Decision Support System for Managers
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Module – 10
Decision Support System for Customer Centric Value Driven Decisions – designing the service system
Lecture – 47
Concept of Variability and Six Sigma (Contd.)

Hello and welcome to "Decision Support Systems for Managers"! We are in module 10, lecture 2; ok. In the previous class, we learnt about 'Decision Support System for Customer Centric Value Driven Decisions' and we clearly explained you what do we mean by customer centric; we also explained you what do we mean by value driven.

We took the example of a shoe and we said that the shoe should have very beautiful padding because it is for 8 to; for about 12 hours a day, your entire body weight is resting on that padding that 1 inch or 2 inch padding that customer centric. Then we told you about pronation; overpronation, underpronation and there we showed you how bending forward and backward puts different pressure points on the shoe sole and so, the shoe sole should be designed according to that. That is value driven.

So, customer centric, value driven, decision making; ok. And then we took you to the definitions of quality; ok. What is quality, how is quality measured, we took you on these dimensions.

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Now, these ended here that is scatter plot, control chart, Ishikawa diagram, histogram, etcetera and we gave you the example of what a scatter plotting.

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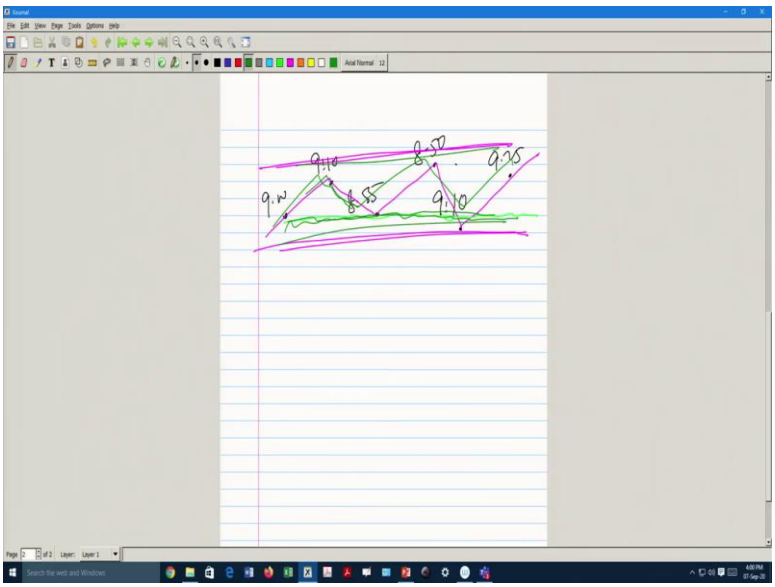

Basically just to have a recap, just to have a recap, this is a scatter plot; ok; this was a scatter plot; now that what we said; ok. What did we say that this was erratic, but if we have a zigzag that helps but this error this erratic part is also within a particular band; ok. So, this is what we mentioned; ok.

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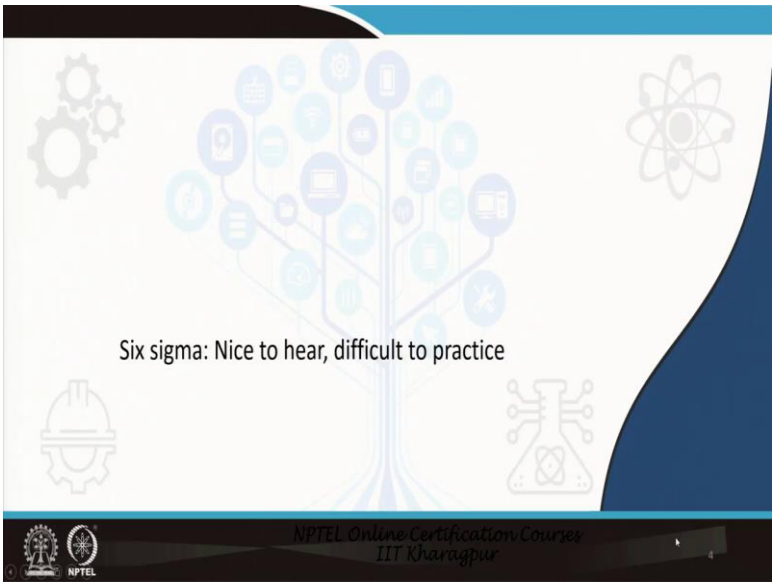

Now, next is Six-Sigma; nice to hear, difficult to practice; very-very difficult to practice; ok; because very-very nice word, beautiful terminology; very difficult to practice. Why? Because lot of control systems, lot of measurements are to be in place; ok.

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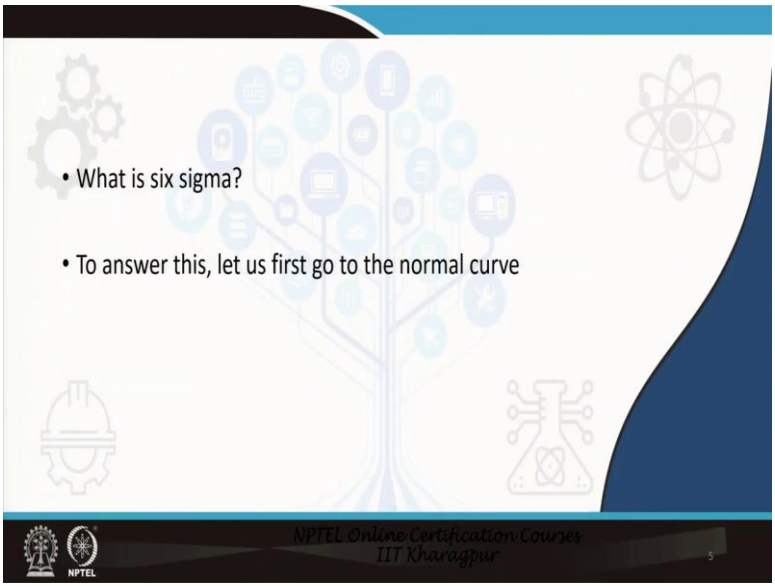

What is Six-Sigma? To answer this let us first go to the normal curve because Six-Sigma directly is better that we answer it in the other way around. Let us first go to the normal curve.

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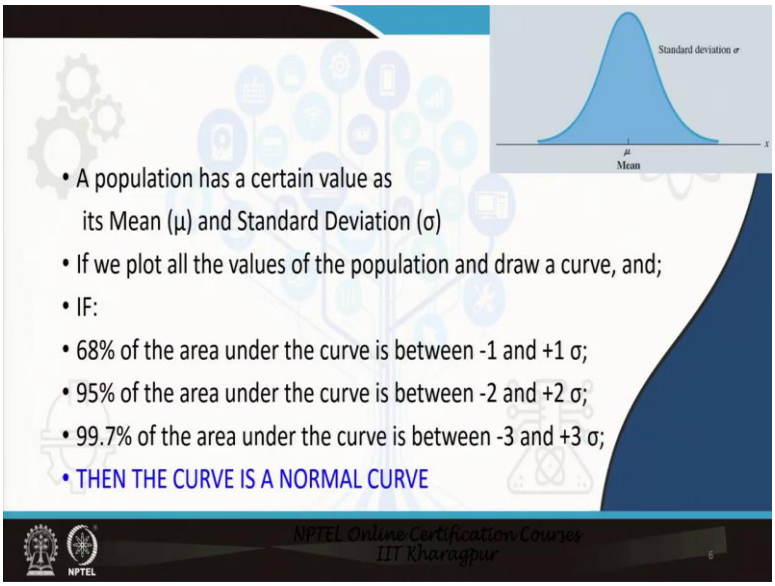

Now, a population has certain value as its mean mu and standard deviation sigma; ok; I am going very slow in this part. A population is certain value as its mean mu and standard deviation sigma; ok. If we plot all the values of the population and draw a curve, let us stop here. What is population?

Population mean does not mean population of the country ok. Say in your office you are doing some survey, among the office employees about something. Maybe some office canteen or maybe a microwave oven whether it is working or not anything, but concerning only the office.

So, what is your population? All employees of the office, population does not mean entire country here for this place. So, all employees of your company is the population. So, population has a average and standard deviation. Say in your office all the employees is your population and this all employees their age is 25, 26, 25, 26, 27, 28.

So, a population; what is an average? Something. So, that is the mu. What is the standard deviation? That is the sigma. So, population has a certain value as its mean and standard deviation; ok.

If you plot all the values of the population and draw a curve ok, let us go to the slide. If we plot all the values of the population and draw a curve, understood; if we plot all the values of the population and draw a curve and if 68 percent of the area under the curve is between

minus 1 and plus 1 sigma, this total area of the curve 68 percent of the area should be between minus 1 and plus 1.

95 percent of the area between minus 2 and plus 2 and 99.7 under the area between minus 3 and plus 3 then the curve is a normal curve ok, clear ok. Let us explain this, what do we mean by this. Let us remember if we plot all the values 68 percent of the area under the curve between minus 1 and plus 1, 95 under the minus 2 plus 2 and 99.7 under minus 3 plus 3 ok. Let us see how to do it; ok.

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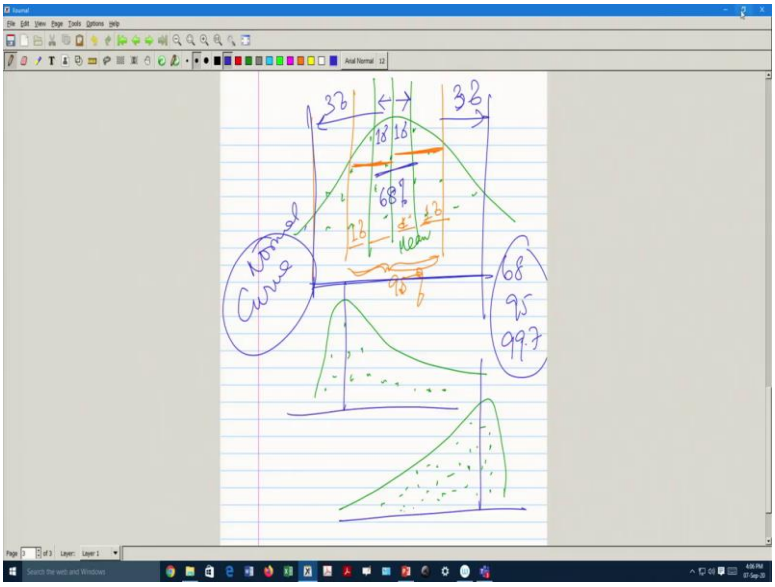

What did we say? We have many values. We have many values and the curve looks like this. Similarly, we have many values. So, what is the curve looking like? This, right. We have many values, what is the curve looking like? This, ok, clear? Now, what we are saying is every distribution has a mean and a standard deviation; every distribution has a mean and a standard deviation. Whatever the distribution may look like that is not a problem.

If 60, this is one standard deviation ok, this is one standard deviation. If 68 percent of the total area, total area is this entire area. If 68 percent of the total area falls under plus 2 and plus 1 and minus 1 this area, if 95 percent fall under another 1 sigma, so, 1 sigma 1 sigma 2 sigma, 1 standard deviation 1 standard deviation ok; so, 2 standard deviation. So, if 95 percent fall under 2 standard deviation and if 99.7 percent fall under 3 standard deviation then the curve is called as the normal curve. The curve may look like anything, curve may look

take any shape. But if that 98 percent rule if this rule 68, 95, 99.7, if this rule applies and the curve is called normal curve from a Layman's point of view; clear.

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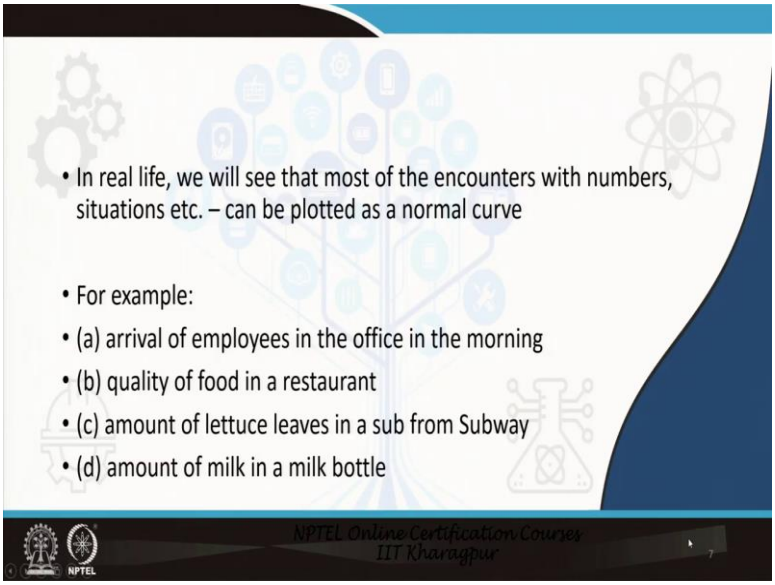

Now, in real life we will see that most of the encounters with numbers, situations, etcetera can be plotted as a normal curve. For example, arrival of employees in the office in the morning, very very important. What is the attendance time? 9 o'clock; some will come 8:30, 8:40, 8:45, 8:50. So, attendance is increasing right, attendance is increasing. When will it reach the peak? At 9 o'clock; some will keep on running 9 o 1, 9 o 2, 9 o 3,

So, then it will come down because most of the people are vented right. So, arrival of employees in the office, same type normal curve. Quality of food in a restaurant: Monday quality is best ok. As you go down to Friday, quality becomes very bad. Amount of lettuce leaves in a sub from Subway, I do not want to mention any brand, but you can go and check. Amount of milk in a milk bottle there is that there is that minor aberrations will be there.

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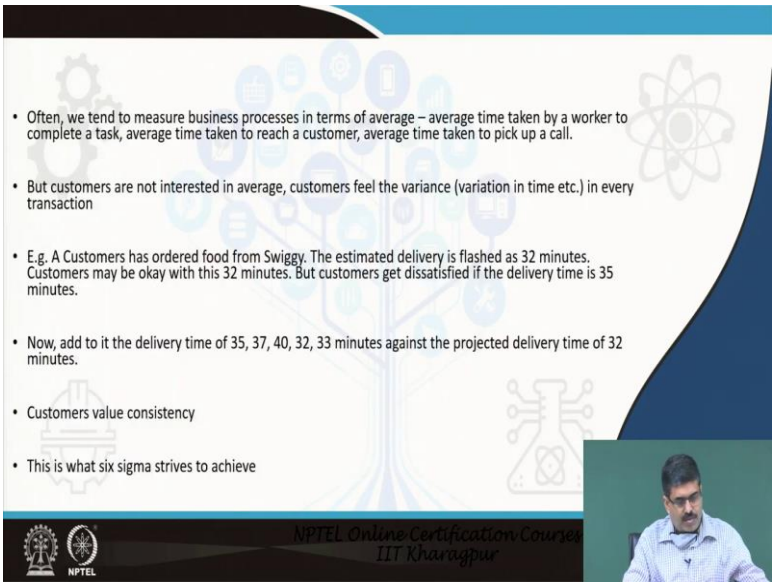

Often we tend to measure business processes in terms of average; average time taken by a worker to complete a task, average time taken to reach a customer, average time taken to pick a call, but customers are not interested in average. Customers are interested in how much variation or deviation was it from yesterday. So, customer is interested in the variance; ok. Customer has ordered food from Swiggy, estimated delivery time is flashed as 32 minutes.

Customers may be with this 32 minutes, but customers get dissatisfied if the delivery time is 35 minutes ok. Now, add to it the delivery time of 35, 37, 40, 32, 33 minutes against the projected delivery time of 32 minutes. Projected delivery 32 minutes, Monday it is taking 35 minutes, Tuesday 37, Wednesday 40, Thursday 32, Friday 33. Tremendous inconsistency, as I was telling customer centric, customer's value consistency, this is what Six-Sigma's tries to achieve.

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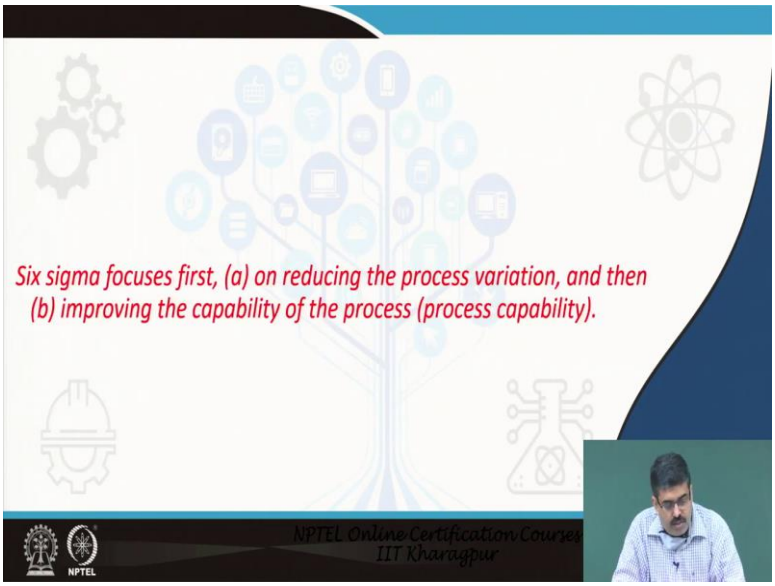

Six-Sigma focuses first on reducing the process variation and then improving the capability of the process. One is process variation you reduce, but then capability of the process is also to be improved, increased.

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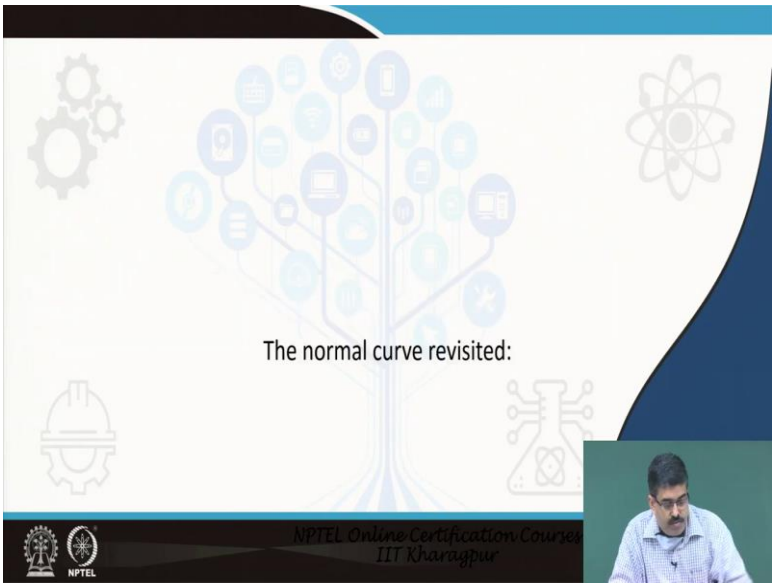

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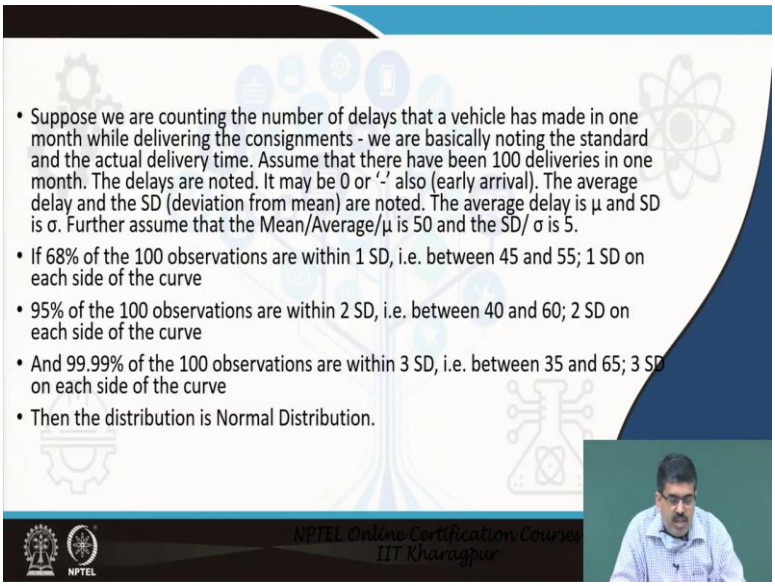

Let us go to the normal curve again. Suppose we are counting the number of delays that a vehicle has made in one month while delivering consignments. We are basically noting the standard and the normal delivery time and this sorry, standard in the actual delivery time. Assume that there have been 100 deliveries in one month, the delays are noted it may be 0 or minus also, means there is no delay early arrival.

The average delay and the standard deviation are noted. The average delay is mu and standard deviation is sigma. Further assume that the average is 50 and the standard deviation is 5. So, if 68 percent is fall within 1 SD between 45 and 50 because standard deviation is 5 [FL].

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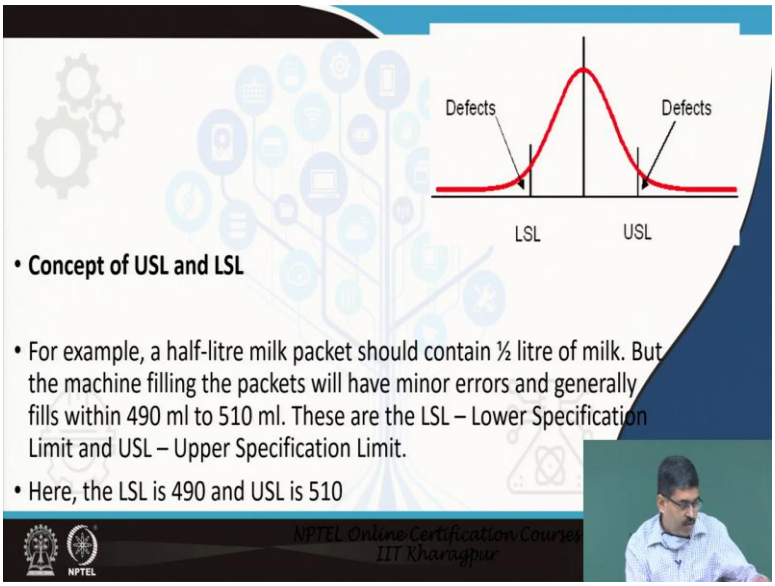

So, within 45 and 55, 40 and 60, 35 and 65, then the distribution is normal distribution. Having said this, remember we had just drawn this graph, the zigzag concept of USL and LSL. For everything there is a least expectation we can say that is LSL and for everything there is a expectation in the higher side that is USL ok, USL and LSL; right.

Are you getting my point or shall I explain again? I think I will explain again ok. You are going to some place. Though in this present times I do not know, but then it is also advisable to stick to your own place unless it is really required to move, anyway. So, fine suppose you are going to some place and you have to go to the nearest railway junction either Mumbai Central or Howrah Station etcetera. If it is Howrah Station then you let be very careful because suddenly you might land up in traffic jam right. You might land up.

So, what is the earliest which you can reach? Your train is at 8 o'clock ok, 8 pm express train always pm. So, the time is at 8 o'clock, 8 pm. So, what is a earliest when you can reach? Given the traffic jam and all you start very early, your houses far away. So, you start early and you reach the place at 6 o'clock in the evening, you just want to be safe that is your upper specification limit.

Though its looks like it is lower, but that is your upper specification limit and if you are if you are certain that you will definitely reach. When will you reach? You will reach at 7:45 that is your lower specification limit, ok, clear. So, that is LSL and LSL.

For example, half-litre milk packet should contain half-litre of milk but the machine filling the packets will have minor errors and generally, fills within 490 ml to 500 ml, 510 ml. These are the LSL, lower specification and USL, upper specification. Here the LSL is 490 and USL is 510; ok.

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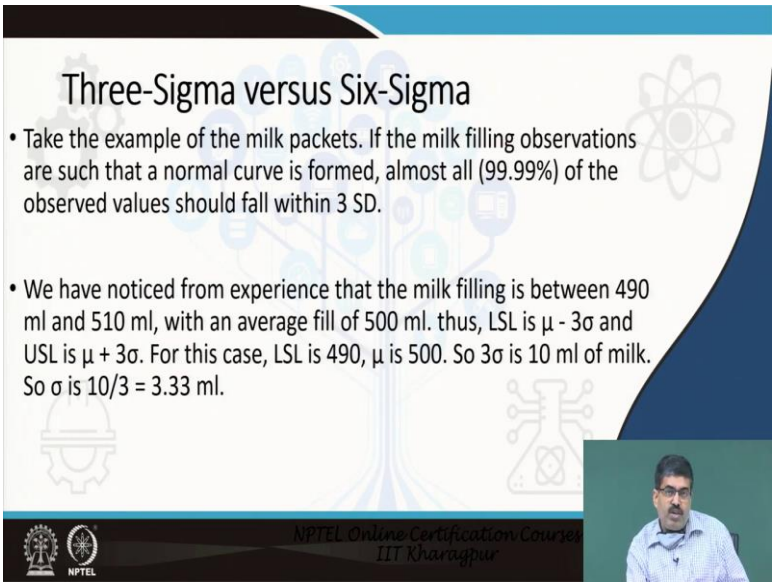

Three-Sigma versus Six-Sigma. Take the example of milk packets. If the milk filling observations is such that a normal curve is formed, almost 99.99 percent of the observed value should fall within 3 SD. We have noticed an experience the milk filling is between 490 and 510 with a average of 500. This LSL is mu minus 3 sigma and USL is mu plus 3 sigma. For this case LSL is 490, mu is 500. So, 3 sigma is 10 ml of milk ok. So, sigma is 10 by 3; 3.33; very simple.

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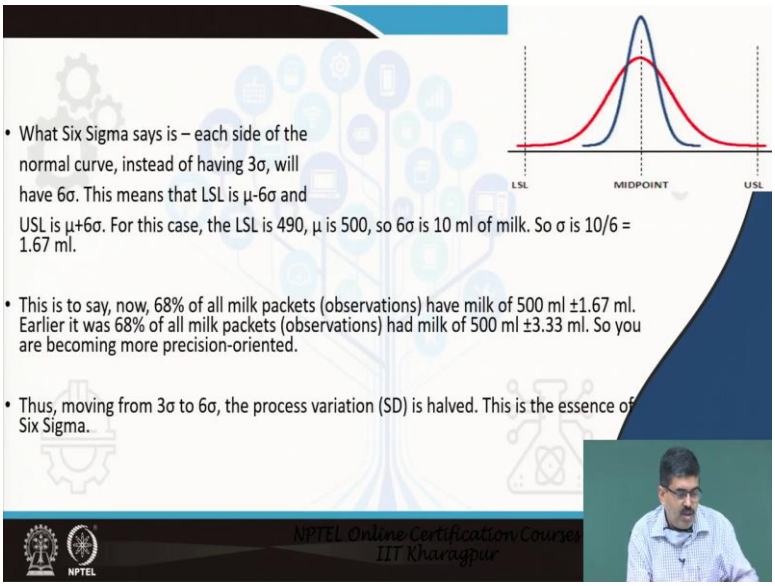

What Six-Sigma says? Each side of the normal curve instead of having 3 standard deviation will have 6 standard deviation. This means that LSL is mu minus 6-Sigma USL is mean plus 6-Sigma. For this case the LSL is 490, mu is 500. So, 6-Sigma is 10 ml of milk. So, sigma is 10 by 6 that is 1.67, ok. That is to say now 68 percent of all milk packets have milk of 500 ml plus 1.67, earlier it was 68 of all milk packets have milk of 500 ml plus 3.33 ml.

So, you are becoming more precision oriented. Thus moving from 3-Sigma to 6-Sigma, the process variation is halved; this is the essence of Six-Sigma.

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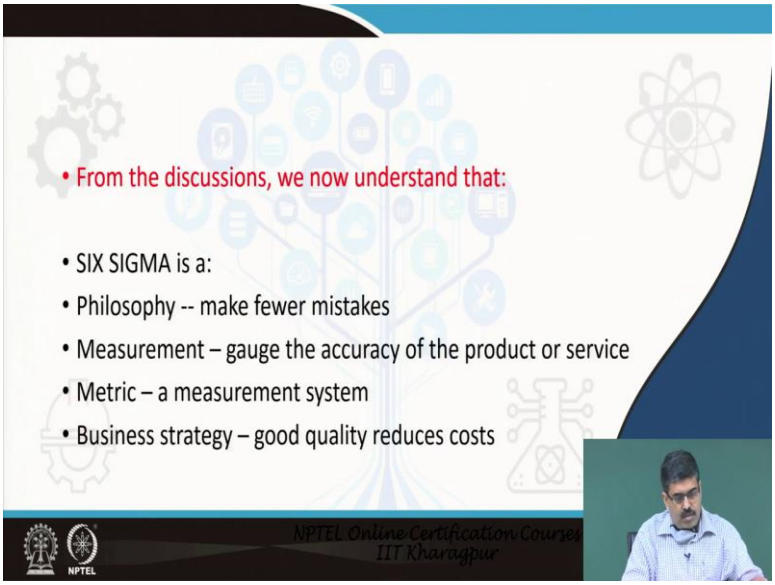

From the discussions we now understand the Six-Sigma is a philosophy - make fewer mistakes. Measurement - gauge the accuracy of the product or service, metric - measurement system, business strategy - good quality reduces cost.

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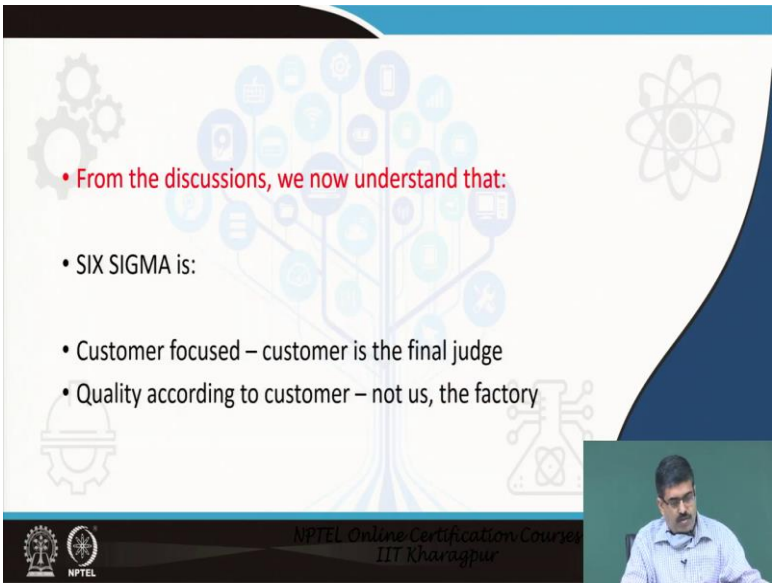

It is a customer focused. Customer is a final judge. Quality according to customer not as the factory. This is what I was telling what do you mean by customer centric value driven.

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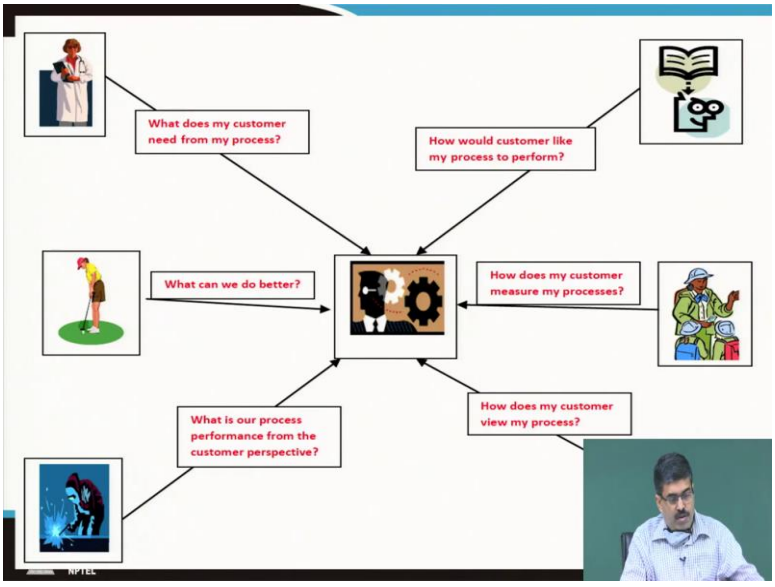

This is a diagram that explains to you the entire arena of Six-Sigma; what does my customer need from my process, what can we do better, what is our process performance from the

customer perspective, how does my customer view my processes ok. So, these are this is these are all the questions that come in.

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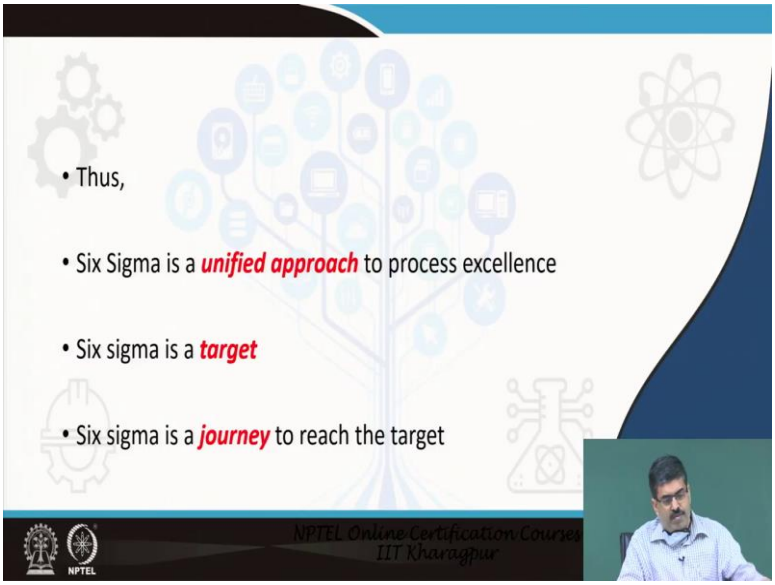

The Six-Sigma is a unified approach; Six-Sigma is a target, is a journey; ok.

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Can you give us a snapshot of areas of application of Six-Sigma?

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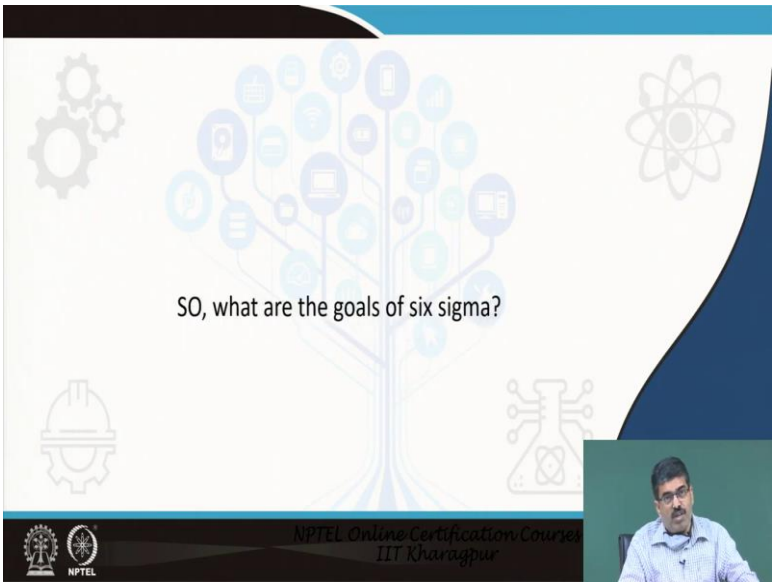

You will see. So, the snapshots are like this you have to think actually, which areas effective, where you can apply. Banks can be one, railways can be one; difficult, but it has to be. So, what are the airlines definitely?

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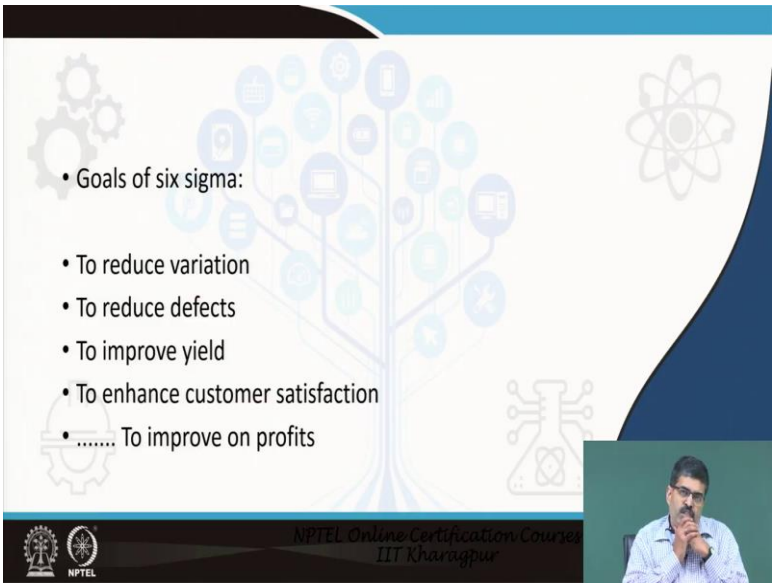

So, what are the goals of Six-Sigma? To reduce variation, to reduce defects, to improve yield, to enhance customer satisfaction, to improve on profits; definitely, to reduce variation. When you reduce variation a defects will also reduce, to improve yield, to enhance customer satisfaction, to improve on profits.

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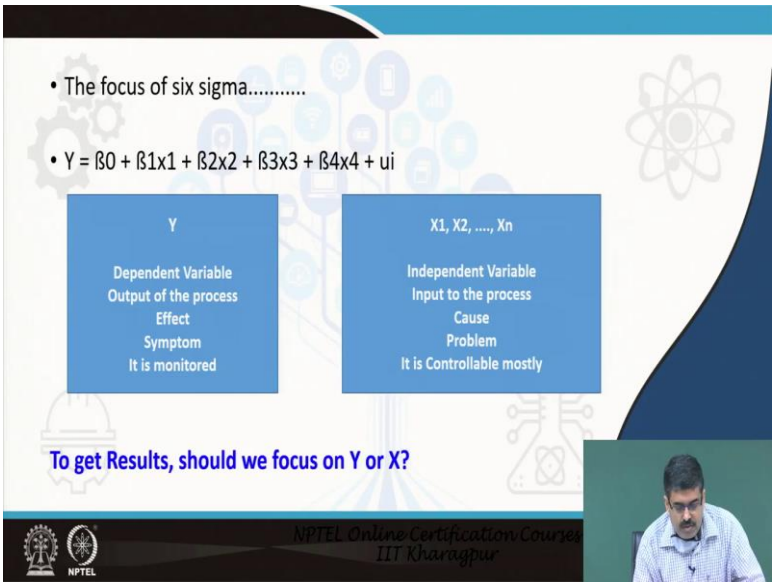

Now, this is the focus of Six-Sigma. Y is equal to beta naught plus beta 1 X 1 plus beta 2 X 2 beta 3 X 3 beta 4 X 4 by ui hat; ui hat is there. Y is dependent variable, output of the process, effect, symptom, it is monitored. X 1, X 2, independent variable, input to the process, cause problem, it is a controllable mostly. So, it is a cause and effect. Now, listen very carefully. Y, X 1, X 2, X n; Y is what? Dependent variable, X 2 is independent.

Output of the process is Y, input of the; X is the input of the process ok. Y is the effect, X 1 is the cause. Y is the symptom, X 1 is the problem ok. Y it is monitored, X 1 it is controllable mostly. To get results should we focus on Y or X? Think over it, to get results should we focus on Y or X. So, the answer is if we focus on Y, Y is dependent on X right. So, you should focus on X.

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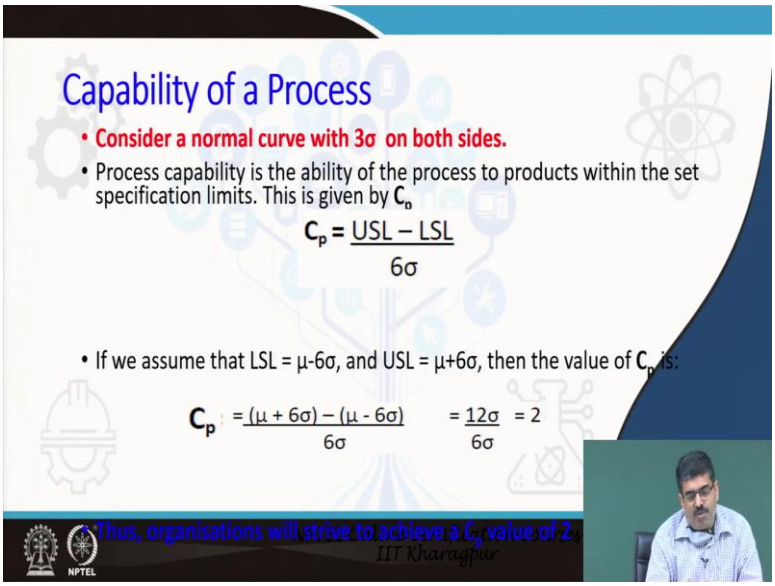

Now, capability of a process. Consider a normal curve with 3-sigma on both sides. Process capability is the ability of the process to produce sorry to produce ability of the process to produce within the set specification limits as simple as that. Your set you have a set specification limit, the milk production example; 510 ml 490 ml; ok.

So, capability of the process is whether the machine will be able to produce within the set specification limit as simple as that and that is equal to USL minus LSL by 6 sigma. If we assumed that LSL is this that C p value will be 2, you can easily measure. You can easily measure.

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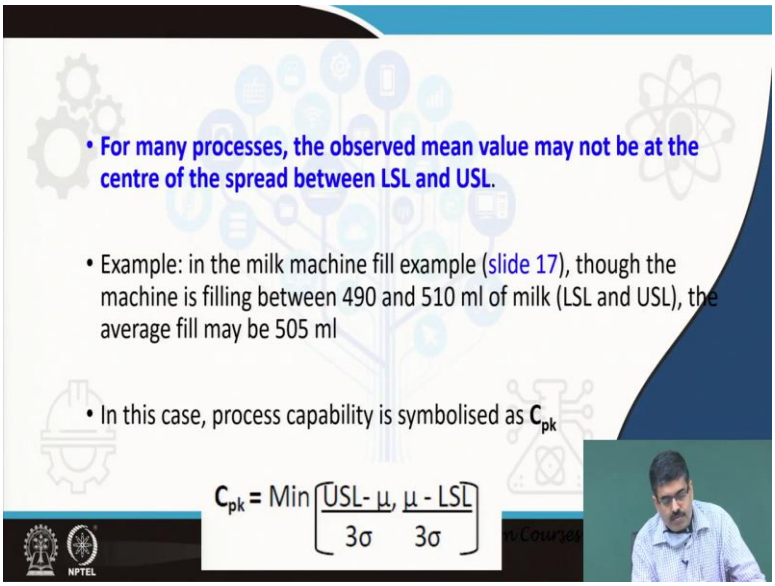

Now, in this example, this, for many processes the observed mean value may not be at the centre of the spread between LSL and USL. Example in the milk filling machine though the slide number is a bit change, though the machine is filling between 490 and 510 ml the average fill maybe 505. In this case process capability is symbolized as Cpk; ok; Cpk min of both these.

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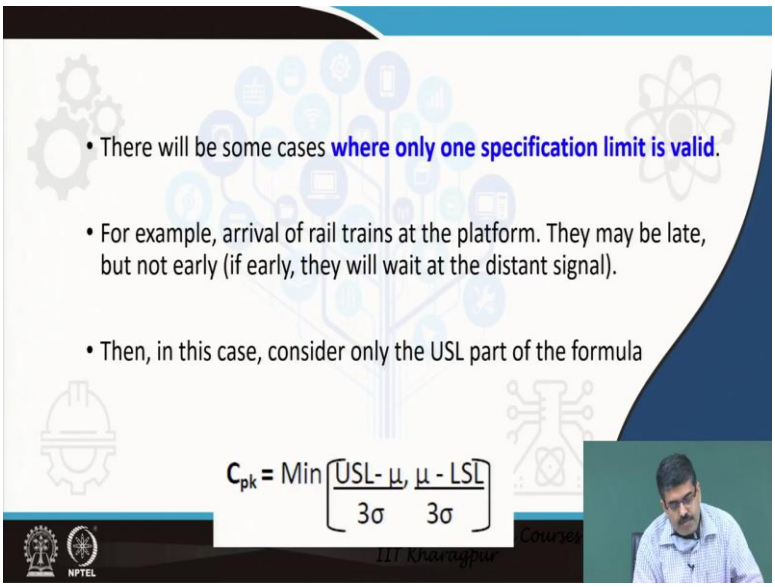

There will be some cases where only one specification limit is valid; ok. So, for example, train late, train early is not valid. Arrival of rail trains at the platform they may be late, but not

early. If early they will wait at the distance signal. Then in this case consider only the delay, upper specification limit part of the formula. Whereas, so, the formula is given by C pk min USL minus mu u mu minus LSL 3 sigma.

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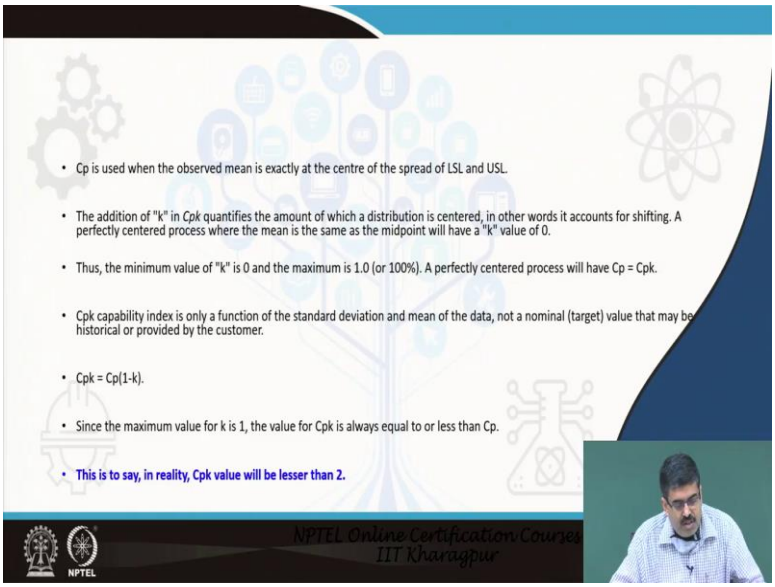

C p is used when the observed mean is exactly at the centre of the spread and C pk when it is not at the centre of the spread. The addition of k in C pk quantifies the amount of which a distribution is centered. In other words, it accounts for shifting. A perfectly centered process, where the mean is the same as the midpoint will have a k value of 0, very simple that is where your C p comes into play.

So, the minimum value of k is 0 and the maximum is 1. A perfectly centered process will have C p is equal to C pk. C pk is only a function of the standard deviation and mean of the data, not a nominal value that may be historical or provided by the customer. Since, the maximum value for k is 1, value for C pk is always equal to or less than C p. So, C pk can never be more than C p that is to say C pk value will be lesser than 2.

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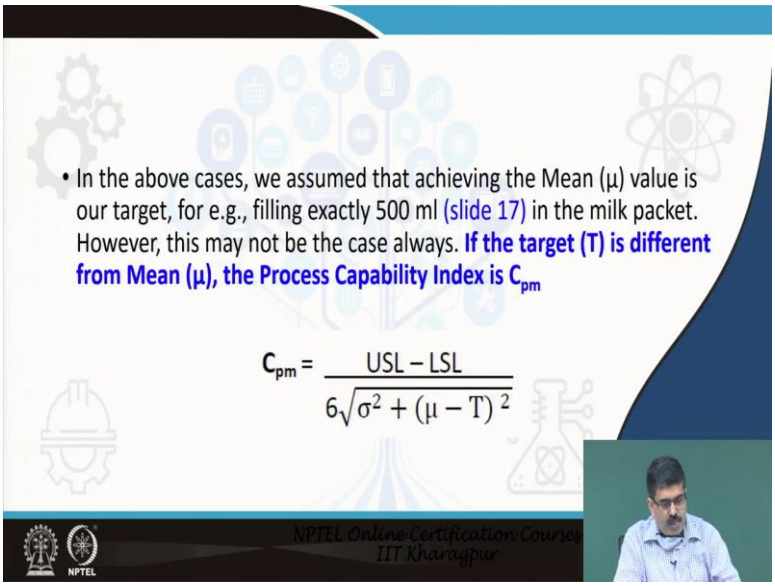

In the above cases we assume that achieving the mean mu value is our target. For example, filling exactly 500 ml in the milk packet. However, this may not always be the case. If the target is different from mean, the process capability index is C is equal to C pm.

For example, we are filling 500 ml is the ideal, but the target may be to fill something else. We are say we are the machine has gone wrong, it should fill 500 it is filling 520. Target is to reduce that filling and bring it to 510 at least. So, we do not lose on so much of milk ok, but what is the target? Sorry, the idea is to reduce it to 510; ok.

So, what is the target? 510. So, if the target is different from mean here, mean was 500 ok, it was filling 520 some cases, but your target is 510 at least or target maybe 500 also, but if the target is different from the mean the process capability index is Cpm; ok.

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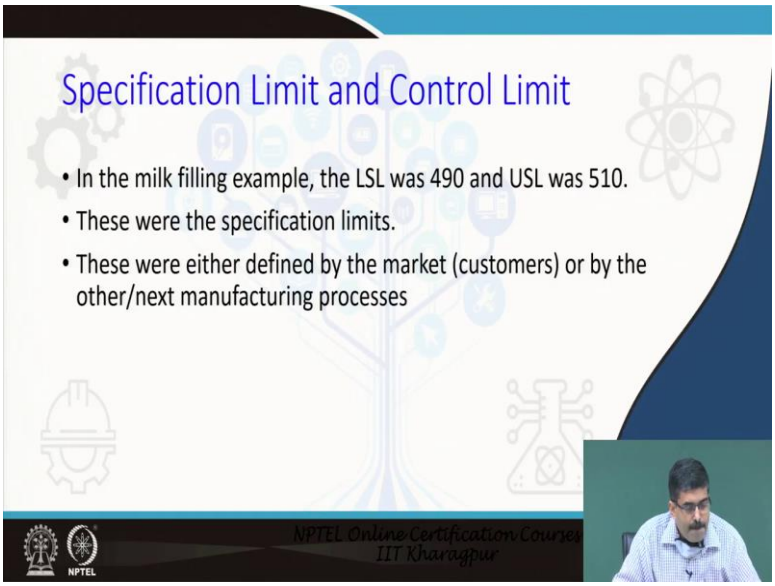

Now, there is a difference, specification limit and control limit. In the milk filling example, the LSL was 490 and USL was 510. These were the specification limits. These were either defined by the market or by the next manufacturing process. So, this was customer driven.

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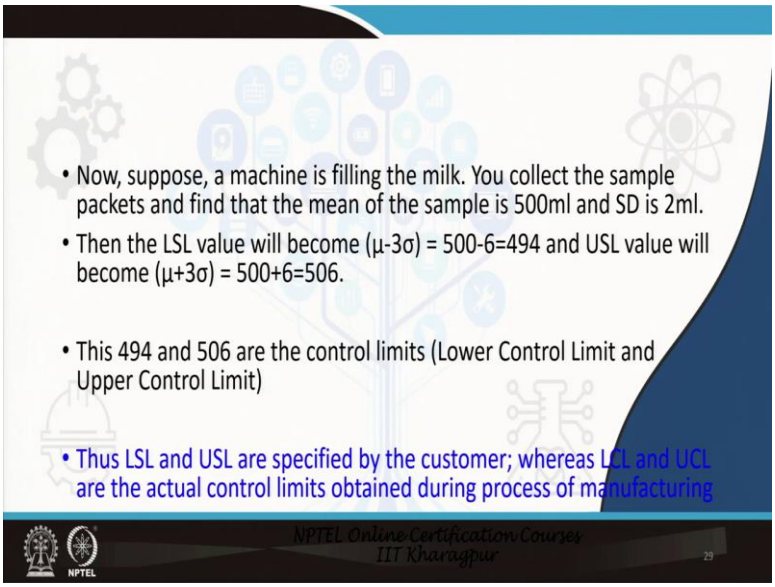

Now, suppose a machine is filling the milk, you collect the sample packets and find that the mean is 500 and SD is 2 ml. Then the LSL is 500 plus 6; mu minus 3 sigma that is 500 minus 6, 494 and USL is 500 plus 6, 506. This 494 and 506 are the control limits; ok. It means what is actually being done by the machine; ok.

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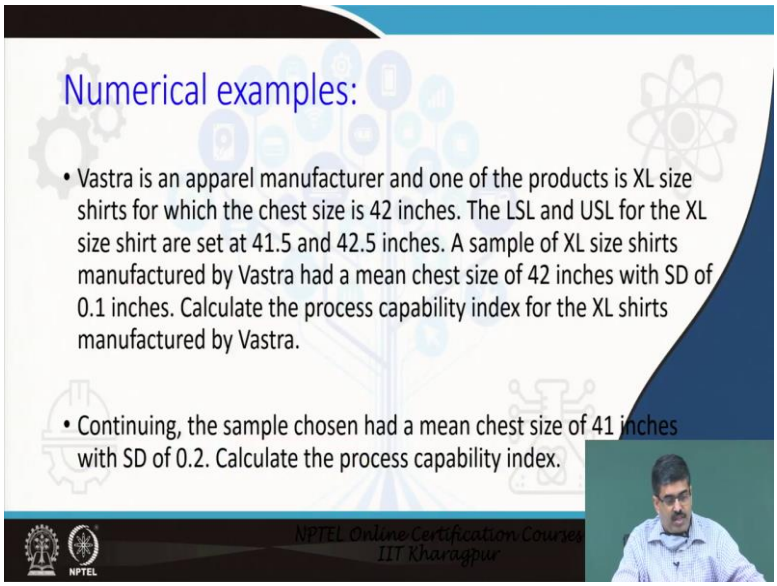

Thus LSL and USL are specified by the customers, LCL and UCL are the actual control limits obtained during the process of manufacturing ok. Numerical example, I think I will just leave it with you like this because you can well see the slide and answer.

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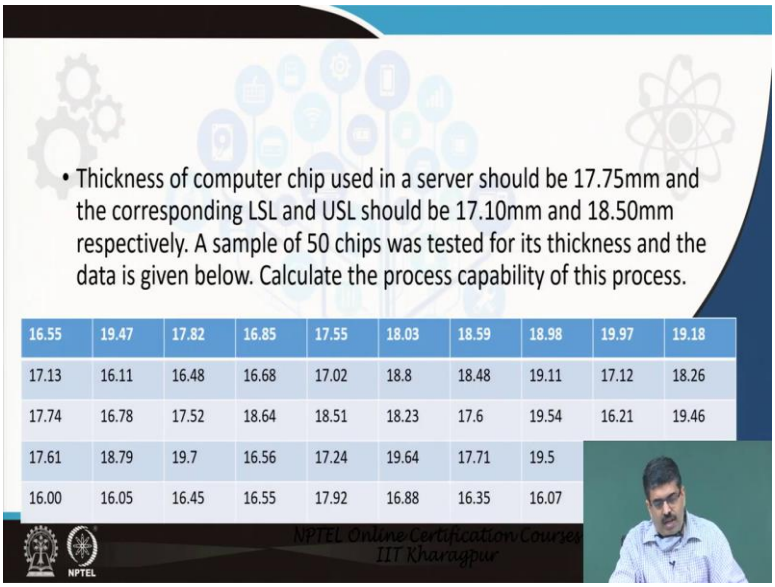

But, I think I have this is another one, thickness of computer chip used in server. This I am leaving this problem also with you, a sample of 50 chips was tested for its thickness and the data is given below, calculate the process capability of this process.

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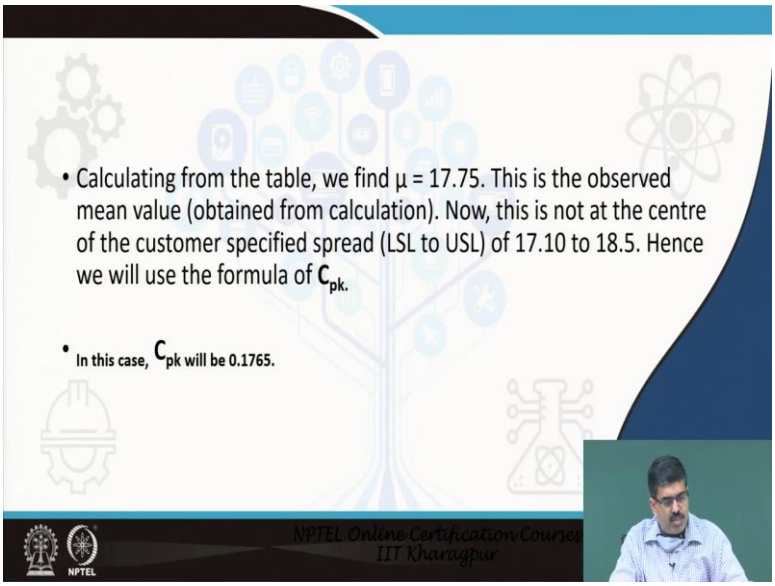

Now, calculating from the table, now this is not the centre. So, you can just have a look at it ok. Now, this is not at the centre. So, we will use the formula of C pk ok. In this case C pk will be 0.17.

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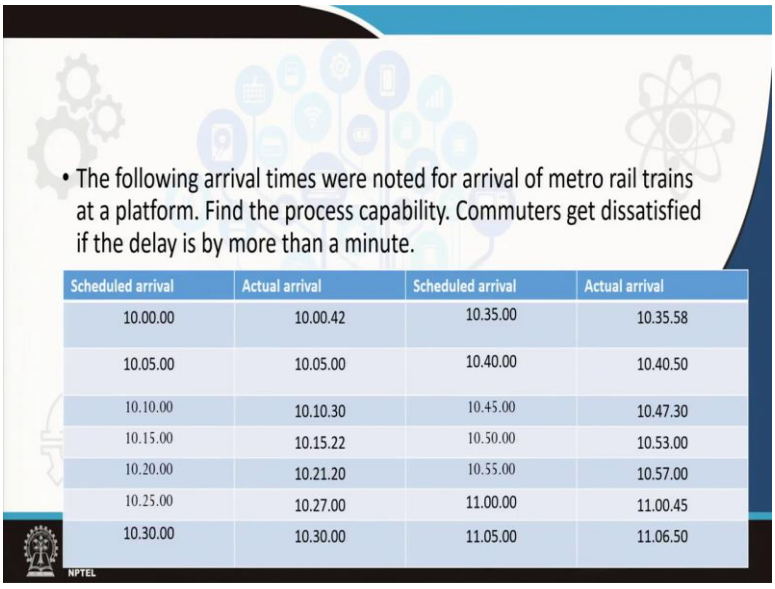

Now, see the following arrival times were noted for arrival of metro rail trains at a platform, find the process capability. Commuters get dissatisfied if the delay is by more than a minute. So, scheduled arrival: 10 o'clock, actual arrival: 10 minutes 42 seconds in next, so, up to

10:30, 10:35. So, scheduled arrival is every 5 minutes, the train should come and there is a delay; ok.

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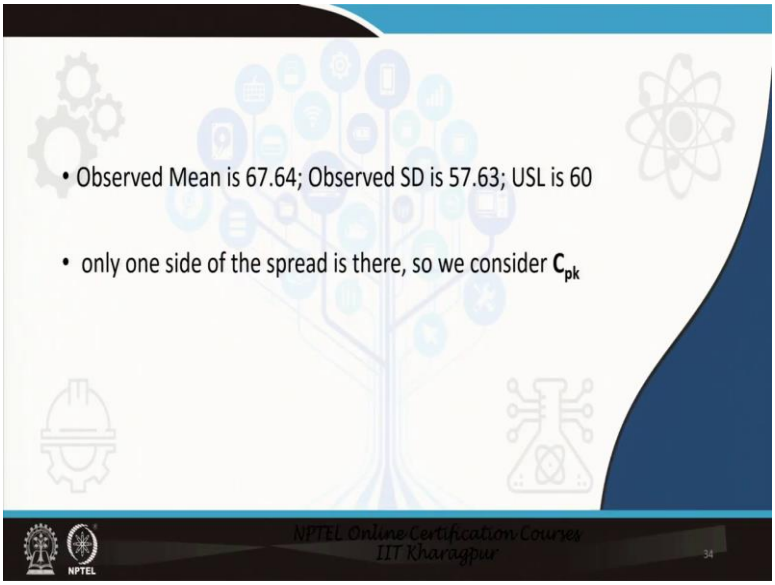

Observed mean is so, when we calculate you will see observed mean is 67.64, observed standard deviation is 57.63, USL is 60 ok. Only one side of the spread is there. So, we consider C pk ok. Now, you have to be very careful with this data because here the time gap is just 5 minutes. So, you will question every data point.

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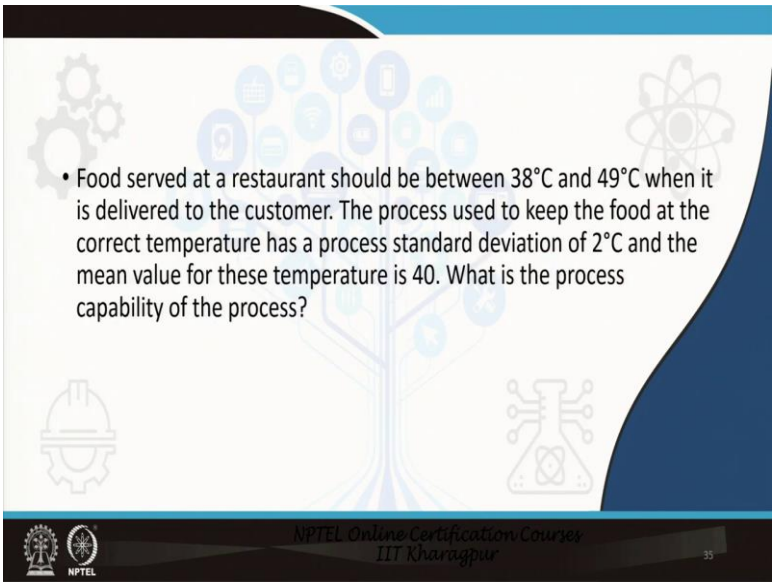

Food served at a restaurant should be between 38 degrees and 49 degrees when it is delivered. The process used to keep the food at the correct temperature has a process standard deviation 2 degrees and the mean value of these temperatures is 40. What is the process capability?

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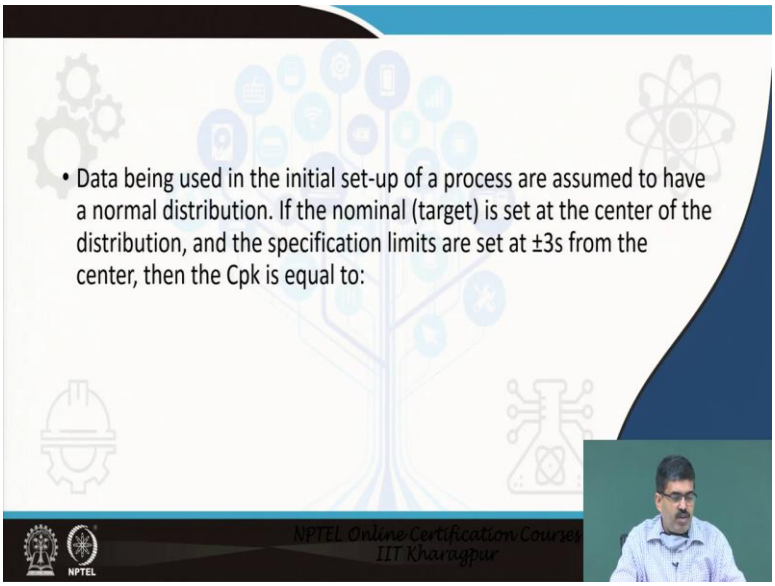

I think these are all very easy. So, you can easily target them; clear.

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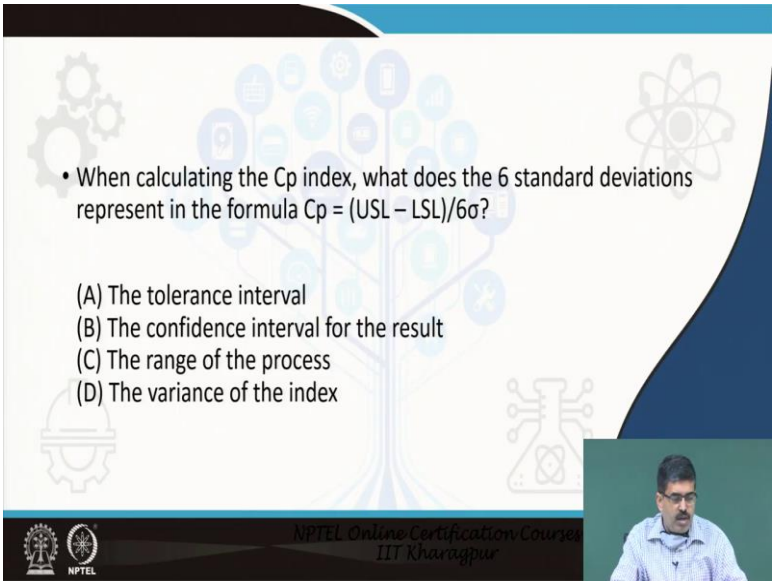

When calculating the Cp index, what does 6 standard deviation represent in the formula? Just as I just put this slide for testing ok, you may try it; ok.

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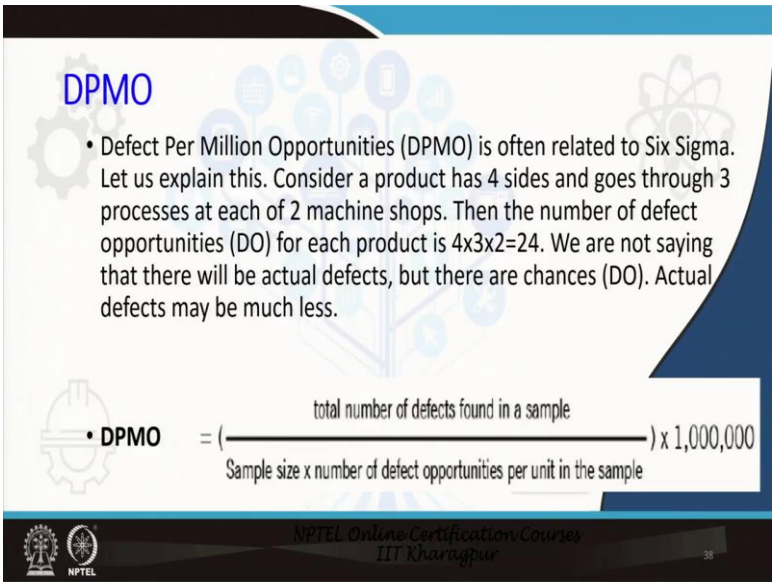

Now, the next is defects per million opportunities, what do you mean by defects per million opportunities. Defects per million opportunity is nothing. It is how many of the; first let us understand what defect opportunities is. Opportunities means defect has not happened, there is chances of defect ok, clear. Consider a product that has 4 sides and goes to 3 processes at each of 2 machine shops.

Then the number of defect opportunities, we are not saying actual defect, opportunities is 4 into 3 into 2; 24. So, defect per million opportunities is total defects by sample size in number of defects per unit in the sample multiplied by 1 million. So, defects per million opportunities ok. I am repeating again.

Total number of defects, so, na by ns something like that. Total number of defects found in a sample divided by number of samples into number of defect opportunities per unit in the sample and multiplied by 1 million.

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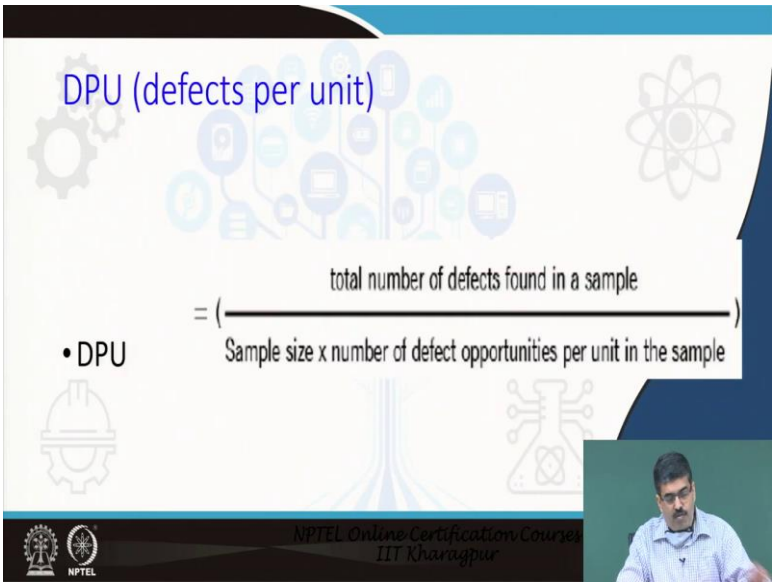

Defects per unit; total number of defects found in the sample; sample size at 1 million is not there nothing else.

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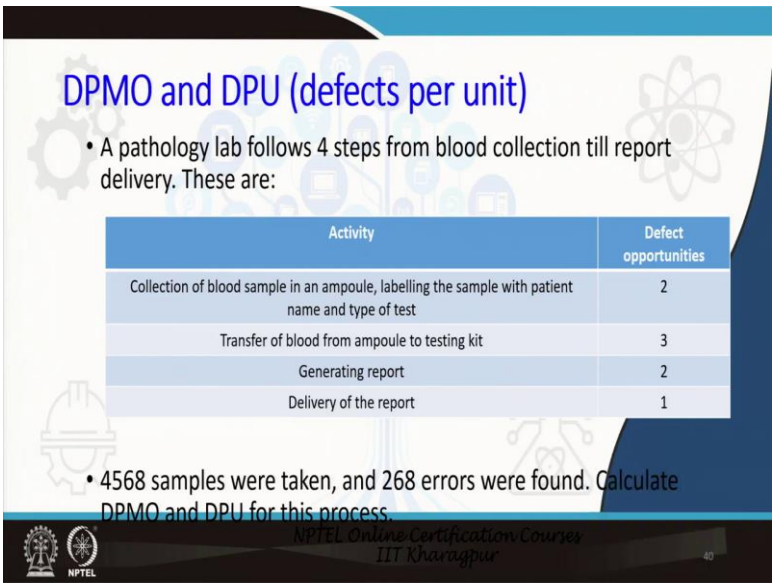

Now, DPMO and DPU; so, you have, you can solve this problem.

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This one we will take in the next module. So, we will just finish off today's lecture; ok.

Thank you! We will pick up in the next module.