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**Lecture - 21**
**Quality Control**

So, the next lecture for discussion is going to be on quality control. Pretty interesting quality is one thing which everybody expects I need a high quality performance product like I need a quality watch, a quality shirt, a quality car, a quality cell phone. But how do you define quality? Quality is a relative term a good quality for you need not be a good quality for me right. So, quality itself is very interesting and it is very abstract for definition. However, people have found out several ways of defining quality. But people expect this quality everywhere.

So, now in this lecture we will see what is quality control. We will try to have an introduction, and then we will try to see some of the process controls statistical process control, design for experiments and sampling techniques little bit.

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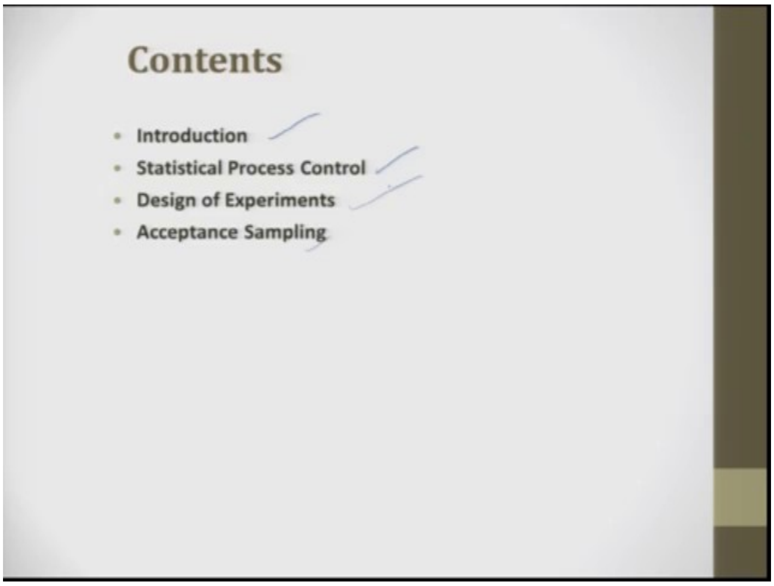


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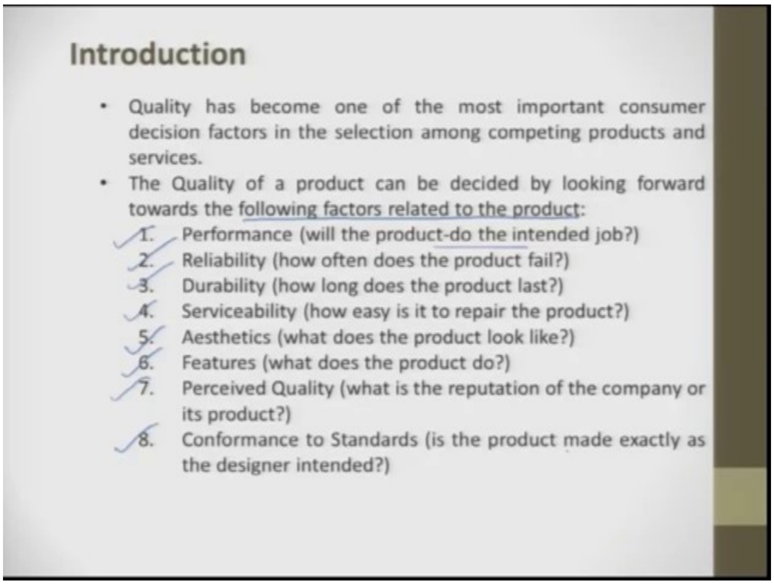


So, quality has become one of the most important consumer decision factor in the selection among competing products and service. The quality of a product can be decided by looking forward towards the following factors related to the product. One is performance: will the product do the intended job? So, pretty interesting pen, you take a pen. So, what is the function of a pen is to write; correct.

So, now people use this pen also as a page marker pen with a cap is used as a page marker. So, when I do it as a page marker many a times the pocket holding that fellow fails right. So, now what was your intended job to be done writing. Now that clip whatever was there has failed because you have tried to push it keeping some 50 pages. Because of the thickness it does not have a space because the pen is intended to just sit in a pocket where the thicknesses defined to a large extent it is defined ok. So, the flexibility is given only to that extent.

Now when I try to hold 50 pages which was not the intent of this pen, now the pen has not performed. Watch now that clip has failed now I cannot hold my pen. When I put my pen without a clip whenever I bend it falls down. Now the pen has lost its credibility because it did the job which was not intended to do. Now is it clear? So, what is intended job and what is not intended job. Many a times the product fails because it was asked to do a non-intended job but finally what happens the product has failed because of that and people say the product is useless ok.

So, keep this in mind performance is very important: will the product do what is intended to do? How often the product will fail? How long will the product last? So performance, reliability, durability is taken care. How easy it is to repair serviceability is taken care. How good does it look? Aesthetics has been taken care. How does the product do? Features is taken care. Perceived quality: what is the reputation of the company or its product? I am trying to hold a pen which is a Parker pen. Parker has its own reputation because of the Parker company's reputation I hold his product my reputation also goes high perceived quality.

What then last is conformance to standards: is the product made exactly for what the designer has intended to do? So, conformance to standard these are some of the factors which are related to the product wherein which the quality of the product is talked about.

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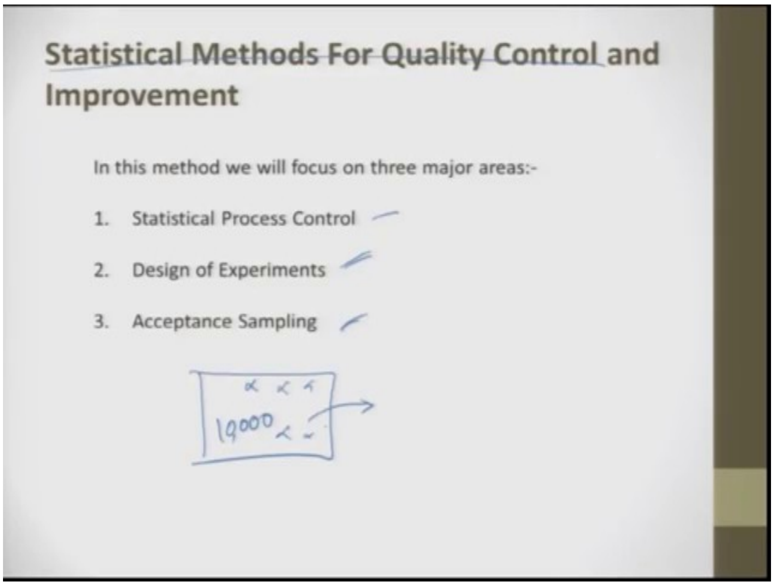


So, statistical methods for quality control and improvement; so there are three major areas where people have been working on drastically and they have included lot of map also behind; that means to say it is a scientific approach statistical process control. People have come out with design for experiments and people have also come up with acceptance sampling. For example, I buy 10000 pieces= in a lot and before I accept if I start checking all the 10000 pieces and then I say yes the lot is good and then I will accept it is going to be time consuming.

But one logic if you see all the 10000 are manufactured from the same company by a machine or by a group of machines. So, then naturally the products which are produced are going to be good. So, every time inspecting 10000 pieces is next to impossible. So, what do I do is I random pick some 5 or 10 and then I check the status of all the 10 and if it is all good then I accept the lot. So, that is what is acceptance sampling.

And here also there are lot of logics. If it is a vital project all 100 percent has to be done. If it is a non-vital with this thing product or a part then what they say is they say out of this 5, 2 fails also is it you can accept the lot. There are certain things like that.

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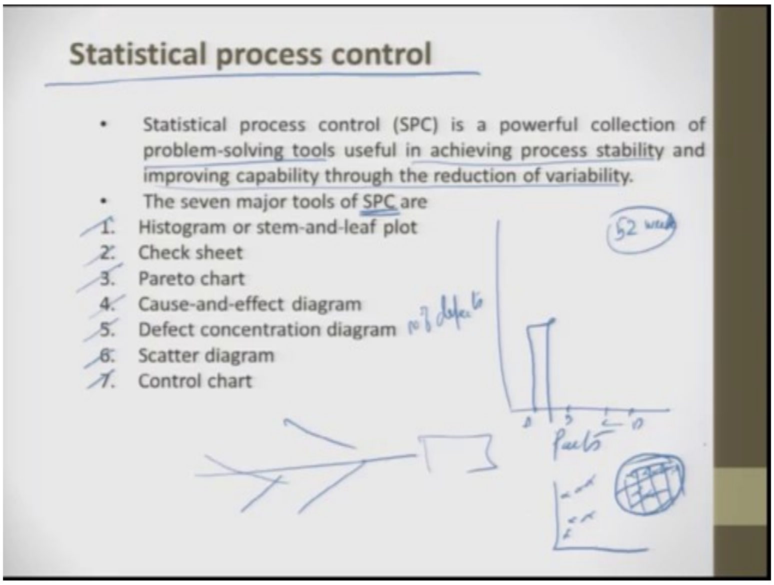


The statistical process control is a powerful collection of problem solving tool useful in achieving process stability and improving capability through the reduction of variability. There are seven tools which are generally used as part of SPC: Histogram, Check sheet, Pareto chart, Cause-and-effect diagram, Defect concentration diagram, Scatter diagram and Control charts. These are the seven tools which are always thought of as part of SPC which is to be followed inside your factory to so, that you produce a quality output.

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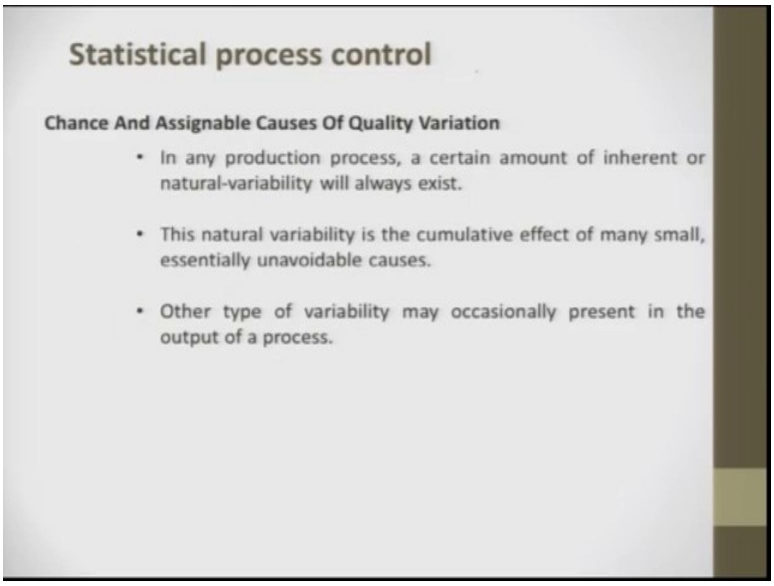


The other thing is Chance and Assignable Cause of Quality Variation. So, in any production process a certain amount of inherent or natural variability will always exist. This natural variability is the cumulative effect of many small essential unavoidable causes. The other type of variability may occasionally present in the output of a process. So, this is called the charts. There are Control Charts; if you go back here this histogram analysis is ok.

Histogram analysis is it tries to say suppose let us put the defects and you say this these are the number of defects or whatever it is. And then you say what are the different y axis can be parts. So, it can say part A, part B, part C, part D. You have a block diagram which says that what is how many parts have failed in that period. So, you can write here 50 second week. In that week how many parts of A failed, B failed, C failed, D failed. So, that is called as histogram analysis.

The check sheet is check sheet you can even go to the you can see in airports and other places where a list of check sheet is given. People ask you to check whether this document is submitted that document is submitted then this then this then this then this then finally you upload. So, that is a check sheet we give a standard procedure you follow it.

Pareto analysis is nothing but it is almost the same. But here we try to see what is the effect of these defects on the output. So, that is what we see in Pareto analysis. Cost-and-effect diagram is something like a fishbone diagram, we try to say these are the causes and this is the effect of it.

And then, defect concentration diagram. Defect concentration diagram is it tries to tell how many defects have happened in that period of time that is called as defect concentration diagram. Scatter diagram is always you try to put all the defects and try to make a cluster. So, then what you do is you try to circle out the cluster and try to figure out what made this cluster to come. So, that is what is scatter diagram and you can talk more about the scatter diagram. Control chart is p chart x chart we will see all those features later.

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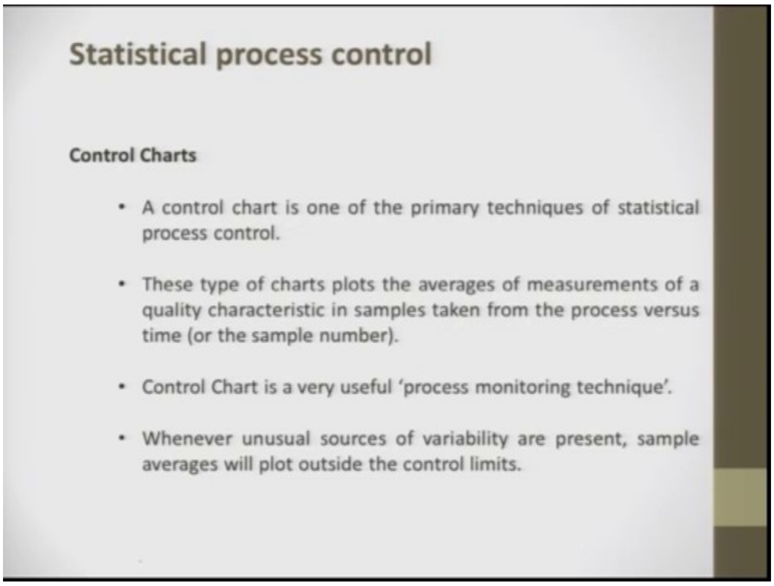


A control chart is one of the the primary technique of statistical process control. This type of chart plots the average of measurements of quality characteristics in samples taken from the process versus time ok. So, we try to take a product we try to take a part which is produced and this part can be ones in 50 parts or it can be ones in half an hour. So, we pull out and then try to check the various dimensions and deviations and note it down.

The control chart is very useful process monitoring technique because at every 50 or every 100 you try to pull out measure the features, report those features and then do it. Whenever usual sources of variability are percent sample average will plot outside the control points.

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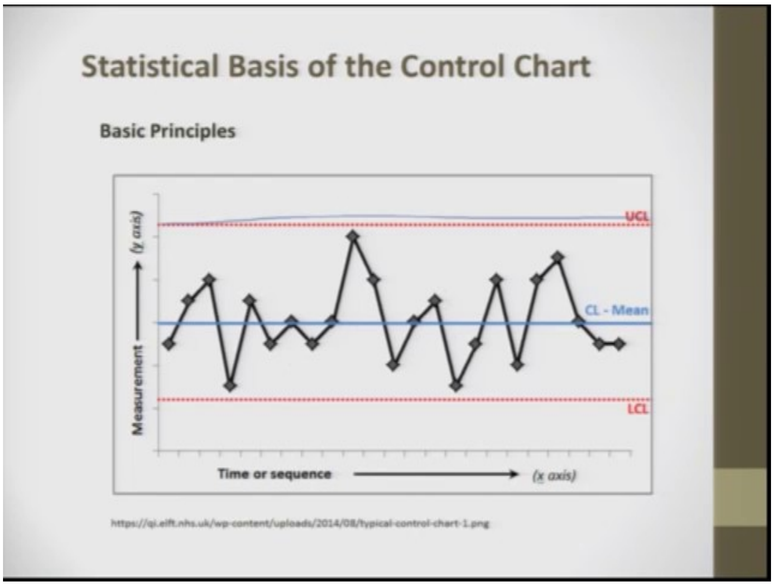


So, you can see that it is called as Upper Control Limit, Lower Control Limit. So this is what is the mean and here is the deviation whatever you have, it can be diameter or something and x can be time or number of parts or whatever it is. Now, if you look at the diagram it is very clear. There is a variation which is happening at regular intervals of time.

So, whenever it tries to go very close to the upper critical limit or to the lower critical limit very close, we try to reset. For example, we try to re-sharp and we try to relook into the fixture. We try to change the tool. So, all those things happen and once it is done, so you can see that it pulls back and it goes into the normal way. So, that is this tries to give me a lead that yes the time has come to reset your process.

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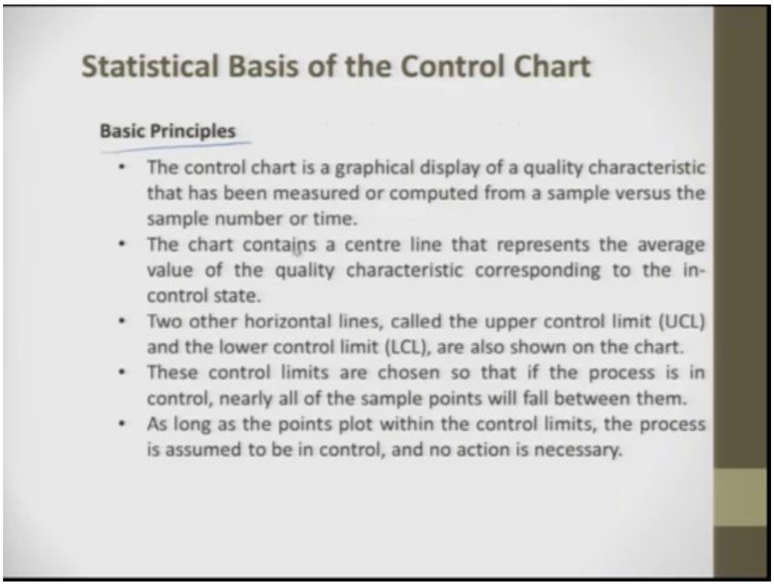


So, basic principle I have already explained to you. So, it talks about the chart containing a central line that represents the average value of the quality, characteristics corresponding to in control states. So, you have an upper control you have an in lower control the deviation has to fall in that only. So, the upper control limit is nothing but sigma mu so that is the mean, the w is the sample statistics; that measures some quality characteristics of interest and suppose the mean of w is mu w and the standard deviation is given a sigma w and then this is the standard line L stands for the distance of the control limits from the centre line.

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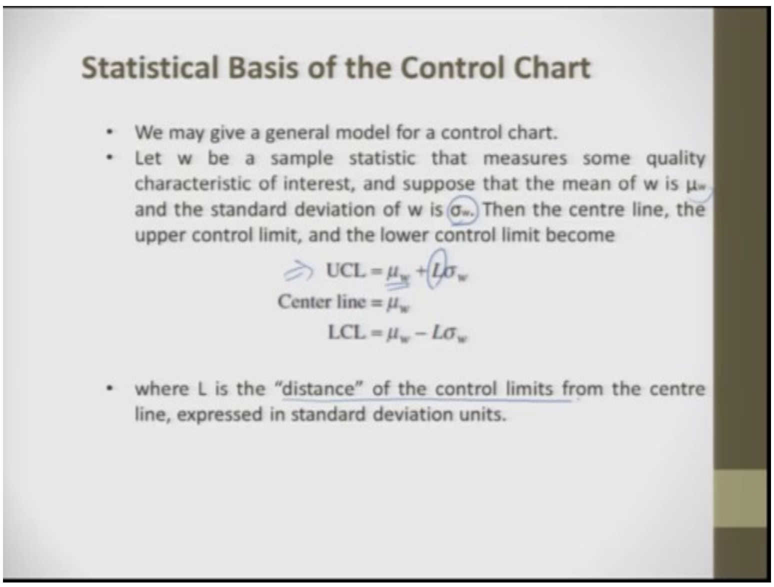

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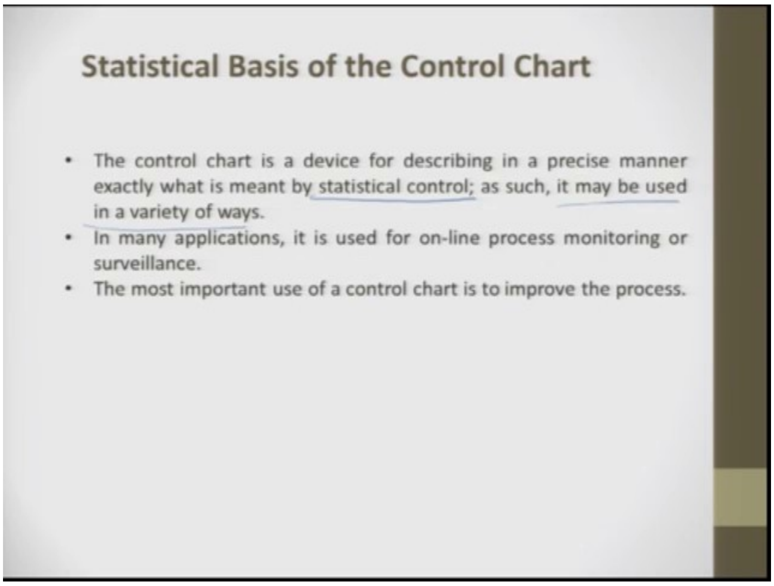


Statistical basis for the of the control chart: the control chart is a device that describe in precise manner exactly what is meant by statistical control such it may be used in a variety of ways. In many applications it can be used online and many a times it can be also used offline.

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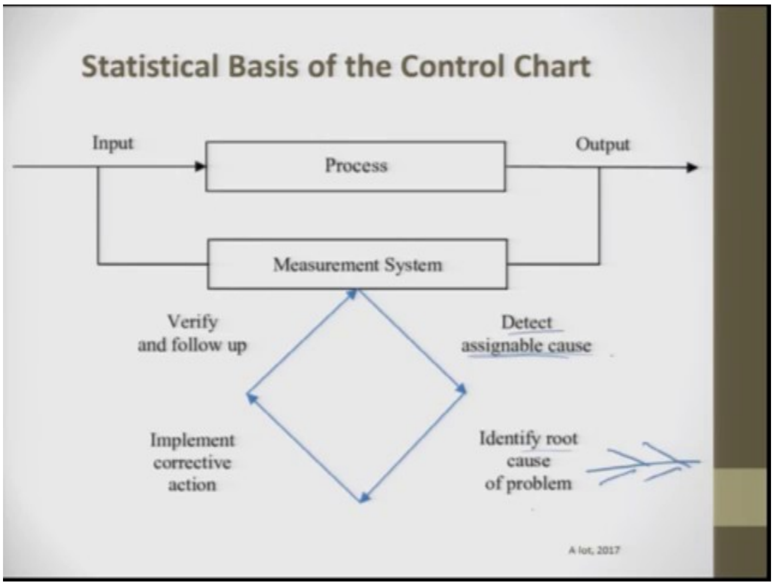


So, input here is a process; process can be reading, process can be cooking, process can be machining, process can be assembly. So, input process you get an output. So, you try to measure. So, when you try to measure you try to detect assignable cause. Then you identify the root cause for the problem. This is done by the Ishikawa diagram and then you try to correct it implement the correction whatever it is. And now verify once again whether the defects are coming or not. If it is not coming it is fine, if it is coming then once again going to this route and then you try to modify it. So, this is called as assignable costs ok.

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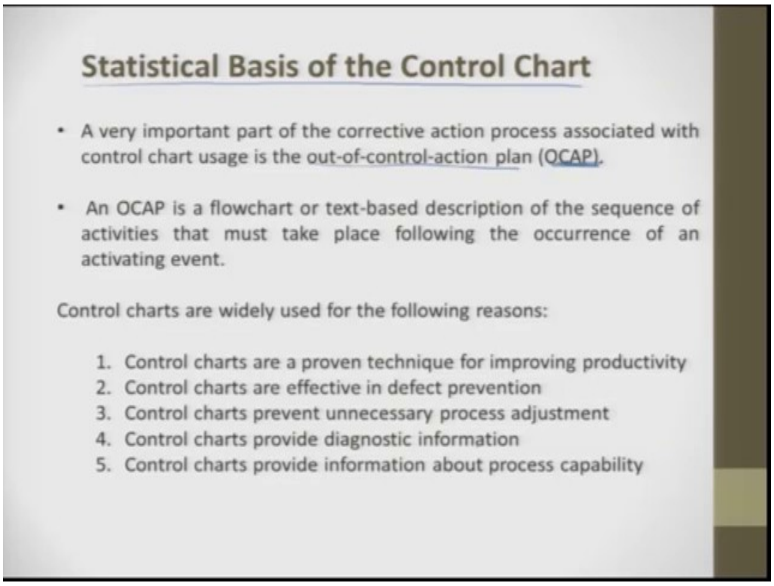


So, then the statistical basis for control chart is it is very important part of the corrective action process associated with the control chart usually in the out of the control action plans out-of-control-action plans OCAP. A very important part of the correction corrective action process associated with control chart usually is the out-of-control-action plan and OCAP is a flowchart or a text-based description of the sequence of activities that must take place following the occurrence of an activated event. So, it is like a cause and it is just what are the sequence of things to be done. So that you can get back to your normal state that is what is out-of-control-action plan ok. When the process goes out so, what is action plan to be taken.

The control actions are widely used for the following reasons: the control charts are proven techniques for improving productivity, to reduce the defects, to prevent unnecessary process adjustments, to provide diagnostic information and to provide information about the process capability.

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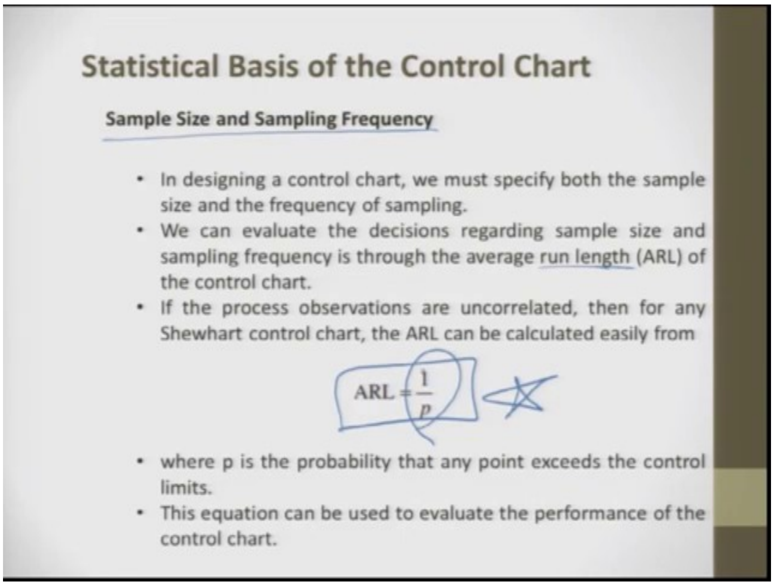


The sample size and sample frequency is another interesting topic which you have to note. In designing a control chart we must we must specify both the sample size and the frequency of sampling. So, frequency of sampling is 1 in 50, 1 in 100. Sample size is within that 50 how may samples you have to take. We can evaluate the decision regarding the sample size and the sample frequency is thought the average run lengths of the control chart.

So, if the process observation are uncorrelated then for any Shewhart control chart, ARL can be calculated as 1 by P. P is the probability that and that any point exceeds the control limit. This equation can be used to evaluate the performance of control chart. This is very important. If the process observation is uncorrelated, then for any Shewhart control chart, the ARL can be calculated easily from ARL = 1 / P where, P is the probability of any point which crosses that limit.

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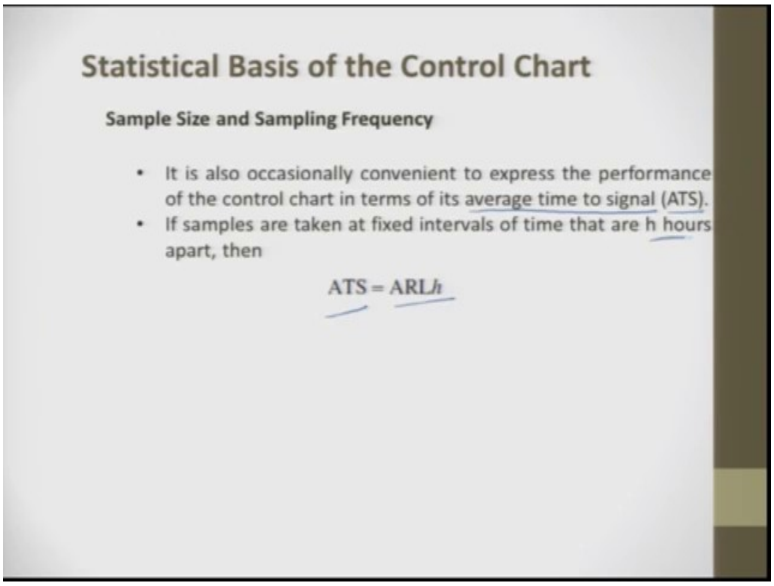


So, it is also occasionally convenient to express the performance of a control chart in terms of its average time to signal ATS. So, ATS is nothing but ARL * h where h is in hours.

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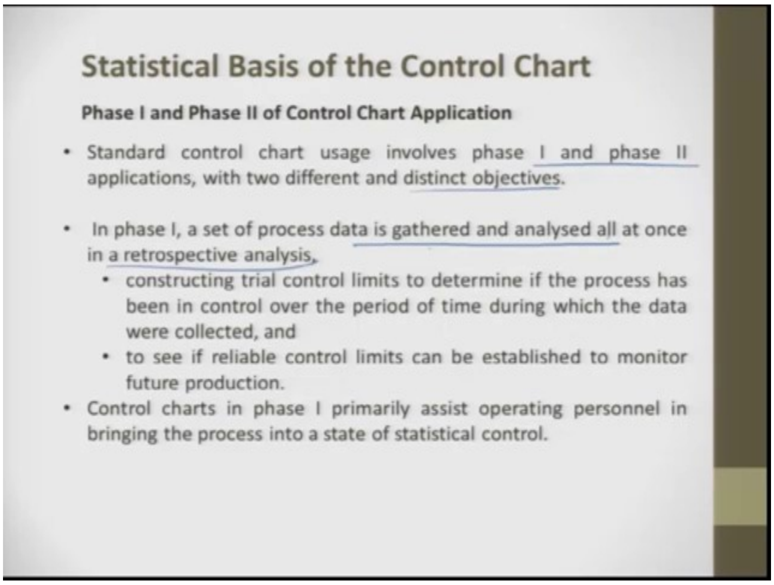


So, there are several phases phase 1 and phase 2 of control chart application. The standard control chart usage involves phase 1 as well as phase 2 application with two different and distinct objectives. In phase 1, a set of process data is gathered and analysed at all at once in a retrospective analysis ok. So, it is done. So, gathering and analysis is done in a retro all at once in a retrospective analysis. So, so next to the control chart in phase 1 primarily assist operating persons in bringing the process into a state of statistical control. So, it is gathering and analysis of the data is done in phase 1.

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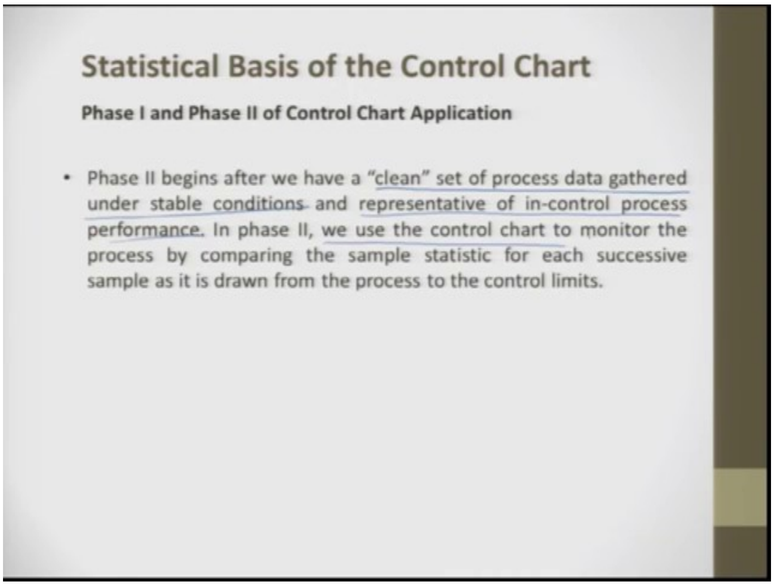


In phase 2 we begin we begins after we have clean set of process data gathered under stable condition and representative of in-control process performance. In phase 2, we use control charts to monitor the process by comparing the sample statistics for each successive samples.

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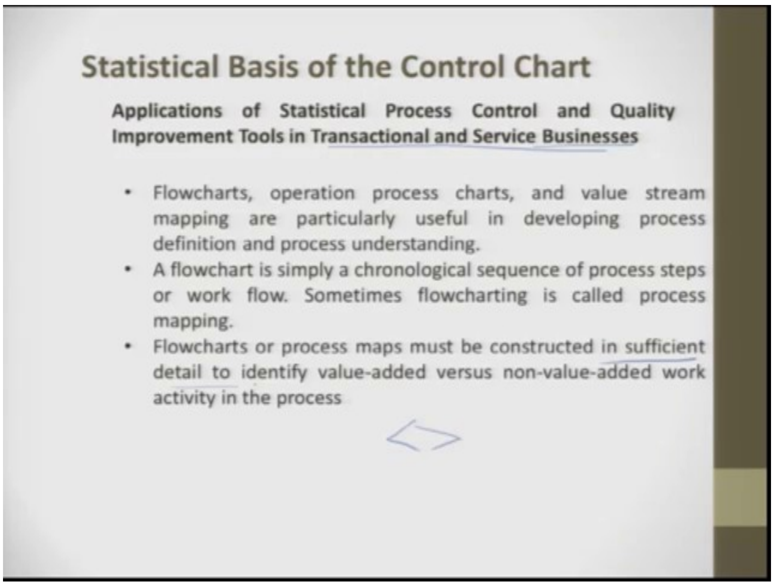

So, application of statistical process control and quality improvement tools in transactional and service business. The flowchart, process operation process chart and value stream mapping are particularly useful in developing process definition and process understanding. A flowchart is what a simple way of simple logical way of representing a matter or a protocol in a see in a pictorial manner. In a chronological sequence and a pictorial manner is the activity of a flowchart. Flowchart or a process map can be constructed in sufficient detail to identify value-added versus non-value-added work activities which is done.

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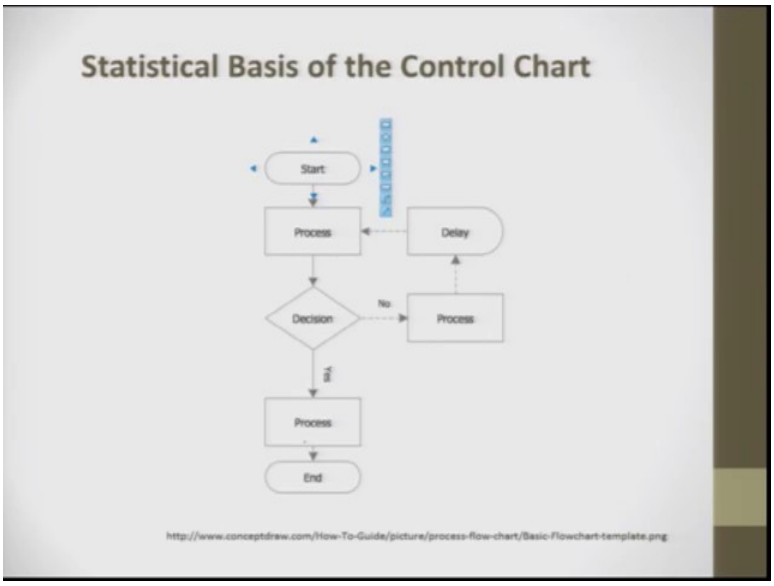


So, this is the statistical base of control chart where we follow a flowchart start process d stands for delay, process is going on. There is a decision which is may taken and then it goes.

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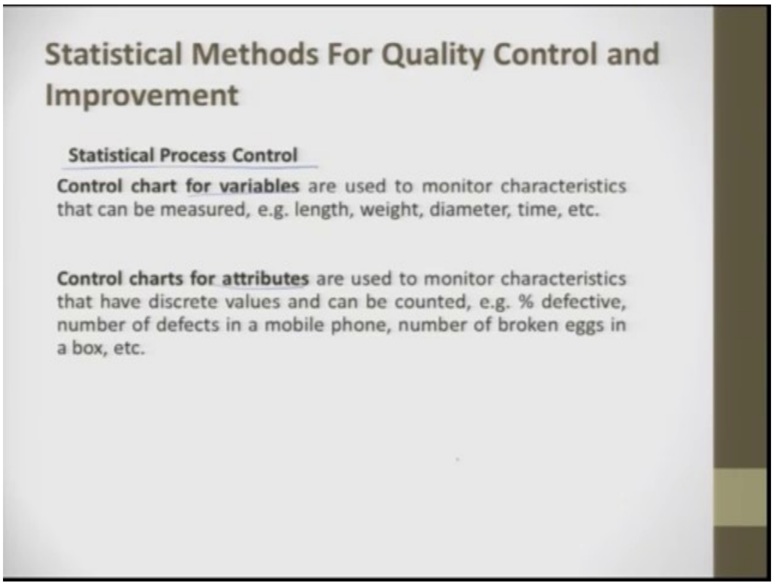


So, when we talk about quality control and improvement statistical process control the control charts are for variables and control chart for attributes are available. When the variables are measurable it is called as we use control chart for variables. When the control charts for attributes we always used with respect to this is whether the yes no factor, something like if the product is working or not working something like that.

So, are used to monitor characteristics that have discrete values and can be counted for example, a cell phone working not working one defective something like that; example def percentage defective of number of defects on a mobile phone, number of broken eggs in a box, etc

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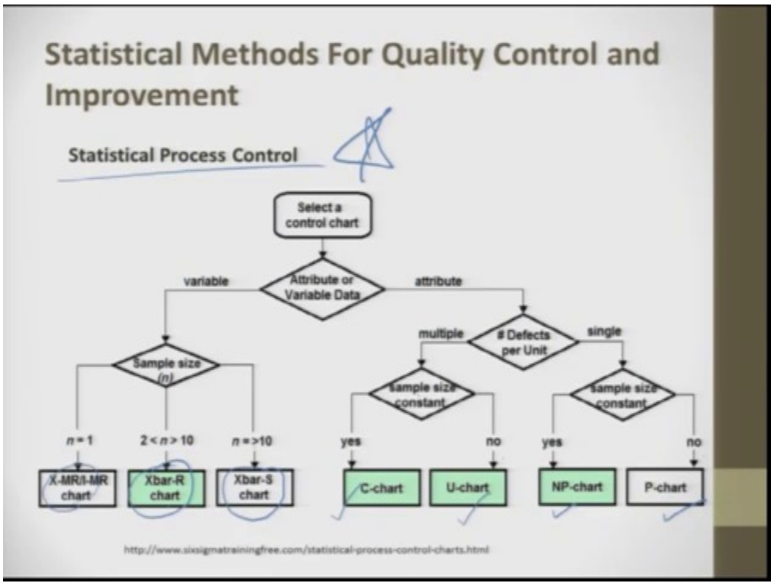


So, Statistical Process Control if you put it in a flowchart you can have variable, you can have attributes, variable you have a sample size and n = 1 you can have this; n = 2 to n = 10 you have X bar chart, n > 10; you will have S bar chart R bar chart S bar chart. So, this is n; n = 1 we do this, n is between 2 to 10 you do this R bar chart and if it is greater than 10 you always go for S bar chart. When you try to do attributes it is single attribute, multiple attributes. In single attribute if it says yes it is an NP chart, if it is no it is a P chart. The sample size constant the sample size constant if it says multiple if it says yes; it is a C chart, if it is no means we use it as a U chart. This is very important chart very important.

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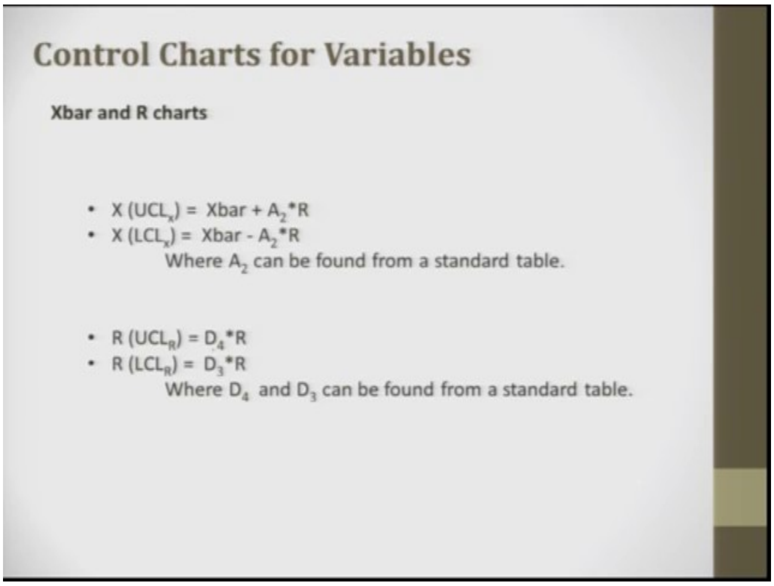


So, here are some of the formulas which are given. So, we are trying to figure out the upper critical and the lower critical value for X bar, upper critical and lower critical for R so all those things. You can expect the problem by I can give you a set of data then ask you to draw a control chart or ask you to find out some value from the control chart or ask you to try to figure out what is the lower critical limit, upper critical limit etcetera, etcetera.

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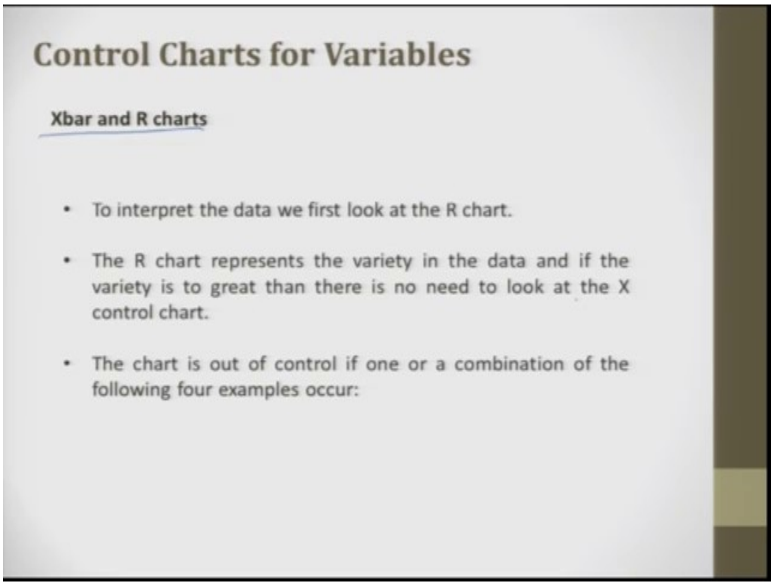


So, I have dealt it X bar chart and R bar chart. X bar chart and R bar chart are here, X bar and R bar 2 to 10 and greater than 10. So, the R bar chart represents a variety in the data and if the variety is to be greater than there is greater than there is no need to look at the X control chart. The chart is out of control then we have to go for this combination.

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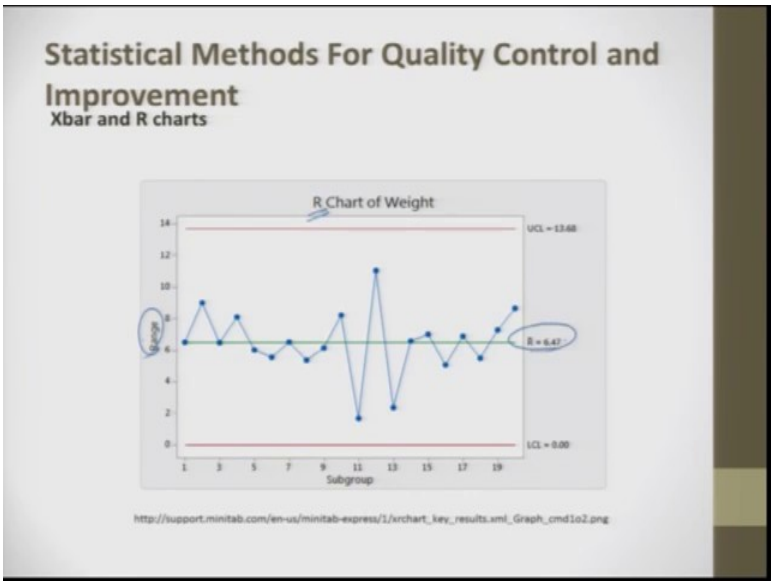


So, this is an R chart. So, you can see the range R bar chart is range is given. So, you see the upper critical lower critical this is the average.

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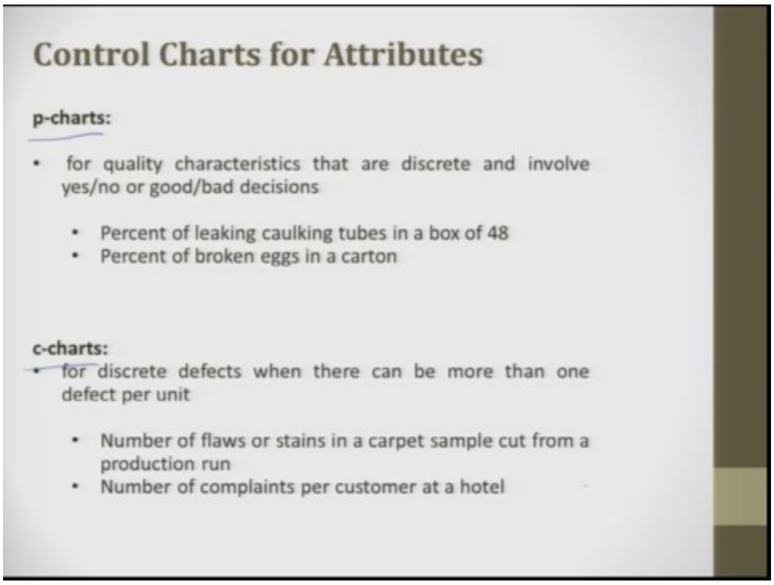


So P chart, P chart and C chart these are all for percentage. Percentage of leaking caulking tubes in a box of 48, percentage of broken eggs in a carton. So, these are all P chart. Number of flaws or stains in a carpet sample cut from a production run. So, that is a C chart number of complaints per customer at a hotel. So, if you go back what is the what C chart, U chart.

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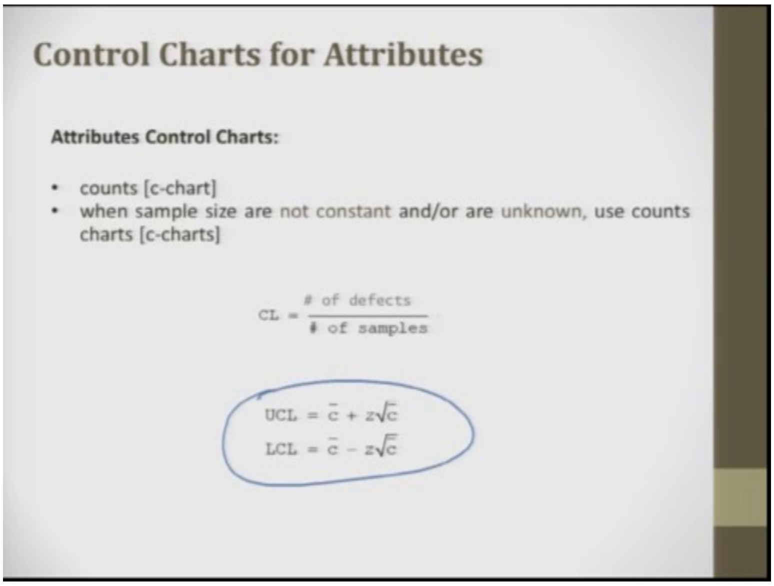


So, the attribute charts how are the formulas done. So, these are the formulas which are used to find out for C chart.

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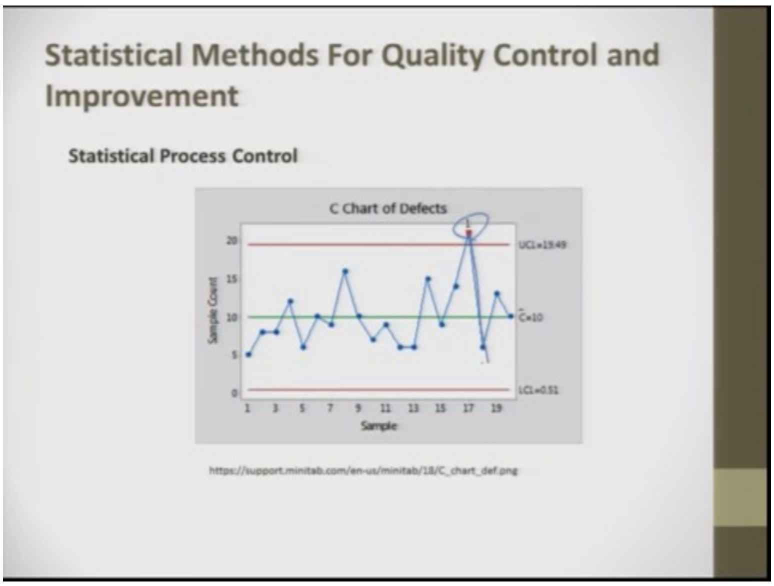


And these are the formula with C chart. So, now this point is gone out of the critical limits. So, before it goes to this point we are supposed to look back at the process and understand and then put it back. So, that it comes back to normal. So here what they have done is they have pulled back the process, reset the process.

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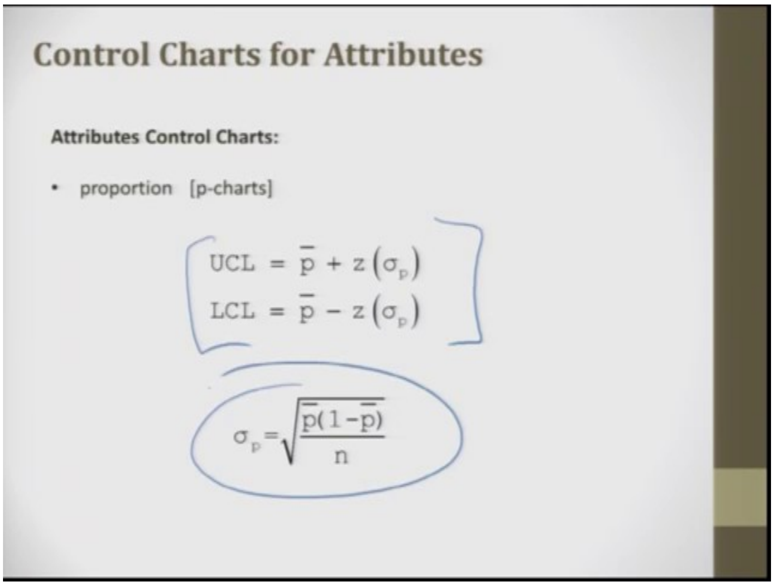


Same way for P chart, this is the upper critical limit, lower critical limit this is how they try to calculate the sigma. So, the CL control limits can be found out by this formula.

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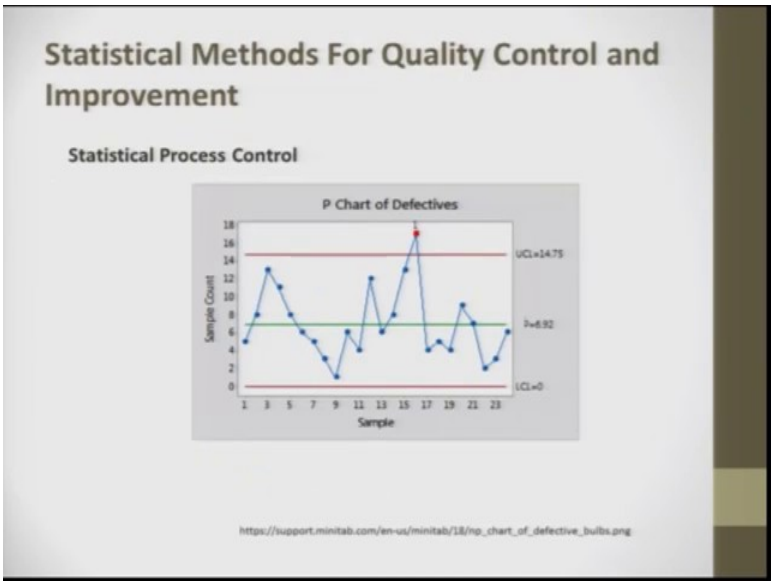


P type again the same pull out is done and then it is come.

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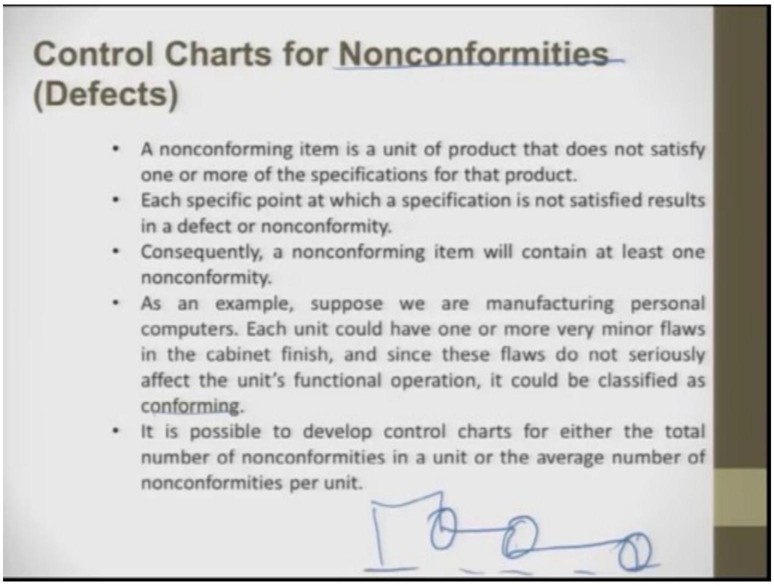


The control chart for non-conformability, Nonconformities so that is defects nonconformities are defects. A nonconforming confirming item is a unit of product that does not satisfy one or more of the specifications of the product. So, that is nonconformity. People always say please submit a non-conformance reports. Non-conformance report means I have given you spec your produce something when I go when I measured it. These are the parameters which did not stick on or which was not seen in your part. So, it is non-conformance.

Each specific point at which the specification is not satisfied results in a defect or a nonconformity point. In fact, you have a shaft and here are some points which where the conformation is not happening. So, this also can be represented in a figure. If you go back to the seven tools defect concentration diagram is that. So, here what we do is we draw the diagram and we try to put in the diagram how many failures have happen in that particular feature or happened or whatever has happened or will happen at that particular feature and then you try to put the numbers.

So, just by looking at the figures I can easily find out where exactly the fault is. So, consequently a nonconforming item will contain at least one non-conformability. As an example suppose we are manufacturing a personal computer each unit could have one or more very minor flaws in the cabinet finish. Since these flaws do not seriously affect the units functioning operation it would be classified as confirming. Nonconforming if it is does not meet the specification. It is possible to develop a control chart for either for either the tool number the total number of nonconformity in a unit or try to take an average.

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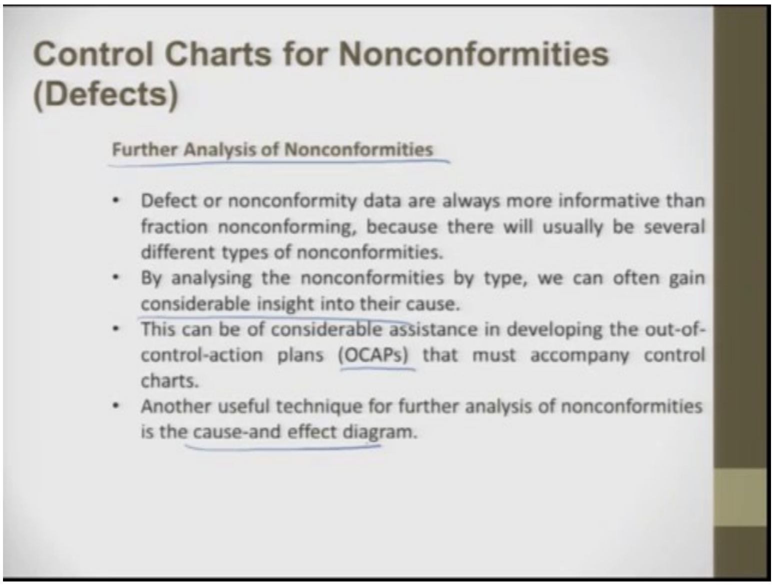


So, further analysis of nonconformities. Defects or nonconformity data are always more informative than fractional nonconforming because they will usually be severe base several different types of nonconformity. By analysing the nonconformity by type we can often gain considerable insight about the defect. So, then we will go to the OCAP chart; out of control action plan chart we revise the process refer it to along with the cause and effect diagram and come out with the solution.

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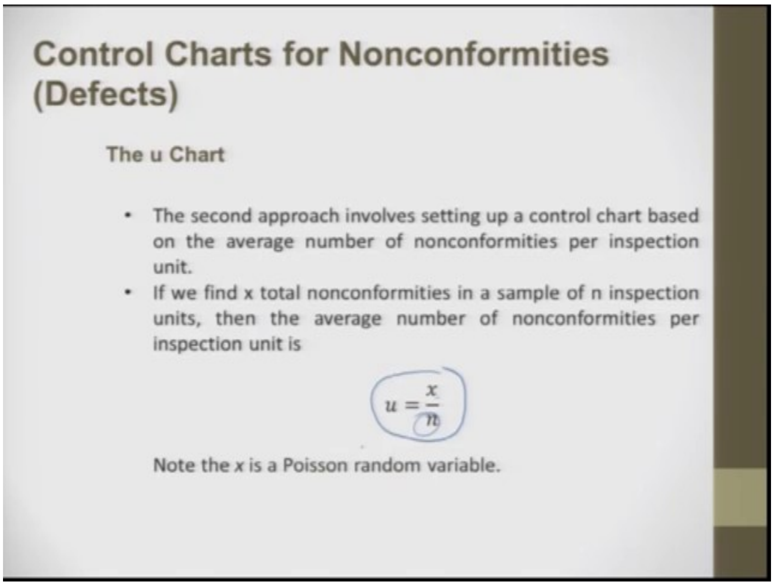


So, it is used by a chart called as u chart. So, the u chart is nothing, but x / n where, x is the total nonconformity in a sample and n is the inspection in a sample of n inspection. So n unit inspection, this is n is number of samples along and x is the total nonconformity in a sample.

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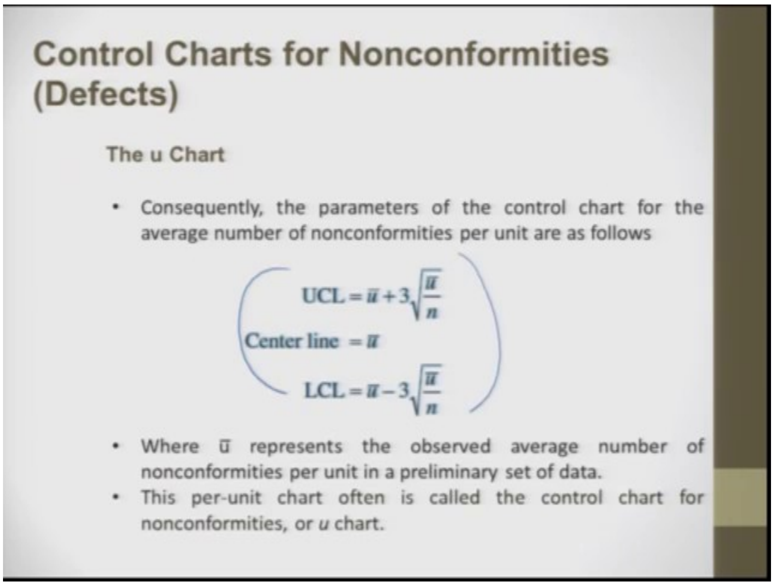


So, you can also have a UCL and LCL for the same and try to do a chart within that.

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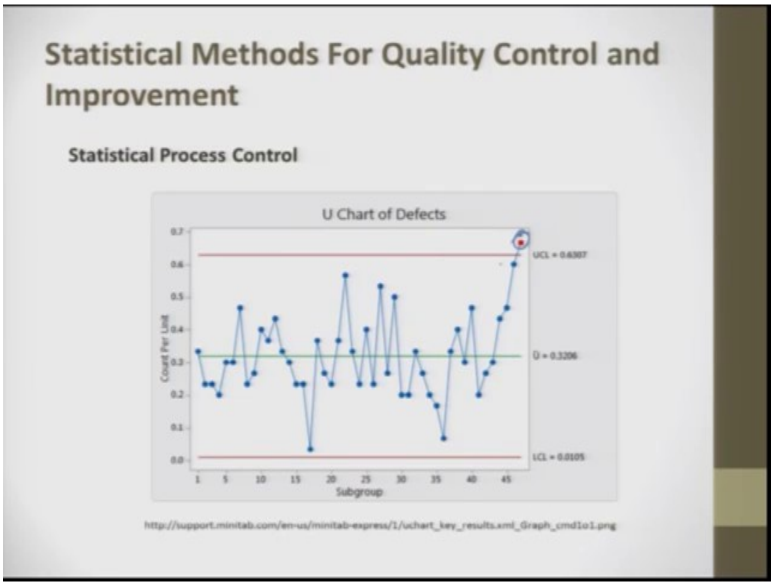


So, currently here it has gone out of control. So now from here what we do is we try to pull it back, reset the process and try to have better control.

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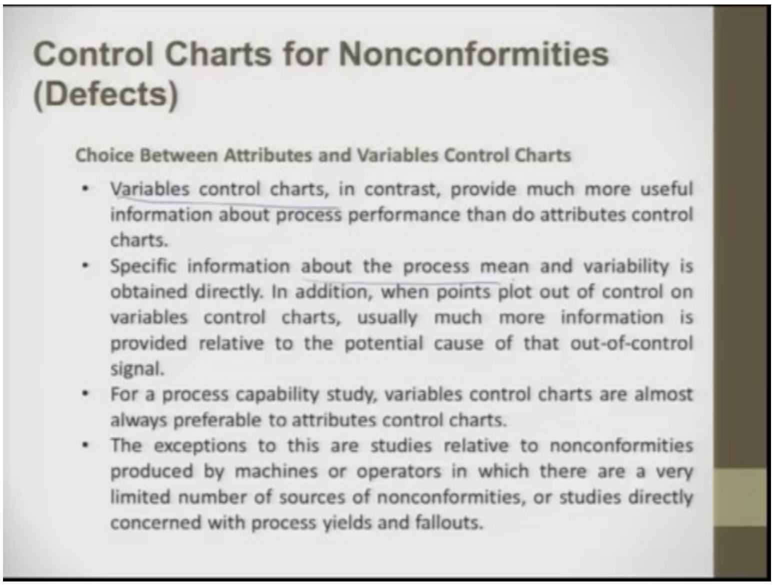


So the choice between Attributes and Variable Control Charts, this is very important. The attributes attribute control chart has the advantage, that several quality characteristics can be considered jointly and the unit classified as nonconforming if it fails to meet the requirements. So, when the when you talk about variables length, height, dimension whatever it is that is variables which can be measured. Attributes are yes and no go no go. So, here there can be so many reasons for it to become no go or so many no go. So, many things are not met the conditions are not met. But still the product is working. So, it will get through. So, so it is attribute control chart is very interesting and it has to be chosen in such a way such that you try to get the exact information out of it.

On the other hand if several quality characteristics are treated as variable, then each one must be measured and either you have a separate or an R chart must be maintained on each or some multivariate control techniques that considering all the other characteristics with the must simultaneously be employed. So, we are trying to take R that is ok. But when you trying to take R, you might have several reasons and if you can make all those reasons are variables you measure it and then do it ok. So, this is the most simplistic technique to do.

The variable control chart in contrast provides more useful information of individual features. It does not talk about the feature; it talks about the dimension of a feature right. The specific in the information about the process mean and availability is obtained directly here. So, this all I have already dealt so, I do not want to go through line by line.

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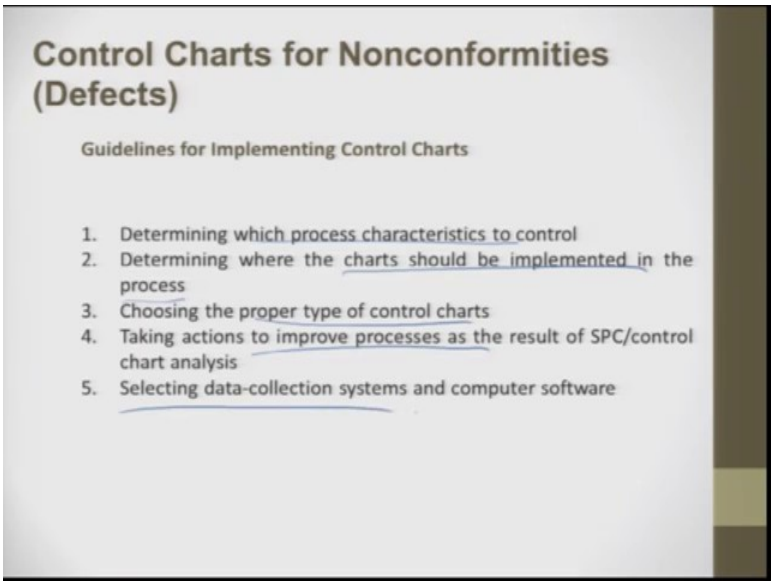


So, guidelines for implementing the control chart. Determine which process characteristics to be controlled. So, before even doing this you should try to figure out those variables where it is considered as controllable variables must only be considered.

If you try to take an atmosphere which is temperature at Kanpur in summer 45 degrees. A temperature at Kanpur during winter, temperature is about 4 degrees. So, temperature is one thing which I cannot control. So, generally what happens we try to take the characteristics of a feature or of a product whatever it is. We try to take that and it has to be a controllable feature and there has to be a proper device to measure the deviation ok. Determine whether the chart should be implemented in the process. Choosing the proper type of the control chart is very important taking action to improve the process as a result of SPC is done then start collecting the data and analysing the data through the software.

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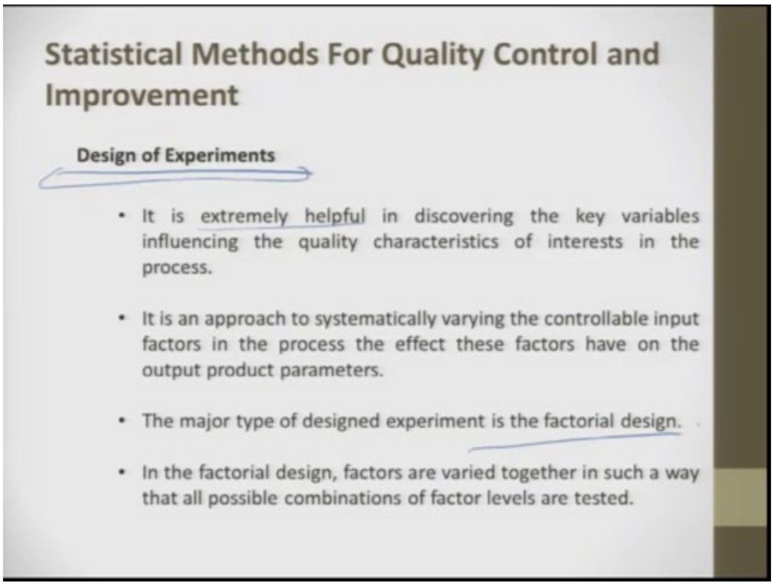


The next important topic of discussion when it comes to the statistical methods for quality control is Design of Experiments. If I have to find out in a process what are the what is the best optimum condition for making this product. So, then I will have to do multiple levels of experiments and then I will come out with the data saying that here are the best process parameters for making this particular product.

So, here what is design of experiment is? I try to design my experiments in such a way such that I try to do lesser number of experiments, but talk more about the more about the process and the levels of the process parameters is called as design for experiments. It is it extremely helpful in discovering the key variables, influencing the quality characteristics of interest in the process. It is an approach to systematically vary the controllable input factors in a process. The major type of design for experiments is factorial experiments. In these factorial experiments the factors are varied together in such a way such that all combinations factors are got.

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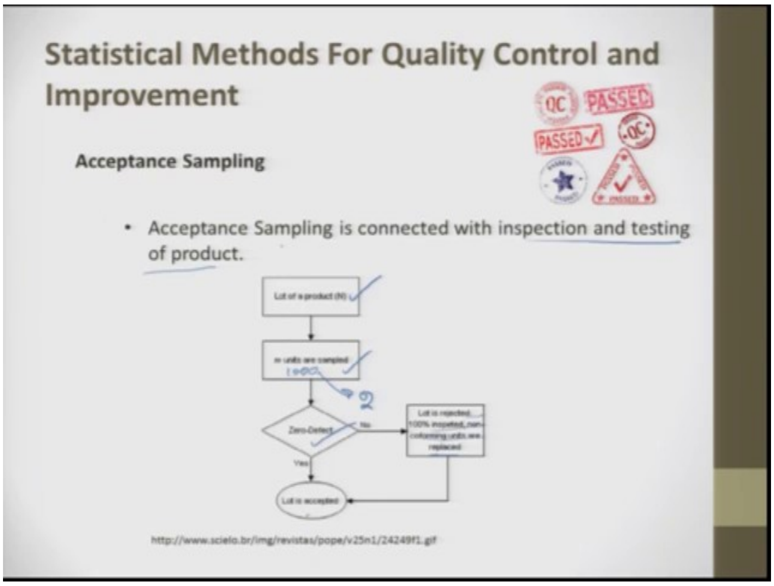


So Acceptance Sampling: acceptance sampling is connected with inspection and testing of a product. So, a lot of product is there; m units are sample zero defects if it is yes lot is accepted. If it is no 100 the lot is rejected, 100 percent inspected, nonconforming units are replaced. So, they do random pick. In the random pick everything is through 100 pieces, there are 1000 pieces the random pick. All the 1000 pieces they check if it is ok. It is the lot is accepted. If the 1000 pieces they have some 2 pieces defective then they do sort out has to be done then you do. So, this is acceptance sampling is connected with the inspection and testing of a product.

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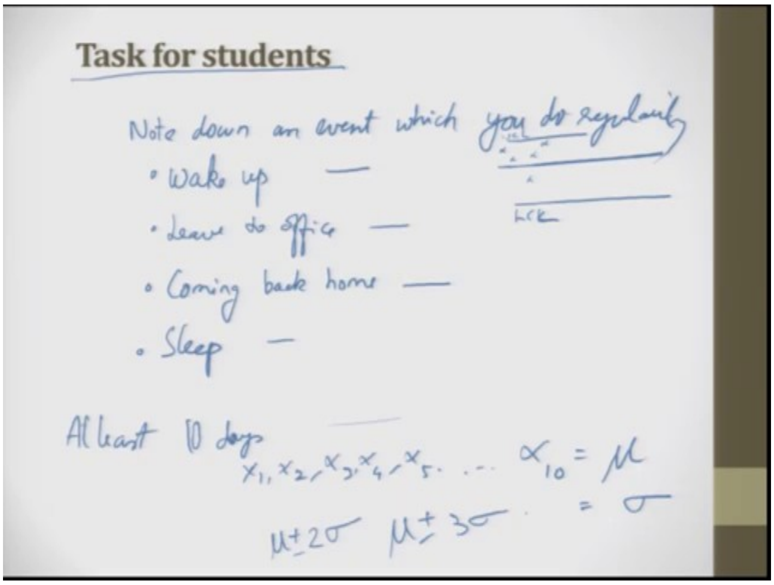


So, the quality test. So, what student is asked to do is, you will try to note down note down an event which you do regularly ok. So, regularly for example, you wake up or you leave to office, coming back home ok. Coming back home and then sleep. So, try to take the data for at least 1 week you try to take the data what time you wake up, what time you leave to office, what time you come back home, what time you sleep. One week you try to take the data.

So, after you try to take the data so then what will happen you will have X one. So, not 1 week you take for 10 days, 1 week is too small. At least 10 days you take. So, you will have X 1, X 2, X 3, X 4, X 5 going up to X 10. So, you try to calculate the mean and then you also try to calculate the sigma for this data. So, then what happens you try to plot a control chart saying that what is your upper critical level? What is your lower critical level? What is your mean and daily at what time you wake up right?

So, if you plot this then you will try to see a naturally occurring event how does this control chart help to improvise. So, when you try to look at this data, so suppose let us assume that you woke up late. Why did you wake up late? Because late night; last night you slept late. Why did you sleep very late? Because I had dinner late; why did you have dinner late? Because I came back home from came back home late. Why did you come back home? I have lot of work in the office. Why did you have work in the office? Because I was just wiling around or I was talking to people when in the peak hours and then I started working late in the evening.

So, now if you look at it by looking at this graph you can try to you can try to backtrack and then find out what all events happen and by asking questions you now know who is the culprit, how have you to improvise your system so that you can try to meet the productivity. So please try to do it for 5 different, 4 different events for 10 days. Plot it try to calculate mean, then try to calculate sigma. Then you decide mu + or ± 2 sigma mu ± 3 sigma.

So, now you can try to tell them how consistent is your process of waking up, sleeping, coming back home or leaving to the office.

Thank you very much.