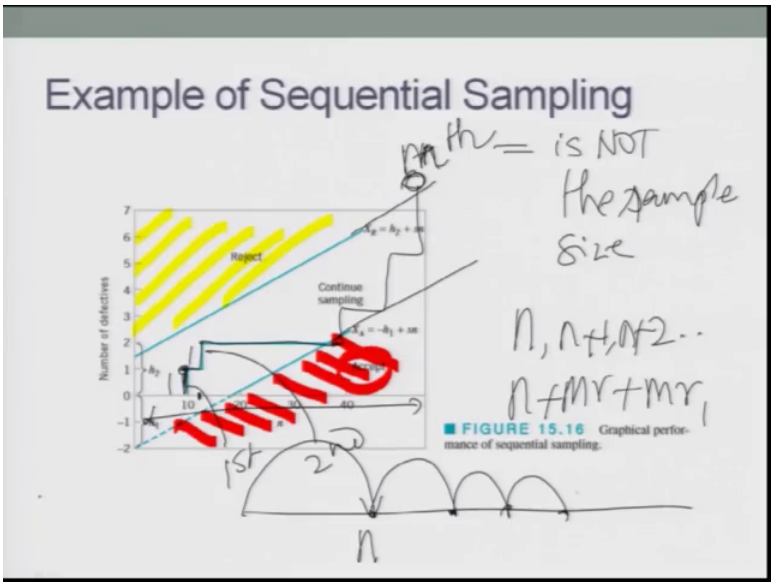
Total Quality Management - I
Prof. Raghunandan Sengupta
Department of Industrial and Management Engineering
Indian Institute of Technology, Kanpur

Lecture – 19
Sequential Sampling, Military Standard and Introduction to R

Welcome back my friends. A very good morning, good afternoon, good evening to all of you. I am Ragunandan Sengupta from the IME department; IIT, Kanpur. And this is the TQM 1 course. And today is the 19th lecture where we are discussing. If you remember we ended yesterday about sequential sampling the plans of double sampling how it can be extended to sequence some sampling based on the stopping rules stopping criteria all these things. Qualitatively obviously, stopping rules and stopping criteria if we remember, I did mention that they would depend on the distribution what plans you have and all those things.

(Refer Slide Time: 01:00)



So, to continue the discussion, the examples of sequential sampling plan are like this. Now you basically consider the number of defects. So, number of defects in a lot. So, in the general sequential sampling is that you pick up, and then check the stopping criteria if the stopping cri is met you stop it if not you proceed. And that procedure to consider whether one observation or more than one observations in at one go would depend on what plans, which you have there are different sequential sampling plans which we know

in literature. It is not part and parcel parcel of this TQM course, but I would like to mention they are the purely sequential sampling plan, then the 2 stage sampling plans, 3 stage sampling plan, accelerator sampling plan, batch sequential sampling plan and all these things are there.

Now, when you want to basically measure the number of defects and whether they pass the quality control based on the stopping criteria. For this for this sequential sampling plan, if you look at the graph which is 15.16 based on the book which is montgomery where we have said time and again and I have said repeatedly is an excellent book. So, we are taking the diagram from that. So, you are trying to measure n along the x axis n the number of observations. And the number of defects are given. So, this between a band. So, if it is plus minus some numbers you would basically accept that. If it is more than that less than that you will take a decisions accordingly so obviously, less than that you will definitely accept more than becomes a rejection.

Now, this is sort of control limits in So as to say. But the control limits which you see in statistical quality control or horizontally drawn on the graph paper, but this would be a little bit tilted because as the see sampling size increases; obviously, the decision whether to accept or reject would be taken accordingly.

So, in one case you have basically and the upper control limit is h 2 or a function of n 2 plus the number of cost total cost which you have for exiting n n number of observations. And in the other case it will be h 1 depending on a function of n 1 you will basically have that cost which is S n. And as you consider this these h8s which are given as h 1 and h 2. So, that will depend on the number of defects which you are considering; obviously, that would depend on the sample size also. So, if you pick up 100 you have some probability that you think that that value see if you remember which should be the average number of observations or objects which are there which are defective.

Similarly, you will take a decisions accordingly as n 2 changes which is more than n 1 or less than n 1. Now here the word n 1 n 2 m not meaning the total combined a sample size. It in if in double sampling we have considered n 2 as the sum of the number of samples which you consider in the first co plus in the second co. Here I am using n 2 word as distinctive from the definition of the combined sample size n 1 would be only for the first sample n 2 would be for the second sample and accordingly.

Now, if you consider h 1 and h 2 which are plus and minus 2 defects in that lot so obviously, you would have a band between which the acceptance and out of that the rejections would be done. So, ro rejections would be done if it is more; obviously, below that what means it is better or on the number of defects are less than that number which is stipulated; obviously, will always accept that. So, if I go to this.

So, in this region all will be rejected because the number of defects which you have would definitely be crossing that. So, in that case whatever the sample you pick up if it is crosses that you rejected. And if I use another different color shading let me change the color to red. So, in this portion it is acceptance. So, if you see the word acceptance here.

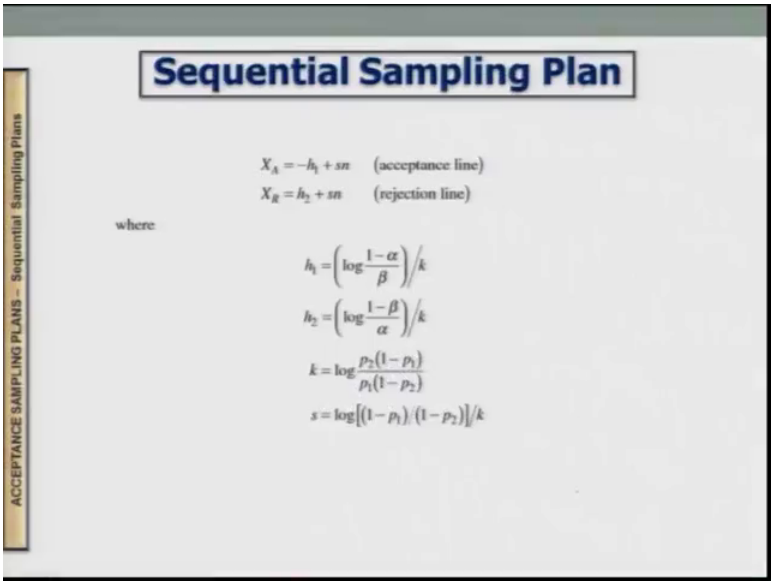
Now, let me come to the concept that how this is tackled (Refer Time: 05:34) with that black color. Now you take 10 observations, and then you find out the number of defects is something. So, this is say for example, the number of defects and it is within this band which I am not highlighting what I am showing. So, you accept then you take some next set of observations. So, this is the next set of observations it goes to say for example, 13 and the again you check in the number of defects are initially it was this side now it is this plus this you again except.

The as you continue going in this direction, there may be some region. So, this I am extending they may be the region where if you go in the nth set of picking. This n this nth sector of picking is not the sample size. So, make it to make it clear let me make it say for example, m. So, m number of such observations are being picked up. So, in the case when the mth one is there. So, this is the first and then you have the second if you continue this is the mth one and m mth one the total number of observations, would be sum summed up from here till the mth stage total number of defects are along the vertical axis as I have mentioned a little bit time ago. And if the number of defects are crossing onto the upper part where the yellow color is. So, you reject if it is below you accept it.

So, this can be extended for a different type of sequence sampling plan depending on whether you take one observation a time. It is like this n, then n plus 1 n plus 2 continues. Another can be n plus say for example, m this m and this m are not equal m is the number of observations you have to take and how many such sets you want to take that is by r. So, it will be m r plus, then the next round becomes m r 1. So, r 1 r 2 r r

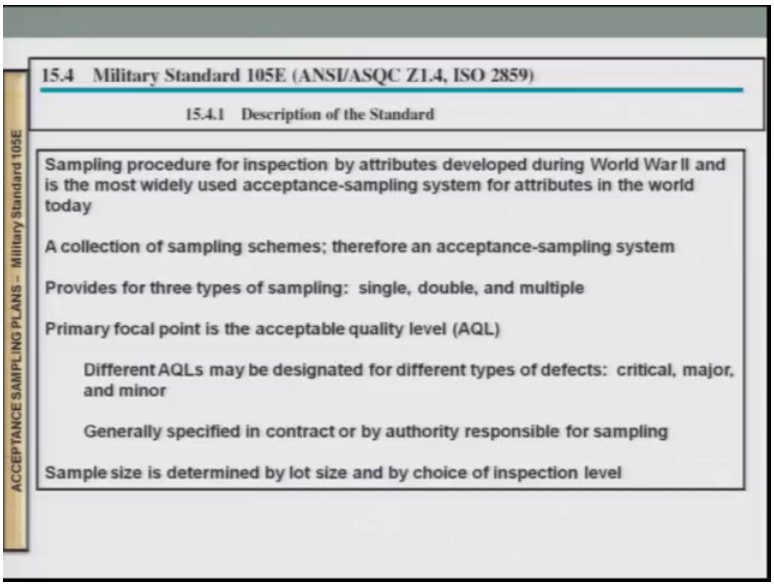
different is like this if I draw straight line. So, basically I make a jump of n observations then basically I start making the jumps accordingly where the number of observations are basically where the highlighting points are in black color. So, we continue doing this any accepted reject. So, this is intuitive field which I am trying to give for the sampling or sequential sampling plan.

(Refer Slide Time: 08:22)



Now the sequential sampling plans as per the general agreed upon norms is that, the acceptance lines would be one would be minus h 1 that is the lower portion plus S into n depending on the cost structure another would be above which would h 2 plus m S into n so obviously, h 1 and h 2 may differ may not differ depending on how the problem had been stated. So obviously, this h 1 and h 2 have been already decided upon and they are given by the corresponding for the formula. So, I am not going to discuss the formulas. Only remember this alpha and beta would be the alpha beta which we are already discussed when we were discussing the oc curves.

(Refer Slide Time: 09:03)



So, there are different type of military strands as all standards also through this military standards are as per the book which would basically be used in the concept of the us armed forces. So, description on the standards are given like this. Sampling procedure for inspection by attribute is developed during world war 2 are being used and they were developed in a very big way. And it is the most widely used accepted sampling system for attributes in the world today. So, based on how sampling could be done how rejections could be done how acceptance could be done. In world war 2 they have been taken for the industrial purposes only; that means, for manufacturing concepts not for the service sectors.

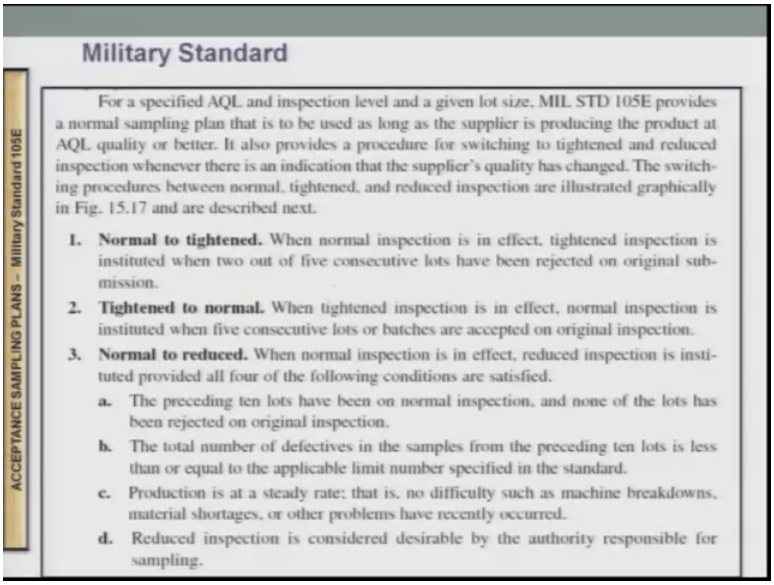
So, collection of sampling schemes have been described in detail therefore, an acceptance sampling system has been proposed. Provides for 3 types of sampling either you can take single you can take double or you can take multiple; obviously, would come in under collectively as a sequential sampling plan. Primary focal point is the acceptance quality level of the AQL level or LTPD concept, which are considered in the oc curves. Different AQL may be a design for designated for different types of defects. It can be critical it can be major it can be minor it can dip depend on the different distributions those critical major minor would also depend on what type of products you have.

Say for example, I am using some component which is used in a pacemaker for the heart. What I am trying to use some material or some product which is doing manufacture and I

want to test the quality of that they would be used in aircraft engines, or they would be used in critical bridge making so obviously, the level of quality inspection and the quality levels would be much higher. In case say for example, I am trying to utilize some material to make a chair or a table, in those levels concept of quality would definitely be there, but the critical level and the emphasis would definitely be different because you have to understand the critical level based on the cost component and how good or bad the effect would be depending on their failures.

So, generally specified in contract or by authority responsible for the sampling. So, it is all you predefined. Sample size is determined by lot size and by choice of inspection level or the plans which has already been decided or predefined.

(Refer Slide Time: 11:28)



So, continuing the military standards for a specified AQL an inspection level, and a given lot size. This military standards provides a normal sampling plan that is to be used as long as the supplier is producing the product at the AQL level or better. It also provides a procedure for switching to tighten and reduce inspection norms, wherever there is an indication that the suppressed quality has changed. So, in case this quality has become bad. So, waste your bit to be cautious in the case the suppliers quality is turning out to be good. You would not relax, but; obviously, the overall emphasis on the major minor risk and the level importance you will place would definitely be not off to that strict level.

The switching presidium between normal tightened and reduce inspections are illustrated graphically in that book, where the figure is 15.17, but we will be just discussed them in words. So, when it when you are going from normal to tighten when normal inspection is in effect tightened inspection is instituted when 2 out of the 5 consecutive loss has been rejected on original submissions. So, 5 out of the 5; 2 have been rejected; that means, there were some problem you should take immediate action, and basically tightened your norms of inspection.

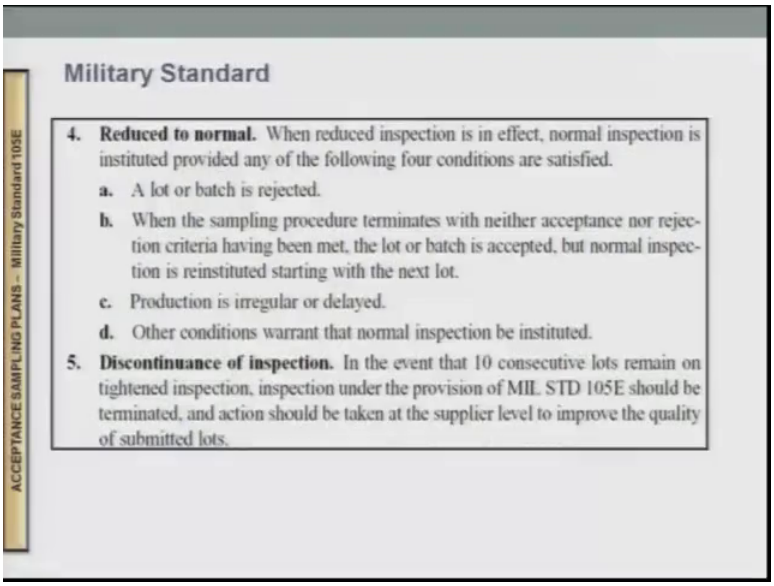
When you are going from tightened to normal when tightened inspection is in effect normal inspection would take precedence and would be replacing the tighten one if when 5 consecutive knots none of them have been found to be defective or they have been accepted. If you are going for normal to reduced when normal inspection is in effect reduces inspection is instituted provided all 4 of these conditions are satisfies, which is number one the preceding 10 lots have been in also these are specifications like 10 or 12 or 13 whatever is mentioned is it is based on the military standards.

The preceding 10 lots have been on non normal inspection and none of the lots have been rejected on original inspection, so that means, your changing from normal to reduced. Another one of them would be that all 4 have to be satisfied the second one would be the total number of defects in the sample from the preceding 10 lots is less than or equal to applicable limit number specified in the standard. Production is at the steady rate that is no difficulty such a machine break drops material shortages or other problems addison be recently record re occurred.

So obviously, they would be considered in as one of those 4 points based on which the normal to reduced inspection concepts can be utilized and the last one be reduce inspection is considered desirable by the authority responsible for sampling because that would basically reduce the cost, but something has to be remembered that if you reduce the cause the level of inspection or the probability of false occurring or your missing the falls which you cannot catch would may increase, but a compromise has to be made depending on what is your cost structure what is the efficiency what is your robustness and sentence sensitivity of this different type of sampling plans.

To continue further with the military standards reduced to normal can all be used when reduced inspection is in effect.

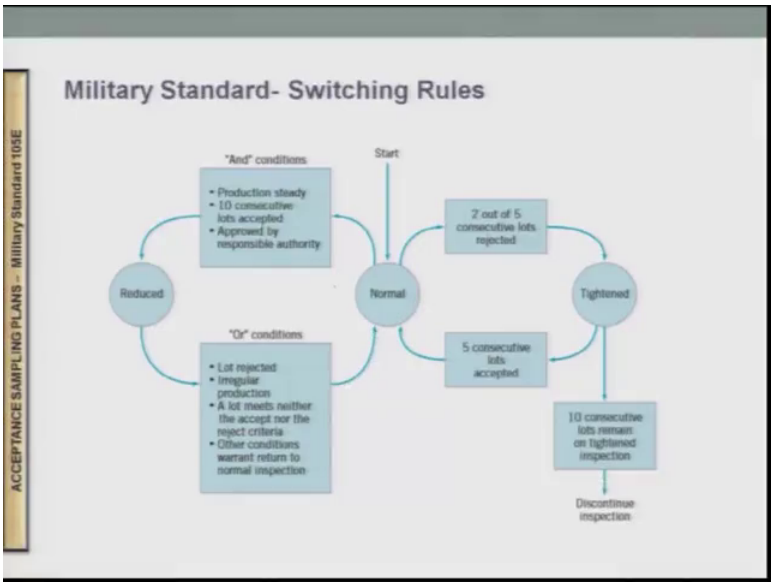
(Refer Slide Time: 14:53)



So, you are Now, basically changing from reduced to normal. So, if all any one of the following 4 conditions are applied that was a union set now it is a intersection any one of them. So, minimum any would satisfy and you will basically take it. A lot or match is rejected when the sampling procedure terminates with neither acceptance nor rejection criteria has been made. And the lot or batch is accepted, but normal inspection is re insti reinstituted starting with the next lot. Production is irregular or delete other conditions warrant that normal inspection should be instituted due to some reasons which are definitely not positive.

Discountenance of inspection would happen in the event 10 consecutive lots remain on titan inspection inspection under the provisions of this of the military standard codes, should be terminated an action should be taken to add the surprise end to improve the quality of the products which they are supplying to the military. Because the reason was military needed absolutely 0 error objects or materials or products so obviously, the standards were based on that. And they were very strict laid down very open norms based on which the supplier once he or she agrees those procedures had to be followed.

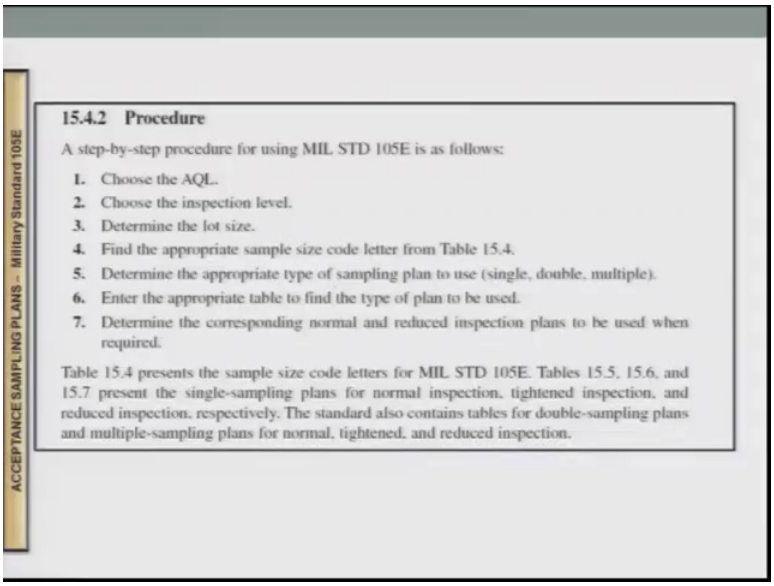
(Refer Slide Time: 16:16)



So, if you see the military standard the switching rules based on whether you want to go from reduced to normal normal to reduce. Then in the nutshell what I discussed is basically given this diagram. So, there are some and conditions and or conditions if you remember I said something to do with the union and some would be the intersection of the minimum one. So, that would give you the picture that the and conditions are there where my finger set of left fingers are and here the or conditions are given. So, and conditions and or conditions are mentioned depending on that you can go for tightened and tighten norms also or you can go from normal to tighten or normal to reduce. And in case if some scrapping of the norms have to be done you will n do accordingly, but there are certain procedures how you go about that.

So obviously, all these are laid down they have to be practice and then once you understand, you will be able to appreciate how the norms are taken this. I have just giving him a theoretical flavor to give you how the norms are basically laid down and what are the general procedure based on which you will take the decision.

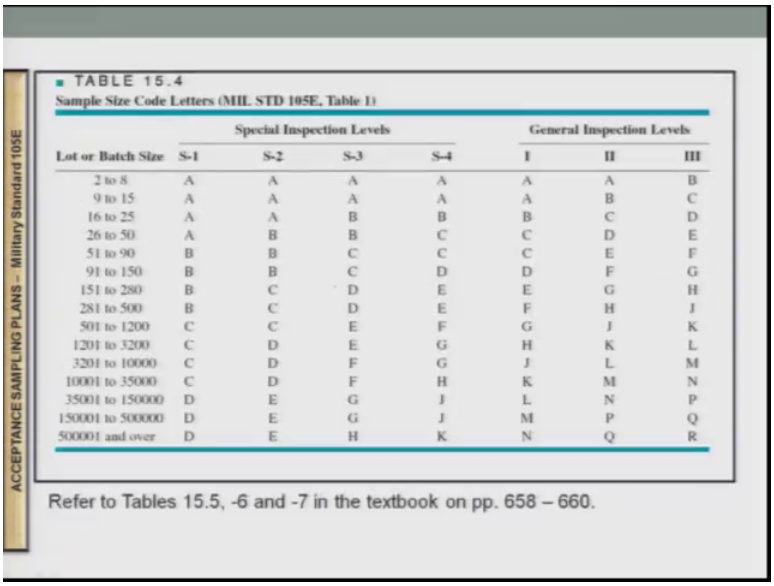
(Refer Slide Time: 17:20)



So, the procedures for the military standards would be the you check the a AQL model and you choose the inspection level. So, at what level you want to do you do; obviously, have to determine the lot size because that will determine what is value of c and that will also determine what is the total cost. Find their previous sample size determine the pre boot type of sampling plan to use. Enter the appropriate table to find the type of plan to be used and determine the corresponding normal and deduce inspection plans to be used when required.

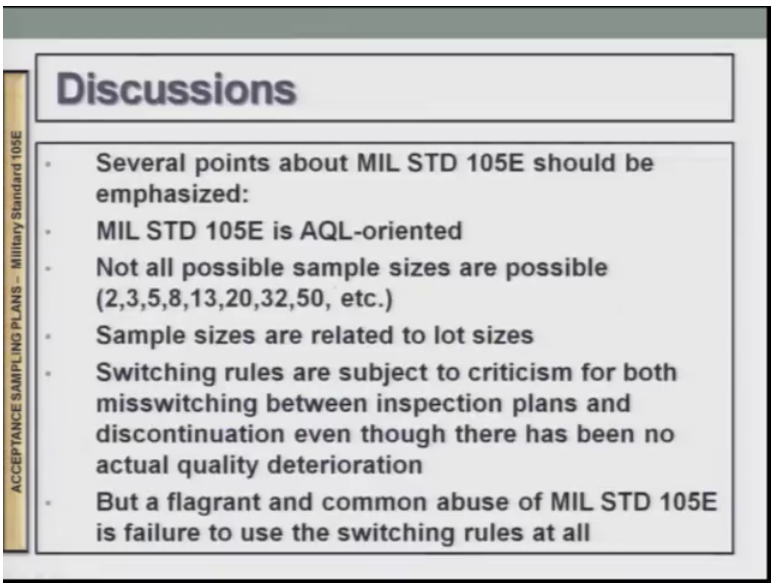
So, if you consider all these things tables in the book like 15.4, 15.5, 15.6 and 15.7 will give you some idea about the different type of rules based on the inspections plans from the military standards.

(Refer Slide Time: 18:02)



So, to continue the tables I will just discuss the tables the are already decided. So, I will only highlight what are the measurements which are being made. So, in this sample size code letters are given. So, the lot size which are given on the for to the leftmost column, they start from 2 to 8 and go till 5 lakh one and overrun that. And then you have the special levels which are given by levels of S 1 to S 4 and general inspection levels are given from one to 3. So, you will basically choose the combinations and make the decisions accordingly.

(Refer Slide Time: 18:38)

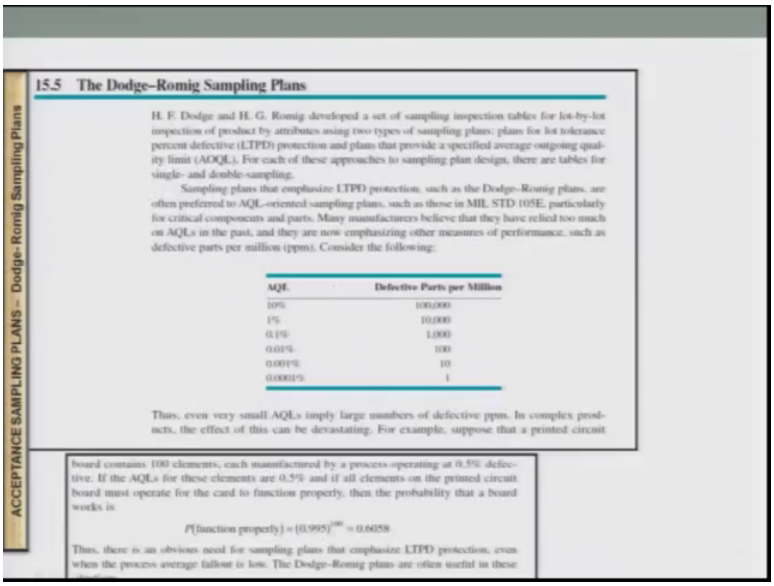


So, several points about the military standard should be emphasized, which are that the emphasis on the AQL orientation problem. And not all possible sample size are possibles if we re remember if small sample sizes they are like 2, 3, 5, 8; obviously, at the boundaries it may not be possible to take a decisions accordingly based on the military standards. Sample size are related to lot size. So, bigger the lot bigger the sample size is smaller the lot smaller at the sample size. Because costs effects efficiency affects; obviously, have to be considered.

Switching rules are subject to criticism for both miss switching and not on and whether you want to switch, when it is not allowed or you do not want to switch when it should be loud. So obviously, there are criticisms so obviously, in some sense they would make give you some idea that there are lots we should not be rejected, but you reject them and vice versa. So, that will give you some informations or bring a simile between the consumer disc and the producer disc. So obviously, that would come because there is a supplier and a vendor. So, or a set of customer. So, the customer the military people of them are the military install installation and the surprise of the vendors are the suppliers for those products on whose products you will do the sampling plans on the sampling inspection.

So obviously, the a major not a problem which is a part and parcel of the military standards, but it does happen that the switching happens quite often which basically breaks, the overall scheme based on which the military stand has had been had been developed and they are used. So obviously, rather than blaming on the overall inspection process which is taking care on an individual basis people are people are tempted to blame the military standard which is structured norms. So, if you follow them they are; obviously, they should get give you the results, but if you try to basically bypass them then the problem occurs for which rather than be blaming the military standards, we should try to analyze the way there such breaking of the rules have occurred or do occur.

(Refer Slide Time: 20:44)



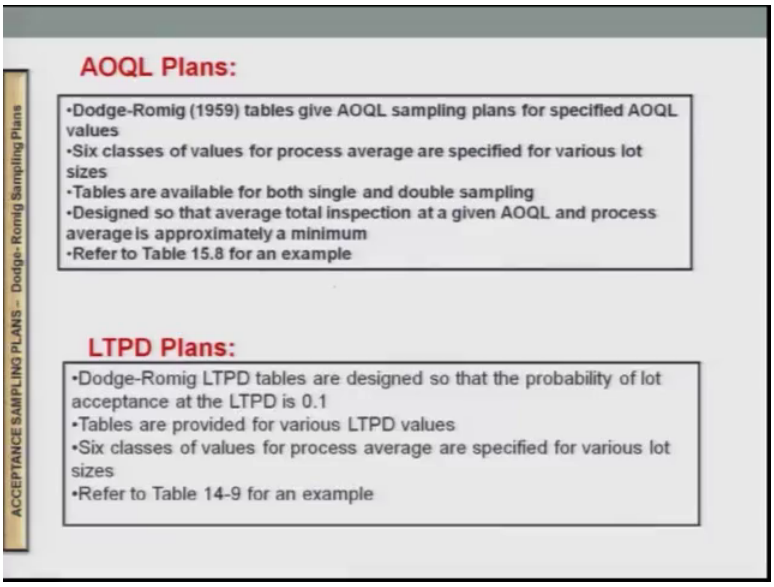
So now, you have the dodge romig plan sampling plan. So, dodge an romig developed a set of sampling plan inspection by lot by lot inspections. So, of products by attributes at the characteristics using 2 types of sampling plans for lot tolerance, which is LTPD concept on the in the qc, oc curves which you consider and the AOQL or AQM levels. For each of these approaches to sampling plan design there are tables for single and double sampling; obviously, those concept of accepted sampling which we considered was single sampling double sampling and multiple sampling. Sampling plans that emphasize LTPDs such as the dodge romig plans are often preferred to AQL, and particularly for critical components critical components if we remembered where the sensitivity or the level of acceptance absolutely have to be perfect.

Many manufacturing believe that they have relate too much on the AQLs in the past and they are now emphasizing. Other measures of performance such as defective parts per million and so on and so forth. So, if you consider the equivalence conversion between a AOQL or AQL and defects parts per million. So, that is given in this table which is part and parcel of 50 sections 15.5. So, on the first column near the AQL value starting from 10 percent going to 0.0001 percentage, and on the right hand column you have the defective spots per million. So, you can make a one to one correspondence and take their decisions accordingly. Thus even very small AQLs imply larger large numbers of defective parts per million. In complex products the effect of this can be demonstrating

and they would be shown in different type of examples which are already discussed in the book.

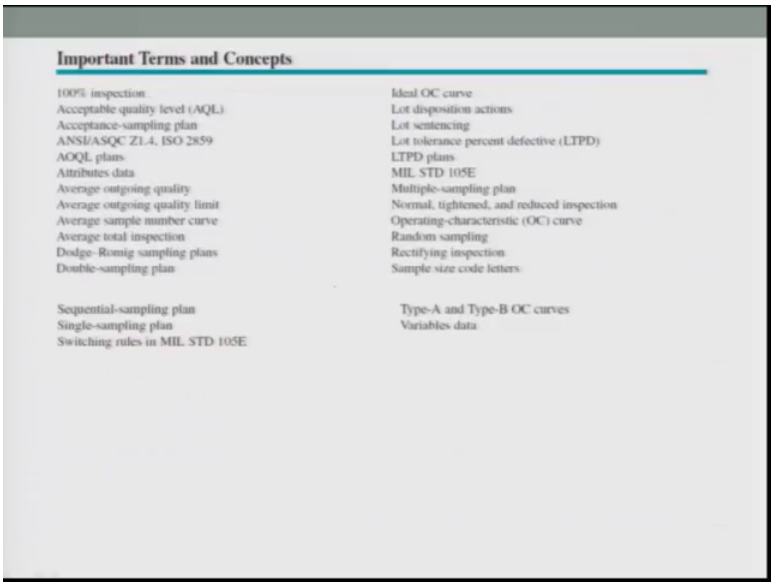
So, based on that we will understand that what would be the ppm conversions with give based on the fact of what is the AQL values, and on the conversion concept between AQL and the ppm you will take a decisions accordingly that what is the sampling procedure of the plan AQL plans.

(Refer Slide Time: 23:00)



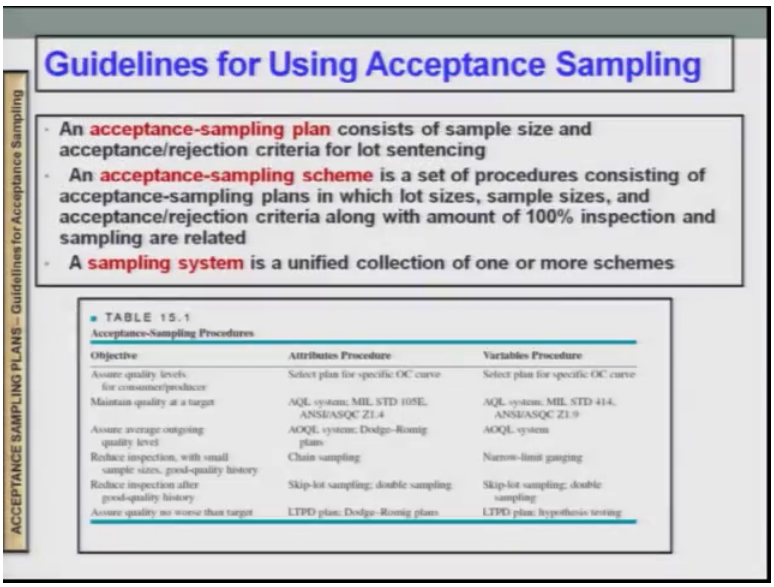
If you basically summarize the bullet points would be dodge romig gave in 1959 gives the AOQL sampling plans for specified AOQL values. 6 values is pluses of values for process averages are specific for various lot sizes. Tables are available for both single and double sampling there is a design. So, that average total inspection at a given AOQL and process average is approximately minimum. And if you go to the LTPD plans. So, dodge romig LTPD tables are designed. So, that the probability of lot acceptance at the LTPD value is given as 0 point one so obviously, they would be one to one correspondence between the ppm and the and the AQL and the LTPD values. 6 classes of values are there for process averages and examples are given in details in the montgomery book.

(Refer Slide Time: 23:52)



So, important terms which we are consider dyes 100 percent inspection AQL value AOQL value attributes sample size average total inspection dodge romig plan sequential sampling was single sampling double sampling, then OC curves lot sized lot size sampling plans multiple sampling plans which is the sequential sampling 1 and so and so forth.

(Refer Slide Time: 24:15)



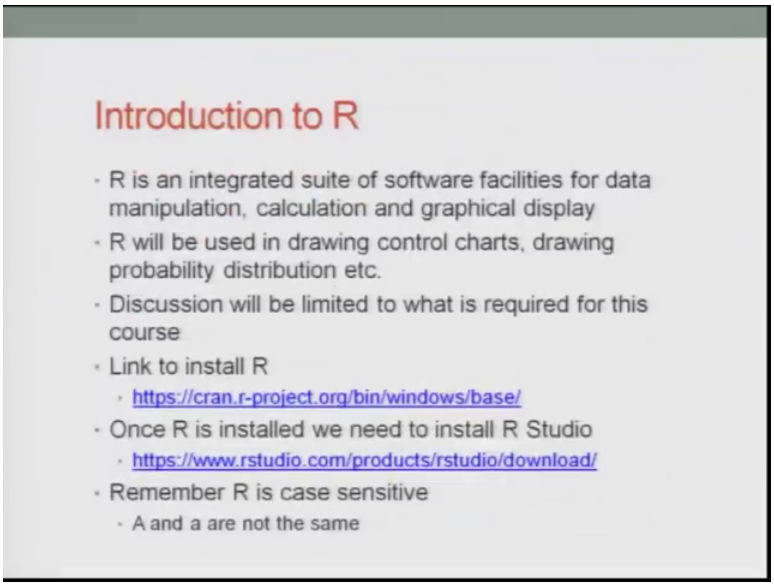
So, guidelines for an using acceptance samplings are an acceptance sampling plan consists of sample size and accepted rejection criteria for lot sentencing. And acceptance

sampling scheme is a set of procedures consistent as acceptance sampling plans in which lot size sample size and acceptance rejection rate is along with the amount of 100 percent inspections are related a sampling plan is a unified collection of one or more scheme based on which you do the sampling.

So, if you consider the accepted sampling plans in the in the topmost row you would have a basically objective. And why you are doing that? The any of the attributes procedure and you have the variable procedures over. One set of characteristics which are which are subjective in nature. Some concepts like the color is not good whatever it is or the decibel level is high based on some that and others are actual quantity values which will definitely define as the variables concept.

So, if you want to assure quality levels for consumer and producer, which is the first point which is may mentioned the leftmost column. Then the attributes procedure and the variable procedure would be select plan for specific oc curves and you will do it same similarly for the variable procedure curve also. So, if you go along the first column they would be maintained quality at target assure average outgoing quality level reduce inspection reduces infection out of good quality history so and so forth. So, if you check The corresponding attribute procedure and the variable procedure, you will cover the whole range of decisions based on which this mapping can be done or the analysis of the accepted sampling procedures can be done.

(Refer Slide Time: 26:01)



Now, with this I will come I will I am not switching the topic, but I with this I will come up to very brief introduction of R. R is a very useful software which is freely available downloadable from net, and you and those library functions are being expanded on an exponential basis daily. And once you are able to understand the general concept of R, I am not going to go into details of R, I will just and mention the main procedures based on which some of the problems have been worked.

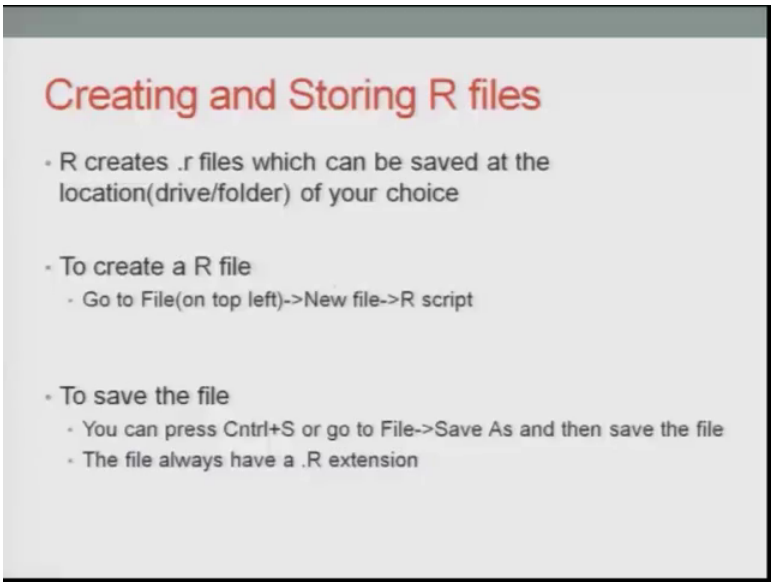
So, I will request urge and plead the students that whether required for this course are not course that is immaterial, but do please pick up R as a topic which you can utilize in diffe,rent spheres, not only in statistics not only in operation is you can use in different fields also. So, R is an integrated suite of software facilities for data manipulation calculation and graphical display. So obviously, the graphical interface is decently value you can formulate different graphs and get the output accordingly.

I will be using drawing control charts drawing probability distributions and etcetera for this TQM one course discussions will be limited to what is required for this course only which I mentioned. So, I am not going to overstep and basically continuing the discussions in R because the discussions in R can be itself a course in nature; that means, people would be more interested to take R and they can apply r in any different fields it can be statistics, it can be optimization, it can be maybe you are trying to use in engineering and so on and so forth.

So, to install R one can open the cran dot R dash project. So, you can find out the link as it is given. Once is R is utilized we need to install the R studio. So, installing the r studio is very helpful because it because a very user friendly interface with the computer and you. So, you have a screen with different windows and you can basically type you will come and get the results accordingly and try to understand how it looks like.

So, then remember R is a case sensitive package. So, if you are writing the codes in r you have to be careful accordingly, I will come to the few details later on.

(Refer Slide Time: 28:26)



So, which means that small n capital a are not equal or capital a small S are not equal accordingly. So, creating and storing the R files would be R creates the dot R file files. So, the extension is given like this like in word document you have dot or dot doc or dot docx files in x any of the dot xls files and so and so, the mat lab e or the dot m files.

So, it creates the dot r files in r which can be saved at the location or drive I specified by you. To create R file you basically go into the fine new file is created and the r script is by can be opened. To save the file you basically press control S as you do in general one or you can go to the menu follow the procedure save it in the directory wait which has been specified for you. I will continue in the discussions of R in a little bit more detail as required and with this I will end this lecture and continue with this twentieth lecture later on.

Thank you, have a nice day.