Work System Design
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Lecture – 47
Procedure of Work Sampling

Hello friends, welcome to the session 47 of our course on work system design and now our focus primarily has shifted to establishing the standard time for performing a task. If we revise what we have already covered, we have covered the different tools and techniques the various graphical aids that can be used for developing one best method for performing a task. If you remember in most of the sessions.

We have covered the different tools and techniques and try to enhance our skills and learn how to develop a better method of doing the job what are the various tools and techniques that we have understood. We have seen that we can use outline process chart we can use flow process chart, we can use two handed process chart, we can use a multi activity chart, we can use a SIMO chart, we can use a string diagram.

So, all these tools and techniques will help us to develop one best method of doing the current job once that method is established we start our focus on home much time an able bodied operator must take to perform the task using the standard a method. Now our focus primarily is time and if you remember in our previous week of the discussion during the previous week we have seen that there are different techniques.

That help us to establish a standard time for performing the task using the standard method of doing the task using the specified method using the protocol using the standard operating procedure for doing the task. Just if we have to count how many types of tools or techniques are available with us to establish the standard time for performing a task. We have stopwatch type of time study number 1 we have work sampling that is number 2.

We have predetermined motion time systems 3, we have synthetic data which is already existing pre-established data for various work elements which can be added up synthesize it to find out

the standard time for performing a new job. So, we have different tools and techniques which help us to establish the standard time for performing the task or for performing the job or for performing the sequence of jobs.

Now in this week we have started the discussion for the tenth week of our course and in this week our target primarily is to understand work exampling PMTS as well as the synthetic data. The session number 46 we have tried to discuss the basic concept of work sampling and we have seen that in work sampling an operator need not observe the operator or a worker from beginning till the end.

Or the time study analyst need not observe continuously the operator on home is performing that time study. He can randomly visit and see that whether the person is working or he is not working. Whether the machine is working or the machine is idle so one-time study analyst can observe a large number of operators whereas in case of stopwatch type of time study continuous observation is there.

Continuous means that the time study analyst continuously observes the operators whom he is going to time or the operator who has been assigned to him for the purpose of time study. So, there are a distinct advantage that we have related to work sampling but another important point is that if you remember in the previous class we have used a few terms like the confidence interval.

We have used the word statistical so here we have to use the statistical techniques for establishing the standard time. Whereas the stop watch type of time study involves simple mathematics only. We just need to take the readings and then we need to add them average them and then multiply with the rating factor or the performance rating factor then add the allowances. So, only operations that are done are additive, multiplicative, divisive division.

Whereas in the case of work sampling we need to have a just basic understanding of statistics also. So, if we have that basic understanding we can very easily use the concept of work sampling for finding the standard time for performing the task. So, in the last session if you

remember towards the end we have tried to differentiate between a stopwatch type of time study and work sampling and that I feel as a teacher is an important thing for all learners to know.

That where we have to apply the stop watch type of time study and where we have to apply the work sampling approach and the word sampling itself signifies that we are not going to continuously observe the worker we are going to take the random samples of the observations and the observations will be of the type that whether the worker is working or he is idle whether the machine is working or the machine is idle.

So, today we will to try to see as the title suggests the procedure for carrying out the work sampling already we know the difference between the work sampling and the stopwatch type of time study. Let us try to see the procedure for conducting the work sampling so work sampling can be divided into the following three phases.

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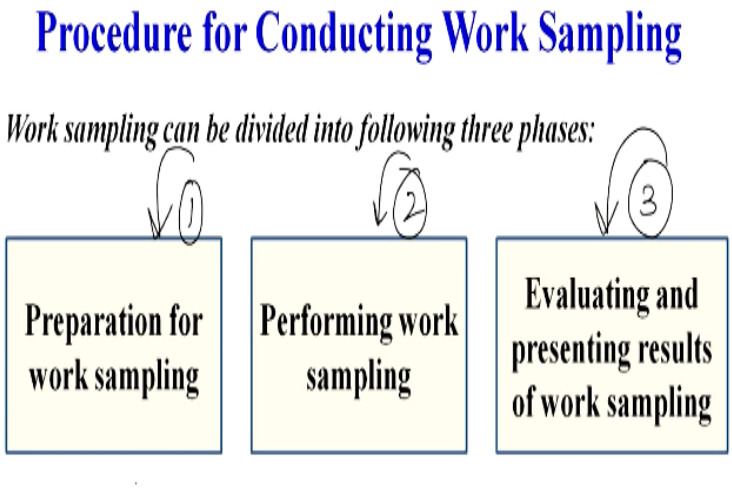

So, the first phase is preparation for work sampling the second is performing work sampling and thirty is evaluating and presenting the results of work sampling. So, basically we are going to move in this direction one phase after the other. So, the first phase is on your screen you can see is the preparation for work sampling which we will try to understand in the subsequent slides.

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So, in preparation for work sampling is the first topic for today.

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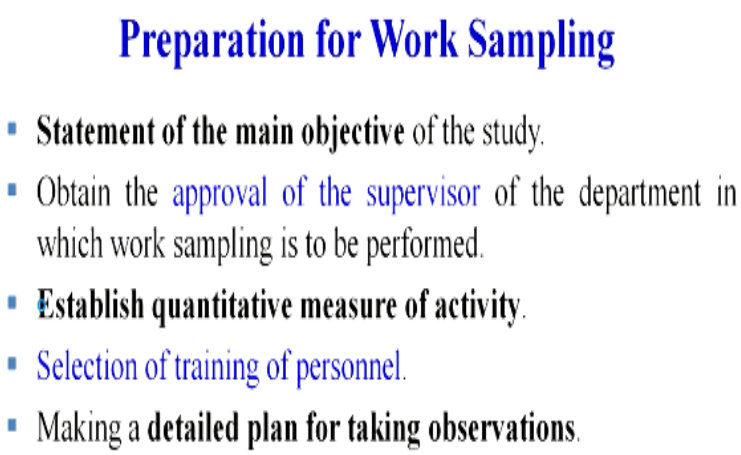

So, preparation of wok sampling what is expected out of us the first thing is statement of the main objective. We must first identify the area the shop department where we have to perform the work sampling. So, first is the statement of the main objective second is obtain the approval of the supervisor I must address here that this is an important point which we all must remember that whenever we are going to conduct a time study.

We must take into confidence the supervisor the manager means that all the stakeholders involved in the process must be taken into confidence. Otherwise we may not get to their desired

results if each stakeholder is not agreeing to or is not in consonance with what is the overall objective of the study I believe that we may not be able to get the desired results He may change deliberately the rate of phase at which he is working.

We may not be able to do the performance rating appropriately so there can be n number of reasons leading to the failure of our time study. So, the most important point is obtained the approval of the supervisor of the department in which work sampling is to be performed. So, this department where we have to work has already been identified in our first stage statement of the main objective of the study.

Then establish the quantitative measure of the activity we have to now quantify the activity or maybe sometimes we may be required to do some prior quantitative analysis before starting the study. Sometimes we may have to predict or we may have to assume that this machine is ideal for this much percentage of time. So, that is just a quantitative background that we are developing for starting or initiating the work sampling process.

So, this we will try to understand with the help of certain examples in our subsequent session that we have to establish the quantitative measure of the activity. Then selection of training of personnel then we have to see that the operators perform the task as per the specified manner or specified protocol or the standard operating procedure then making a detailed plan for taking the observations.

Because here the time study analyst is not going to continuously observe the worker but in this case he is going to randomly observe the worker, he is randomly going to go there and observe that whether the worker is working or not working. So, therefore a detailed plan for taking the observation has to be worked out in the very beginning itself.

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The next is performing the work sampling. In performing the work sampling what do we have to do.

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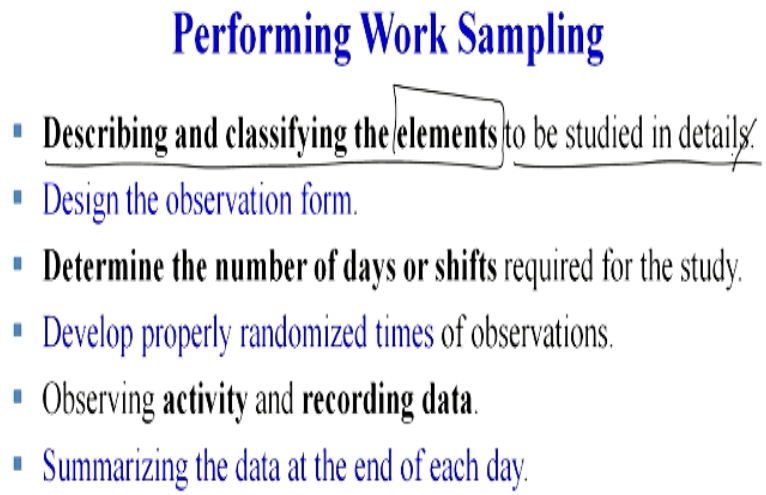

Describing and classifying the elements to be studied in detail. So, we have to first describe and classify the work elements. For example, 3 machines or maybe 2 workers or we may further classify the work also. So, that the classification has to be done in the before we actually perform the work sampling. So, we have to design the observation form which may list out all the elements which may list out all the members.

Or all the workers on whom we are going to perform the time study using the work sampling

approach. Then determine the number of days or shift required for the study. So, basically we will calculate statistically how many observations are required for doing the statistics or for a significantly establishing that whatever results we have got are correct. Now how those observations have to be found out based on statistical formula.

That we will try to understand in the sub sequent slides today and with the help of examples in the next class. So, basically we have to determine the number of days or shift how we will determine that we will be able to determine that through the number of observations required and then once we know that this is that total number of observations required to perform the work sampling.

We can divide those number of observations that every hour this many observations we are going to take. So, we can very easily calculate that this many observations n number of observations can be completed in this much amount of time. So, therefore thereby we can calculate the days and shifts required for the study. So, this calculation of the number of observations is also syllabus for our course.

So, we will be covering it in the subsequent sessions develop the properly randomized times of observations. So, in our previous slide we have seen that the checking or the observation can be random it can be random and also we have seen that in many cases we may also like to go for periodic observation also. So, develop the randomized times of observation then observing the activity and recording the data.

So, basically when we are performing the work sampling we must know how many number of observations are required we must have a data sheet on which we are going to record. We must classify the work elements of the operators on whom we are going to do the work sampling and then we have to physically go at the time study analyst and look but rather the parson is working or he is idle.

Similarly, we have to see that whether the machine if machine also is our subject and we have to understand the idle time for the machine. We will go in to check that whether the machine is

working or idle then once we have observed the activity and we have recorded the data now data can be it can be either working or it can be idle. So, that is another thing that we can record the data then summarizing the data at the end of each day.

So, every day we may summarize so we can have a number of observations which can be total number of observations we can see and for working we can have number of observations when the machine is idle. So, this way we can make a table and we can classify the data that when the worker was working or how much proportion of the time he was working for how much proportion of the time he was idle.

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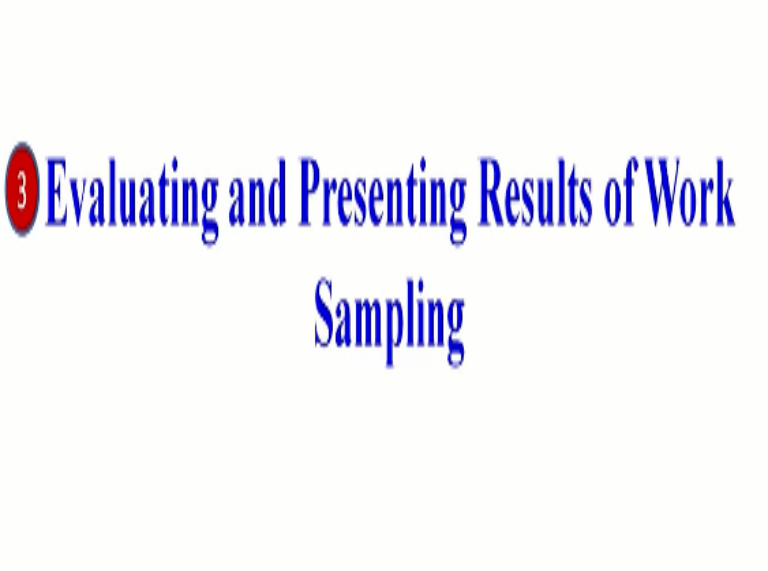

Then Evaluating and presenting results of work sampling.

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Evaluating and Presenting Results

- Evaluate the validity and reliability of data.
- Presenting and analyzing data.
- Planning for future studies.

So, we have to evaluate the validity and reliability of the data sometimes the data may not be correct or may not be truly representing the actual work being done. So, in that case we have to first establish the velocity, the truthfulness the validity of the data and if the data is of very very random nature then we may again go and do another work sampling procedure and try to find actually represent the work being done in the form of the data.

Then we will present and analyze the data and then we can finally planning for the future studies. So, the approach is more or less very very standard so the first is we have to prepare we have to see identify what we need to investigate what we need to analyze using work sampling that is the very first stage maybe while performing we have to feed the data we have to go physically we have to observe, we have to calculate how many number of observations have to be taken.

We have to see classify the work elements for the work being done and finally the when we get all the data we have to see whether the data is truly representing the actual work being done or there is some randomness which cannot be explained and finally we have to present the result and take certain decisions based on the final result. In many cases it can be the standard time which we have calculated using the sampling approach.

And based on the standard time we can do the further calculations related to the number of machines required. The number of man or woman required it can be the how the salaries can be

given to the worker how the bonus can be given how to plan our productions. So, all other decisions can then later on be taken based on the third phase that is the establishment of the results based on the sampling approach.

This is a standard approach now let us see the design of work sampling.

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There are three phases which we have already seen one is before the preparation for the work sampling performing the work sampling and finally analyzing the results established by the work sampling or analyzing the data found out from the work sampling procedure and establishing the results.

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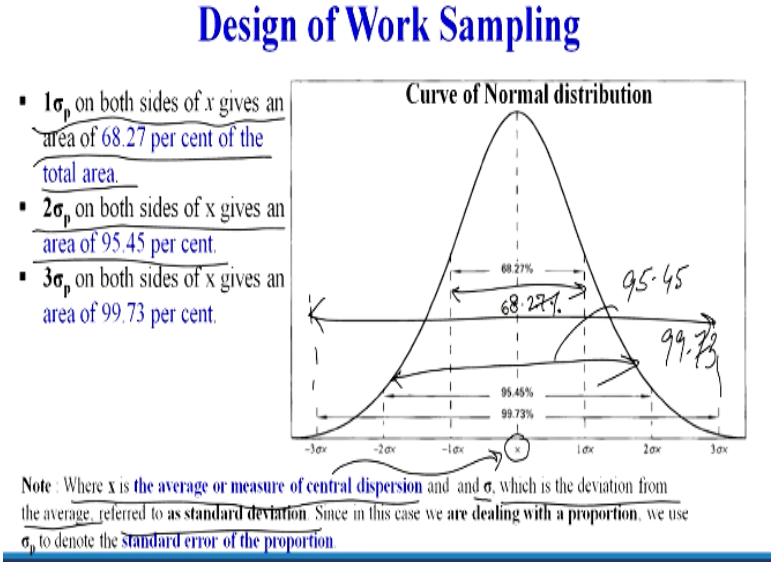

Now design of work exampling let us see this is now the statistical part so if you can see the curve of normal distribution this is a point x here so you can see 1 sigma p on both sides of x gives an area of 68.27% of the total area. So, this is representing that area already is depicted it is 68.27% similarly the limits of 2 sigma p on both sides of x gives an area of 95.45% this is giving 95.45% and 3 sigma limits all of us know about 3 sigma limits.

So, these 3 sigma limits give an area of 99.73% so this normal distribution curve is known to most of us now how it is related to work sampling that we will try to understand. So, where this x is the average or the measure of central dispersion and sigma which is the deviation from the average. So, x is representing the average of the measure of central dispersion this is the average value x and sigma is the deviation of from the average referred as the standard deviations.

All of us know the basic definition of standard deviation since in this case we are dealing with a proportion. Because here if you remember what is a proportion for example a time study analyst goes and checks maybe 10 times in a day or that how many times how many observations the worker was working and in how many observations the worker was idle. So, he is taking now reading so if suppose he goes 10 times and take at random intervals of time.

And take the reading or observation in 2 times you find that the worker was idle, 8 times you find the worker was working. So, we will get a proportion so that is a proportion of the worker

being idle that is 2 times/the total number of observations that is 10. 2/10 so that basically is a proportion with which we are dealing here in a case of work sampling and we use sigma p to denote the standard error of proportion.

So, this sigma p is representing the standard error of proportion so that is our target when we are trying to understand the normal distribution curve specially in case of work sampling approach. Otherwise the standard this normal distribution curve 1 sigma limits 2 sigma limit 3 sigma limits the standard approach which is followed in other aspects of engineering and science also.

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Design of Work Sampling

Calculation of standard error of proportion σ_p *:*

- 95% confidence level or 95% of the area under the curve = $1.96\sigma_p$
- 99% confidence level or 99% of the area under the curve = $2.58\sigma_p$
- 99.9% confidence level or 99.9% of the area under the curve = $3.3\sigma_p$
- For a large 'n' ,number of observations (as a rule of thumb if $n \geq 30$)
- $\sigma_p = \sqrt{\frac{p(1-p)}{n}}$

p = percentage of idle time
$(1-p)$ or q = percentage of working time
n = number of observation

Now calculation of standard error of proportion why we are calling it sigma p what is p I have already explained in the previous slide now we are trying to understand the 95%confidence level which is given here. So, 95% of the area under the curve in that case we will have 1.96 sigma p 99%confidence level or 99% of the area under the curve that is 2.58 sigma p and similarly 99.9% 3.3 sigma p.

So, basically for a large number and which is the number of observations and depicts the number of observations I think n is coming for the first time so we must take into account that wherever the n will come small n in our discussion it will represent the number of observations. So, for large that is large number of observation so as a rule of thumb we say it is a >30. Sigma p can be represented by this simple formula sigma p=square root of p*1-p/n.

And n is the number of observations which is written here p it is given here percentage of idle time and 1-p or q= percentage of the working time. So, it is percentage of idle time*by the percentage of working time/the total number of observation and the square root of this is going to give us the standard error of proportion. So, this we will try to when we do the calculations for the number of observations.

So, basically if you remember we have 3 stages in case of a procedure for work sampling first one is preparation second one is actually performing the work sampling and finally we have to analyze the result. So, one thing that we need to find out in the most of the cases is the number of observations that how many number of observations we must take in order to make statistically significant results.

And another thing is p in many cases in the beginning we have to assume this value of p so that we are able to calculate the value of n and in many cases we have to revise keep on revising the value of p so that our n also keeps on changing and our results become statistically significant after maybe 2 or 3 iterations. So, that is the next level of calculations but today at least we must know that how we are going to calculate the number of observations.

Because these are required to perform the work sampling procedure and already this 95% I assume that most of our learners are well aware of this statistical normal distribution curve and are aware of the sigma p or the sigma limits 1 sigma limits,2 sigma limits +-2 and +-3 sigma limits and if again I can go back to this this is 3 sigma limits which is 99.73 area under the curve 95.45 is for 2 sigma limits it is written here 95.45.

And 68.27 is for 1 sigma limits which is given 68.27 for 1 sigma limits so there may be deviation around the average value or the average or the measure of central dispersion. So, this will be used in our calculations when we calculate the standard time.

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Determination of Sample Size

- The formula for determining the number of observations required is given by
- $p \times S = K \times \sigma_p$
- $p \times S = K \times \sqrt{\frac{p(1-p)}{n}}$
- Where, p = percentage occurrence of the activity(working or non-working) being measured in fraction
- S= error (accuracy) of the activity
- K = a factor depends on the level of confidence
- n= no. of observations required for the desired confidence level

But this is a formula for determining the number of observations required which I have already told it is given to by p*S=K*sigma p sigma p already we have seen this in the previous slide. Now what is p S and K we will try to understand now p percentage occurrence of the activity working or non-working being measured in the fraction. So, this is the p which we have seen that maybe 25 times the worker was found to be idle out of a total of 100 observations.

So, p will become 25/100 and represents the idle percentage so p the percentage occurrence of activity working or non-working being measured in fraction. S is error accuracy of the activity which means we may like to have our results falling in +-5% or we may like to have our results falling in +-10% limits. So, S is the error accuracy of the activity error of the activity which is acceptable.

Then K is a factor which depends on the level of confidence so we can have 95% confidence interval 99%confidence interval 90% confidence interval which we have already seen let me go back and show the confidence intervals again that this is the 95% confidence interval 99% confidence level or 99.9% confidence level and accordingly this parameter give change. So, for a 95%confidence interval K=1.96 for 99.99% confidence K=3.3.

So, accordingly the value of k will change depending upon the confidence level which means that 95%confidence level means that it is estimated it is it can be statistically said that the values

will lie within this sigma limits.

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So, setting performances standards with work sampling. So, then we can see the next stage and the last class in the next session we will cover the next topic in which we will do the calculations. I can understand that some of you may not be having may not be very conversant with this theory that we have tried to cover but when we see the examples the things will become even more clear.

So, 4 important parameters are here one is sigma p, which is giving us the proportion the deviation again sigma p. I can go again go to sigma p just to revise sigma p , the meaning of the sigma p it is a standard error of proportion than your p is the percentage occurrence of activity, S is error +-5% +-10% and K is the factor which depends on the level of confidence. So, these are the 4 things of you must know before we can calculate the number of observations.

Or the standard time for performing the task. Setting the performance standards with work sampling. Now if you remember we have used the term performance rating when we were doing the stop watch type of time study. So, here again we will see procedure to develop performance standard are detailed below.

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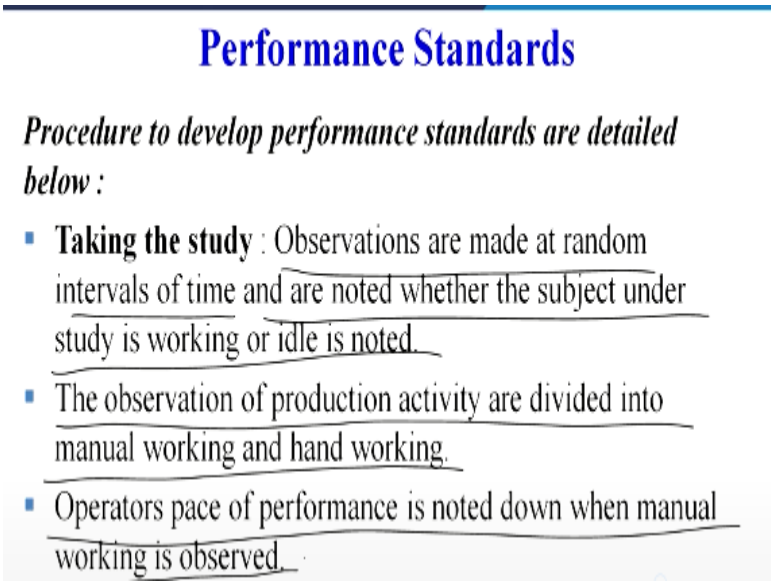

Taking the study observations are made at random intervals of time and are noted of whether the subject understudy is working or idle is noted. The observation of production activity are divided into manual working and hand working. Operators pace of performance is noted down when manual working is observed which means that whenever the machine working is there we ignore the operators pace of performance.

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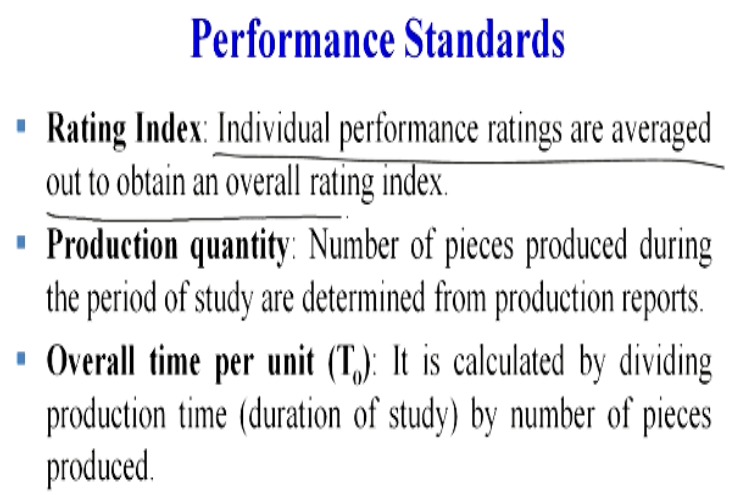

Now rating index is calculated individual performance ratings are averaged out to obtain an overall rating index. Production quantity we can easily get the number of pieces produced during the period of study and are determined from production reports. Over all time per unit it is calculated by dividing the production time or the duration of study by number of pieces

produced.

Now for example 5 days 8 operators are working for 8 hours every day /for example 1000 pieces they produce so that we will be able to calculate the overall time per unit. So, 5 operators 8 working days 8 hour shift 1000 pieces produced so in that way we can calculate the overall time per piece or per unit.

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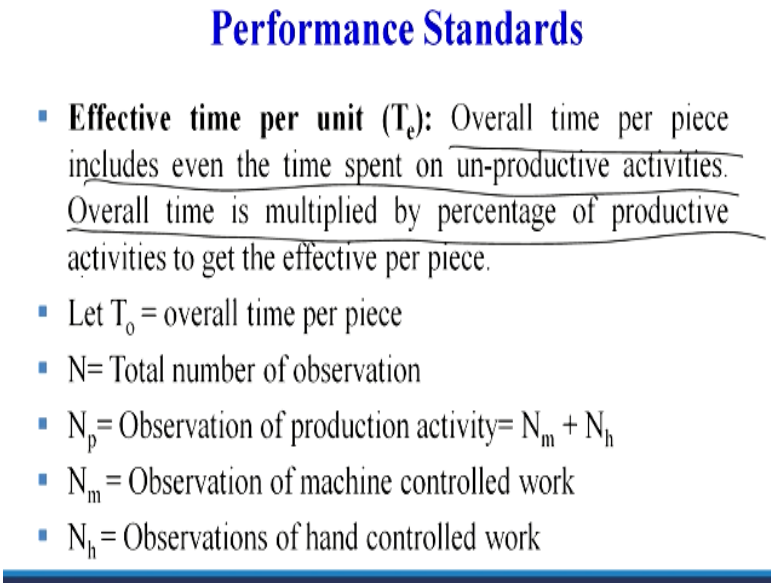

Now performance standards we can see effective time per unit also we calculate overall time per piece includes even the time spent on unproductive activities. Overall time*the percentage of productive activities to get the effective time per piece. If you go back to the previous slide we have calculated the overall time per unit but that may not be the true representative time. So, then we calculate the effective time per unit.

So, there has to be a difference between the overall time per unit and the effective time per unit. So, the effective time per unit is calculated by multiplying by the percentage of the productive activities to get to the effective time per piece. We will ignore the nonproductive or un productive activities or we will take a fraction of the productive activities as compared to the observations total number of observations.

So, let T0 the overall time per piece which was given in the previous slide which we have seen in

the previous slide and is the total number of observations. Np is the observation of production activity that is Nm+Nh that is for machine and this is for hand Nm is the observation of machine controlled work and Nh is the observations of the hand controlled work. So, this is the data which we can record during the work sampling procedure.

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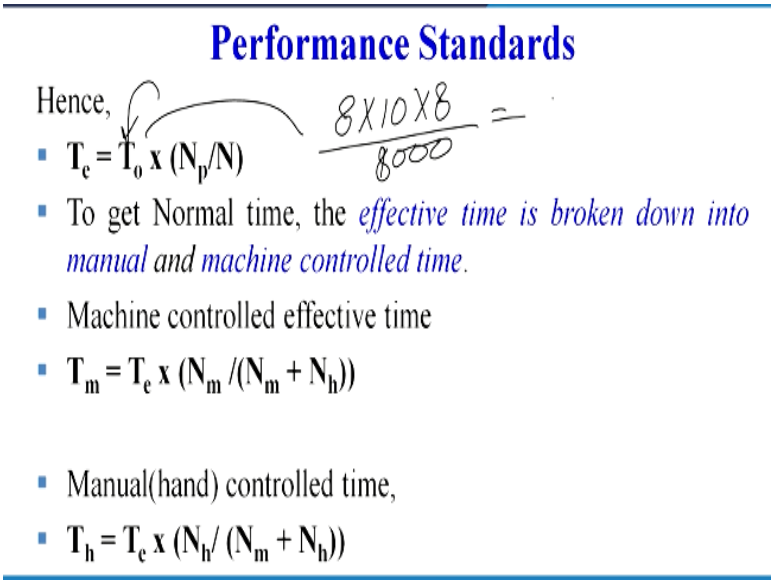

Now we can calculate T T0 already we know I have given an example 8 workers working for maybe 10 days for 8 hours per day/the total number of suppose they produce 8000 pieces we will easily get the T0 that is overall. But then number of productive observations and total number of observations and P and N we have seen in the previous slide what is going to be observational production activity and N is a total number of observations.

So, N P productive/the total number of observation so to get to the normal time the effective time already this is the effective time which we have calculated from the overall time * by the fraction in which the productive observations/the total number of observations. So, the normal time the effective to get the normal time the effective time that we have already calculated is broken down into a manual and a machine controlled time.

So, machine controlled effective time is Tn which you have to calculate the machine controlled time this is the effective time * the observations for the machine when it is working/the total observations for machine and the hand. Similarly, manual hand controlled time that is Th it is

also calculated in terms of the effective time * the observations where the hand work is being done/the total number of machine+ hand observation.

So, this way we can calculate the machine controlled effective time and the hand controlled effective time. So, I think with this we can conclude the todays session in todays session we have tried to see that how to perform a work sampling in as per the standard procedure what are the 3 phases and then we have tried to introduce a little bit of statistics and we have seen that we calculate value called sigma p which is used for further calculation of the number of observations to be done to make the result statistically significant.

So the value of n how we will calculate we will try to see with the help of certain example. So, what are the things required for calculating the value N we require to go and take observation for how much percentage of time for how any number of times the worker is working for how many number of times the worker is not working.

So, we have to take that fraction from there we will calculate sigma p that sigma p relation is we must know that what level of confidence we want to have 95%, 99%, 99.9%. So that will also give us one indicator or one value which will be used for calculation of the number of observations required doing work sampling and the last thing that we need to have is the accuracy level desired that we need to have +-5% accuracy level +-10% accuracy level.

Based on that we will be able to calculate the number of observations that must be made in order to perform the work sampling or in order to calculate the standard time for performing the task. In our next session we will try to solve problems, examples related to work sampling. Thank you.