the average total inspection. The ATI number, the ATI number basically is the total amount I afford that you to put in into what we call the inspection effort.

Now, remember if you look at the number of items that we have to inspect we obviously have to inspect the sample. The sample that I picked, if I picked a sample of 3 or 4 items or 10 items, 20 items. I have to inspect them all without that I cannot find d and I cannot compare that to c. n and c are the two parameters of the single sampling plan. Unless I know c, I really cannot do anything. I cannot really decide on the fate of that lot there and c by itself is not good enough I need to know d and I compare d to c. Once I do that and that actually means I must inspect everything that is there in the sample. All the items in the sample that means I must be at least inspecting the little n items and that is what I inspect right there.

So, if you look at the average total number inspected. This n is always there when you got the rectifying inspection which means the lots of the rejected. 1 minus P a fraction of the lots could be rejected. Their size is n this n has been inspected 100 percent. So, I subtract that from this and I multiply this. This is the average number of items that I need to inspect in an overall basis. Now, what is this a function of? It is a function of P a, n is fixed, big n is fixed this is fixed.

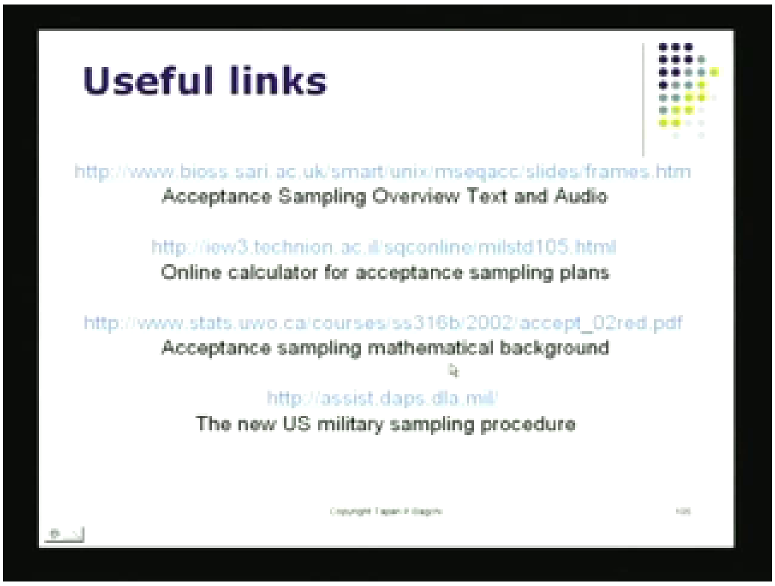
But, this P a depends on p is your lot quality. p is your quality of the input material. So, little p determines P a and therefore, ATI is also dependant on P a. So, it is not really to that this ATI will remain a constant number as you apply in sampling plan. It turns out if you are generally speaking, if your lots arrive at reasonably good quality a ATI number would not be very high. And this is something you have got to keep in mind. You have got to make sure that we bring my P a as close to 1 as possible. That means that will happen only if my little p which is lot quality of the input is as close to 0 as possible. Lot quality is as close to be perfect as possible that which is p value should be very close to 0. If that is there of course, I will end up with this small value of ATI which is good for me.

(Refer Slide Time: 51:28)



Then of course, I have got something called the average sampling number and as I mentioned to you deduction is peaking. Single sampling plans they require the largest number of samples. Largest number of items in a sample then of course, double sequential sampling plans will give you the smallest number of samples that is there. And then of course, I have got double sampling, multiple sampling or sequential so, there are choices available beyond my single sampling plan to be able to do this.

(Refer Slide Time: 52:04)



And depending on economics and the complexity with the help of which you would like to implement your sampling plan. You would probably use either the single sampling plan or the double sampling plan or the sequential sampling plan or perhaps some other plan for example, the mil STD1O5E. I have given you some links here and feel free to go in there and check out any of these things, I cannot really remember if all of them are active today. And let me just do one thing, I just clicked somewhere and I am not sure if the network is connected and it looks like the network is not connected. And with that I may be able to bring out one on to your applications which I dependant on this. They will take you to the point; no it is not connected right now.

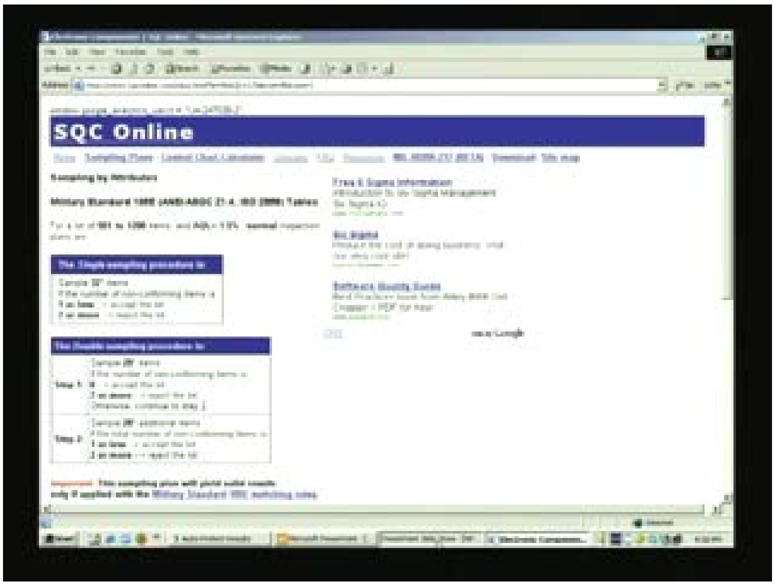
(Refer Slide Time: 52:56)

So, that is little unfortunate if you if it could be done let us see if we could still do something. I got some calculator on and let us just go on for a minute, I have what they have done is they have converted the old sampling plan to a mil plan. And they have shown these things and no they do not really show , but it is possible it is possible that you are able to utilize one of these plans here.

(Refer Slide Time: 53:28)

If I go in there, if I click there then it gets you batch size, give in my batch size and batch size in our case was remember 1,000 and AQL we took 1.5 and type of inspection was normal a level inspection was one let us try to make it one and normal inspection and let us submit. Let us see what results we get?

(Refer Slide Time: 53:54)



We got 32; you remember we somewhere we used 32 as our number there and let me just see if I could find that. So this is going to be a confirmation of what we are doing that is not so bad that is pretty good actually. That we ended up with, I have a feeling it was 32 when we used it and 32 is the number there and it turns out one is the one or less except the lot so, n is 32 and that is 0. This has come by the way from an online help and that came basically from what we had there. We had this power point there and all I did was clicked that number there clicked that U R L there.

So, kindly do this, if you wish to and check out some of these things, it is also got a couple of other places where you got, you know other references provided to you those you could check out. I certainly appreciate your sitting through this session, it is been a little heavy for you I am sure. And there is going to be a lot of other interesting things coming along in this six sigma, we have reached about the midpoint of this six sigma program. And we have completed 20 lectures, and then 20 more to come, and once that are going to come our include design of experiments in actual six sigma cases, these are going to come down the road. Thank you very much, thanks you.