Prepared by: Assoc. Prof. Dr. Adham MACKIEH

TIME STUDY: TIME STUDY EQUIPMENT; MAKING THE TIME STUDY

Time study, predetermined time systems, standard systems, standard data, and work sampling are used for measuring work in industry.
Time study is the most versatile and the most widely used.
Time standards obtained from these data are used as the basis for company-wide wage incentives.

Definition: Time study is used to measure work. The result of time is the time that a person suited to the job and fully trained in the specified method will need to perform the job if he or she works at a normal or standard tempo. This time is called the standard time for the operation.

Uses for Time study:

Although time study originally had its greatest application in connection with wage incentives, it and the other methods of measuring can be used for many other purposes including:

1. Determining schedules and planning work.
2. Determining standard costs and as an aid in preparing budgets.
3. Estimate the cost of a product before manufacturing it. Such information is of value in preparing bids and in determining selling price.
4. Determining machine effectiveness, the number of machines which one person can operate, and as an aid in balancing assembly lines and work done on a conveyor.
5. Determining time standards to be used as a basis for the payment of a wage incentive to direct labor and indirect labor.
6. Determining time standards to be used as a basis for labor cost control.

Time study equipment:

The equipment needed for time study work consists of a timing device and an observation board.
The devices most commonly used for measuring work are:

1. Stop watch or electronic timer (i.e. decimal stop watch).
2. Motion picture camera (with constant-speed motor drive or with a micro-chronometer in the picture to indicate time).
3. Electronic data collector and computer.

Other equipment:

A speed indicator, or tachometer, is needed where machine-tool operations are studied. The analyst should check speeds and feeds in making a time study, even though the machine has a table attached which gives this information for each setting of the speed and feed-control levers.

Making the Time study:

The exact procedure used in making time studies may vary somewhat, depending upon the type of operation being studied and the application that is to be made of the data obtained.

These eight steps, however, are usually required:

1. Secure and record information about the operation and operator being studied.
2. Divide the operation into elements and record a complete description of the method.
3. Observe and record the time taken by the operator.
4. Determine the number of cycles to be timed.
5. Rate the operator's performance.
6. Check to make certain that a sufficient number of cycles have been timed.
7. Determine the allowances.
8. Determine the time standard for the operation.

Request for a Time study:

A Time study is not made unless an authorized person requests it. Usually, it is the supervisor who requests that a study be made, but the plant manager, chief engineer, production control supervisor, cost accountant, or other member of the organization may make such a request.

- It is the supervisor's responsibility to make certain that the operation is running satisfactorily before requesting the study.

- The supervisor should also see that the operators have thoroughly learned the job and they are following the prescribed method.

- The supervisor should inform the operators in advance that a Time study is to be made, stating the purpose of the study.

Is the job ready for Time study?

The analyst should go over the job with the supervisor of the department. As they discuss each element of the operation, the analyst asks the questions:

1. Can the speed or feed of the machine be increased without affecting optimum tool life or without adversely affecting the quality of the product?
2. Can changes in tooling be made to reduce the cycle time?
3. Can materials be moved closer to the work area to reduce handling time?
4. Is the equipment operating correctly, and is a quality product being produced?
5. Is the operation being performed safely?

Note: The time standard for a job will not be correct if:

1. The method of doing the job has changed.
2. The material does not meet specifications.
3. The machine speed has changed.
4. Other conditions of work are different from those that were present when the Time study was originally made.

The Time study analyst therefore, examines the operation with the purpose of suggesting any changes that he or she thinks should be affected before the Time study is made.

It is expected that the Time study analyst will be trained in Motion study and will bring all possible knowledge in this field to bear on the operation about to be studied.

Any suggested changes that the supervisor wishes to adopt should be made before the study is started.

The supervisor of course makes the decision as to the way the job is to be done, but the analyst and the supervisor should discuss each element of the operation and should agree that the operation is ready for a time study.

Making the Time study:

1. Recording information.
2. Dividing the operation into subdivisions or elements.
3. Listing the elements in proper sequence.
4. Timing the elements with the stopwatch and recording the readings.
5. Determine the number of cycles to be timed.
6. Noting and recording the operator's tempo.
7. Making a sketch of the part and the work place.

Reasons for element breakdown:

1. One of the best ways to describe an operation is to break it down into definite and measurable elements and describe each of these separately. These elements of the operation that occur regularly are usually listed first, and then all other elements that are a necessary part of the job are described. The beginning and end points for each element may be specifically indicated.
2. Standard time values may be determined for the elements of the job. This makes possible, to determine the total standard time for an operation.
3. A Time study may show that excessive time is being taken to perform certain element of the job or that too little time is being spent on the element. Also the analysis of an operation by elements may show slight variations in method that could not be detected so easily from an overall study.
4. An operator may not work at the same tempo throughout the cycle. A Time study permits separate performance ratings to be applied to each element of the job.

Rules for dividing an operation into elements:

All manual work may be divided into fundamental hand motions or therbligs. These subdivisions are short in duration to betimed with a stopwatch. A number of them, therefore, must be grouped together into elements of sufficient length.

The following **rules** should be followed:

1. The elements should be as short in duration as can be accurately timed.
2. Handling time should be separated from machine time.
3. Constant elements should be separated from variable elements.

Taking and recording data:

The three most common methods of reading and stopwatch are:

1. Continuous timing.
2. Repetitive timing.
3. Accumulative timing.

Number of cycles to be timed:

If precision is 5%:

$$N'_i = \left(\frac{40\sqrt{N\sum_{j=1}^{N} X_{i,j}^2 - \left(\sum_{j=1}^{N} X_{i,j}\right)^2}}{\sum_{j=1}^{N} X_{i,j}} \right)^2$$

If precision is 10%:

$$N'_i = \left(\frac{20\sqrt{N\sum_{j=1}^{N} X_{i,j}^2 - \left(\sum_{j=1}^{N} X_{i,j}\right)^2}}{\sum_{j=1}^{N} X_{i,j}} \right)^2$$

For all ellements i=1, 2, ….., N

Rating

As the time study analyst records the data, the analyst is also evaluating the operator’s speed in relation to his opinion of normal speed for such an operation. Later, the rating factor will be applied to this “representative time” to obtain the normal time for the element.

A common method is for the analyst to determine a rating factor for the operation as a whole.

Normal Time = Selected Time x (Ratings/100)

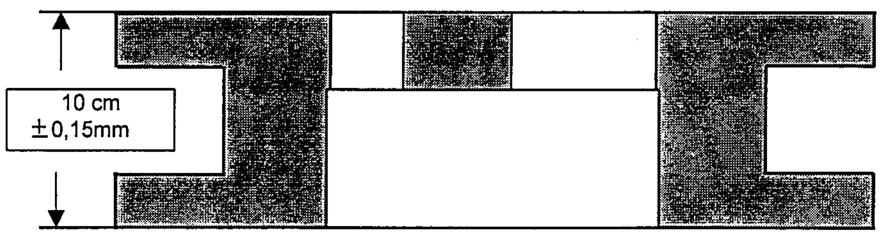
Selecting the operator to be timed:

If more than one person is performing the same operation, the Time study analyst, as a custom, times the operator working at nearest to normal pace. Because a rating factor is used to evaluate the operator's speed, theoretically it makes no difference whether the slowest or fastest operator is timed. However, it is admittedly more difficult to rate correctly the performance of a very slow operator.
It is not desirable to time a beginner, because the method is seldom the same as it will be when he/she has attained greater proficiency through experience on the job.

Example-1:

In a workshop, a repetitive stopwatch time study was conducted on the machining operation of a "Gear- Case Casting" shown in the following drawing:

(a)Sketch of gear-case casting showing surface to be machined and dimension



This operation was divided into 7 elements (A, B, C, D, E, F, G). Only G element is not occurring regularly in every cycle, since it is to clear the table of the machine from metal ships. Therefore, element G is occurring every 2 cycles. The stopwatch readings(in seconds) are shown in the following table:

	Cycles										
Elements	1	2	3	4	5	6	7	8	9	10	Ratings %
A	23	23	25	24	24	27	25	28	25	22	115
B	25	27	25	28	27	27	23	22	25	26	95
C	12	13	13	13	-	12	13	12	13	13	75
D	20	18	18	20	20	23	22	18	18	20	85
E	25	23	25	20	23	20	23	26	25	17	*
F	23	25	25	23	23	19	32	25	26	23	115
G		10		12		12		10		13	80

* It is not rated, since E is a machining element.

Q-1. The manager of this workshop agrees to use 5% as Personal and fatigue allowances and 2% as Delay allowances. Find the standard time to produce one Gear- Case?

Q-2. Assuming 10% accuracy, calculate the required number of observations from element G? Hint:

$$\mathbf{N'_i} = \left(\frac{20\sqrt{N\sum_{j=1}^{N} X_{i,j}^2 - \left(\sum_{j=1}^{N} X_{i,j}\right)^2}}{\sum_{j=1}^{N} X_{i,j}} \right)^2$$

For all ellements i=1, 2, ….., N

Q1.

CYCLES

Elements	1	2	3	4	5	6	7	8	9	10	Ratings %
A	23	23	25	24	24	27	25	28	25	22	115
B	25	27	25	28	27	27	23	22	25	26	95
C	12	13	13	13	-	12	13	12	13	13	75
D	20	18	18	20	20	23	22	18	18	20	85
E	25	23	25	20	23	20	23	26	25	17	100
F	23	25	25	23	23	19	32	25	26	23	115
G		10		12		12		10		13	80

Selected Time	Normal Time	Percent Allowances	Standard Time
24,6	28,29	7	30,42
25,5	24,23	7	26,05
12,67	9,50	7	10,22
19,7	16,75	7	18,01
22,7	22,70	2	23,16
24,4	28,06	7	30,17
5,7	4,56	5	4,80
		Total:	**142,82** Seconds

Q2. $N'_G = 4.43$

Note: Normal Time = Selected Time x (Ratings/100)
Standard Time = Normal Time x [100/(100 - %Allowances)}

Example-2:

The ACE HEXNUT Company sells hex nut and bolt assemblies. Their rather primitive assembly method is to have the operator place the bolt, head down, into the holding fixture. The operator then places the hex nut on the threaded end and manually tightens the nut. The completed assembly is then removed from the fixture and placed in the shipping barrel. Each operator is provided with two fixtures, two stockpiles of raw material, and two shipping barrels. These permit the operator to simultaneously assemble two products at one time. The following elements have been developed for performing a time study:

1- **Reach for and grasp bolt.**
2- **Place bolt in fixture.**
3- **Release bolt; reach for and grasp hex nut.**
4- **Place hex nut on end of bolt.**
5- **Fasten nut to bolt.**
6- **Place bolt in shipping barrel.**

Continuous Stop Watch Time Study was used. Five cycles were timed and each element was rated. These results appear in the table below. Unfortunately, stopwatch was not reset at the beginning and it was read before start as 3.15 minutes.

	CYCLES					
	1	2	3	4	5	Rate
Element 1	3.2	3.93	4.58	5.25	5.84	100
Element 2	3.25	3.97	4.62	5.29	5.88	120
Element 3	3.35	4.07	4.72	5.38	6	100
Element 4	3.4	4.13	4.78	5.43	6.05	110
Element 5	3.77*	4.42	5.06	5.68	6.3	80
Element 6	3.85	4.5	5.14	5.76	6.38	100

*** Sneeze.**

Note: All readings in the above table are in minutes.

a)- Use 3% as personal allowances and of 4% as delay allowances to calculate the standard time to complete one assembly.

b) How many assemblies should the worker be able to complete in one hour?

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Note: Normal Time = Selected Time x (Ratings/100)
Standard Time = Normal Time x [100/(100 - %Allowances)}

	CYCLES							
	1	2	3	4	15	Rate	T(selected)	T(Normal)
Element	0.05	0.08	0.08	0.11	0.08		0.08	0.080
1	3.2	3.93	4.58	5.25	5.84	100		
Element	0.05	0.04	0.04	0.04	0.04		0.042	0.050
2	3.25	3.97	4.62	5.29	5.88	120		
Element	0.1	0.1	0.1	0.09	0.12		0.102	0.102
3	3.35	4.07	4.72	5.38	6	100		
Element	0.05	0.06	0.06	0.05	0.05		0.054	0.059
4	3.4	4.13	4.78	5.43	6.05	110		
Element		0.29	0.28	0.25	0.25		0.268	0.214
5	3.77	4.42	5.06	5.68	6.3	80		
Element	0.08	0.08	0.08	0.08	0.08		0.08	0.080
6	3.85	4.5	5.14	5.76	6.38	100	TOTAL:	0.586 minute/2 units
							T(Standard):	0.630 minute/ 2 units

In one hour, we can produce: 190.5 Units

In one hour, we can produce: 2 x (60/0.63)= 190.5 Units/hour

Note: Total allowances are considered as 7% for all elements.

TIME STUDY: DETERMINING THE RATING FACTOR

After the time study has been taken the next step is to subtract successive watch readings in order to get the time for each element.

Selecting time values:

It now becomes necessary to **select from these data a time value**, for each of the elements **that will be representative**.

Occasionally there may be an abnormally high or low time value, which may require special attention.

The fact that there is considerable variations in successive times for certain elements, however, does not mean that all high and low elements should be thrown out. In many cases there are good reasons for such data (e.g. An occasional hard casting may require longer drilling time). If such time values are typical or representative of what may be expected on the job, they should not be eliminated from the study. It is a good policy not to eliminate any reading unless there is a definite reason for doing so.

Many organizations use the **arithmetical average** of the stopwatch readings in determining the representative time for the element.

The **modal method** consists of taking the time that occurs most frequently for the element. High and low time values will have less effect upon the selected time by this method than by the average method.

Determining the rating factor:

Perhaps the most important and the most difficult part of time study is to evaluate the speed or the tempo at which the person is working while the study is being made. The time study analyst must judge the operators speed while making the time study. This is called rating.

Definition of rating:

Rating is that process during which the time study analyst compares the performance (speed or tempo) of the operator under observation with the observer own concept of normal performance. Later this rating factor will be applied to the selected time value to obtain the normal time for the job.

Systems of rating:

1. Skill and effort rating: Around 1916, Charles E. Bedeaux introduced the Bedeaux system of wage payment and labor control. His plan was based on time study, and his time standards were expressed in points or “Bs.” A point or B was simply another name for what we now call a standard minute. His time study procedure included the rating of the operator’s skill and effort and the use of a standard table of fatigue allowances. Bedeaux used 60 points equal to standard performance. In other words, an operator working at a normal pace was expected to produce 60 Bs per hour and it was expected that the average incentive pace would be around 70 to 85 points per hour. Before Bedeaux, the performance rating was mainly selecting the stopwatch readings, from the data of the time study. Thus, if an operator were judged to be working at a fast tempo, a watch reading considerably above average would be selected as the representative time for the element.

2. Westinghouse system of rating:

A four-factor system, for rating the operator performance, was developed at Westinghouse and it was originally published in 1927. These four factors are (1) skill, (2) effort, (3) conditions, and (4) consistency. A scale of numerical values for each factor was supplied in tabular form, and the selected time obtained from time study was normalized or leveled by applying the sum of the ratings of the four factors.

Skill			Effort		
+0.15	A1	Super skill	+0.13	A1	Excessive
+0.13	A2		+0.12	A2	
+0.11	B1	Excellent	+0.10	B1	Excellent
+0.08	B2		+0.08	B2	
+0.06	C1	Good	+0.05	C1	Good
+0.03	C2		+0.02	C2	
0.00	D	Average	0.00	D	Average
-0.05	E1	Fair	-0.04	E1	Fair
-0.10	E2		-0.08	E2	
-0.16	F1	Poor	-0.12	F1	Poor
-0.22	F2		-0.17	F2	
Conditions			Consistency		
+0.06	A	Ideal	+0.04	A	Perfect
+0.04	B	Excellent	+0.03	B	Excellent
+0.02	C	Good	+0.01	C	Good
0.00	D	Average	0.00	D	Average
-0.03	E	Fair	-0.02	E	Fair
-0.07	F	Poor	-0.04	F	Poor

Example:

Let;

Selected time = 0.50 minutes,

Therefore,

Normal time=0.50 x 1.13 = **0.565 minutes**.

Excellent skill, B2 +0.08

Good effort, C2 +0.02

Good condition, C +0.02

Good consistency, C +0.01

Total= +0.13

3. Synthetic rating:

Evaluate operator's speed from predetermined time values.

The procedure is to make a time study in the usual manner, and then compare the actual time for as many elements as possible with predetermined time values for the same elements. A ratio can be established between the predetermined time value for the element and the actual time value for that element. This ratio is the performance index or rating factor for the operator insofar as that one element is concerned.

R= P/A where, R: Performance rating,
P: Predetermined time …
A: Average actual time…

4. Objective rating:

First the operator's speed is rated against a single standard pace which is independent of job difficulty. The observer merely rates speed of movement or rate of activity, paying no attention to the job itself.

After the pace rating is made, an allowance or a secondary adjustment is added to the pace rating to take care of the job difficulty.

Job difficulty is divided into six classes, and a table of percentages is provide for each of these factors. The six factors or categories are (1) amount of body used, (2) foot pedal, (3) bimanualness, (4) eye-hand coordination, (5) handling requirements, and (6) weight of the job.

5. Physiological evaluation of performance level:

Heart rate in beats per minute and oxygen consumption in calories per minute can be used to measure physiological work. Moreover, electronic equipment is available for monitoring and recording such information with a minimum of interference with the activity of the person.

The increase in the heart rate and the increase in oxygen consumption above the resting level is an indicator of the physiological cost of the work performed.

Assume that an operator works on a job for which there is a time standard and that the number of pieces produced shows that his or her performance level is 100 percent. During this same time the operator's heart rate in beats/minute and oxygen consumption in calories/minute are measured. If the same operator work on another job, we can judge from either heart rates or oxygen consumption on his/her performance rate.

6. Performance rating:

The most widely used system of rating is that of rating a single factor-operator speed, pace, or tempo. This system is called "performance rating."

The rating factor may be expressed in percentage, in points/hour, or in other units. Here we shall use the percentage system (with normal performance equal to 100 percent).

<u>The range of human capacities:</u>

In a factory, if a large group of people did exactly the same manual task using the same method, the fastest operator would produce approximately twice as much in a given time as the slowest operator.

This range 1 to 2 would be expected only if we consider a large sample of people just as they would be found in a factory.

<u>Frequency distribution</u>:

With the range of working speeds or operators tempo, we are interested in knowing what the distribution would be for a group of factory workers all doing the same job.

Graphical representation, such as the frequency distribution, can help us to find out the distribution of observations.

<u>Establishing a standard as the basis for rating</u>:

The data obtained by a time study show the actual time taken by operator to perform a series of consecutive elements of work. They tell nothing of the pace at which the operator worked while the study was being made. It is necessary to consider the operator’s speed in order to determine a standard that will permit an operator working at a normal pace to do the task in the time set for the job.

The need for rating has been pointed out, and the way the rating is used has been indicated. It is obvious however, that some bench mark or some standard of comparison is required if rating is to be used as a measuring device. We must define our normal or standard. To say that normal speed is that speed expected of a qualified person working without incentive or at a day-work pace, using a standardized method, does define the term adequately. However, normal speed or normal rate of movement can be demonstrated; motion pictures can be made of typical factory jobs with the operator working at a normal tempo or at a known level above or below normal. Almost any person can be taught to rate operator tempo in terms of the established standard.

e.g.

-Walking on the level at 3 miles/hour is a normal tempo.

-Dealing a deck of cards into 4 equal piles (0.50minutes) is a normal tempo.

<u>Rating film</u>:

Perhaps the most common form of rating film is made, by having experienced operators performing the same operation, work at a number of different speeds. Then the several section of film are placed together, separated from each other by a few feet of blank film, and each selection is identified by a code.

The relation of "Normal Pace" to "Average Incentive Pace":

Because time standards are often used as the basis for some form of wage incentive plan, we are interested in the relationship between normal pace and the average pace expected of those on incentive.

The performance of the great majority of workers on incentive should be fairly close to the average for the group.

Note: There is considerable evidence to show that if the working speed of each member of a large group of people, such as would be found in a factory, were arranged along the base line according to magnitude in percent of normal, and if the vertical scale indicated frequency, the shape of the curve would fit fairly closely the normal bell curve.

Note: It is not expected, of course, that any group of workers would exactly fit the normal curve.

DETERMINING THE RATING FACTOR 299

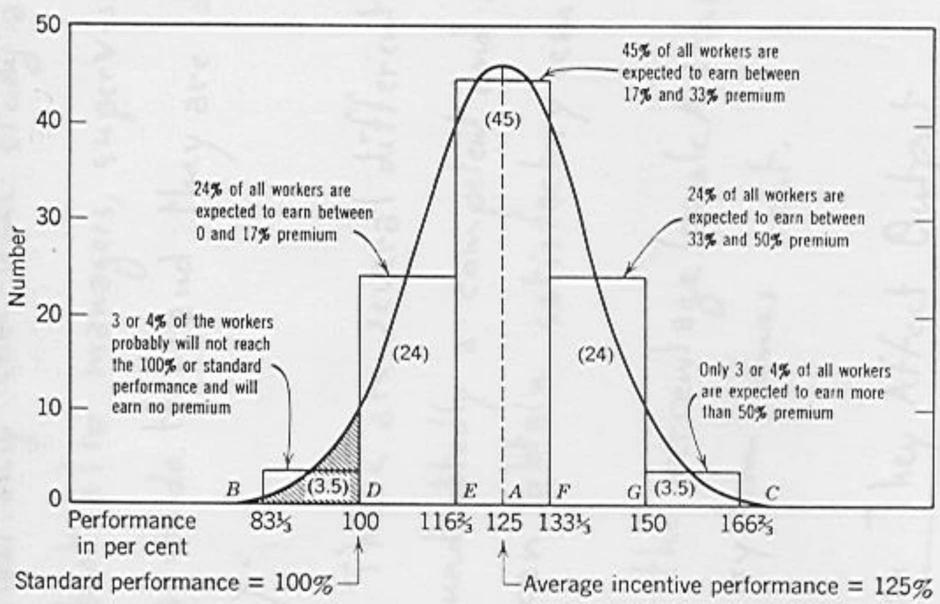
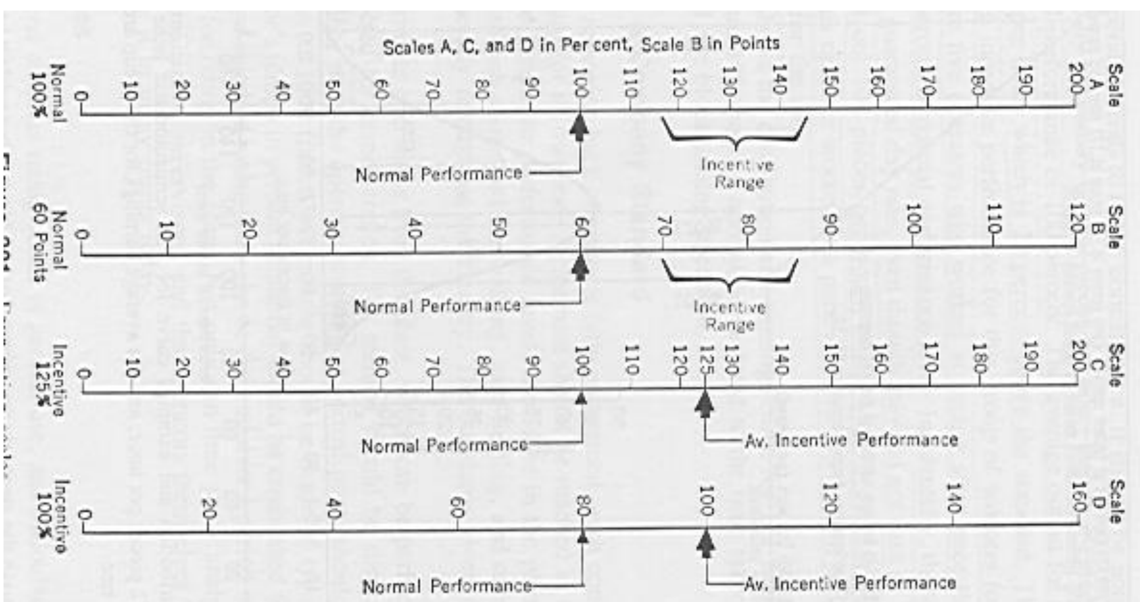


Figure 199 Chart showing the number of workers in each class interval through entire performance range, as determined from the normal distribution curve. Ratio of slowest worker (83⅓%) to fastest worker (166⅔%) is 1 to 2. A 100% premium plan of wage payment is used. It is assumed that a premium is paid for all production above standard. That is, for each 1% increase in production above standard, the worker is paid 1% additional wage above his hourly base rate. The base rate is the guaranteed wage paid to all workers whether they reach 100% performance or not. This hourly base rate is established by job evaluation.

Establishing a company standard:
After the basic reasoning back of rating is fully understood, each company should establish a standard for its own use. Agreement should be reached as to what the normal or standard tempo, or performance level, should be in the plant.
Then, some simple operations from the plant, which can be performed by anyone, should be selected for demonstration.
The method should be standardized, and the time for each job, with the operator working at normal pace, should be established.
Thus, a library of standard films can be built up over a period of time for use as a bench mark for rating in plant. Not only can time study analysts be taught to rate, but also managers, supervisors, and the operators themselves can do this; and they are doing it in many plants today.
Rating scales:
There are several different rating scales in general use, and undoubtedly a competent and well-trained time study analyst can obtain satisfactory results with any one of them.
A survey shows that the percentage (scale A) has greatest use and the point system comes next.



Speed and method as they affect output:
There are two main factors that affect the number of units of work that a person on manual operations can produce in a given time. They are:
1)- Speed of muscular movements,
2)- Method of doing the task.

TIME STUDY: DETERMINING ALLOWANCES AND TIME STANDARD

Determining Allowances:

The normal time for an operation does not contain any allowances. It is merely the time that a qualified operator would need to perform the job if he/she worked at a normal tempo. However, it is not expected that a person will work all day without some interruptions. The operator may take time out for personal needs, for rest, and for reasons beyond his or her control. Allowances for such interruptions to production may be classified as follows: (1) personal allowance, (2) fatigue allowance, or (3) delay allowance.

The standard time must include time for all the elements in the operation and in addition it must contain time for all necessary allowances. Standard time is equal to the normal time plus the allowances.

Allowances are not a part of the rating factor, and best results are obtained if they are applied separately.

Personal Allowances:

Every worker must be allowed time for personal needs. The amount of this allowance can be determined by making all-day time studies or work sampling studies of various classes of work. For light work, where the operator works 8 hours per day without organized rest periods, 2 to 5 percent (10 to 24 minutes) per day is about all that the average worker will use for personal time.

Although the amount of personal time required will vary with the individual more than with the kind of work, it is a fact that employees need more personal time when the work is heavy and done under unfavorable conditions, particularly in a hot humid atmosphere. Under such conditions, more than 5% allowance should be made for personal time.

Fatigue Allowance:

In the modern well-managed plant so many steps have been taken to eliminate fatigue. In fact, fatigue is of such little consequence in some kinds of work that no allowance is required at all. There are many reasons for this. The length of the working day and the length of the working week have been shortened; machinery, mechanical handling equipment, tools, and fixtures have been improved so that the day’s work is more easily done and the employee works in greater physical comfort than formerly.

There are, of course, some kinds of work that still involve heavy physical exertion and are performed under adverse conditions of heat and humidity,

and therefore require rest for the operator. Fatigue results from a large number of causes, some of which are mental as well as physical.
There is no fully satisfactory way of measuring fatigue. Physiological measurements are the most objective means of determining the time and duration of periods of work and rest during the day.
The problem of determining the amount of time to be allowed for rest is very complex. Time needed for rest varies with the individual, with the length of the interval in the cycle during which the person is under load, with the conditions under which the work is done, and with many other factors.
Organized rest periods, during which time all employees in a department are not permitted to work, provide one solution to the problem. The optimum length and number of rest periods should be determined. Perhaps, the most common plan is to provide one rest period during the middle of the morning and one during the middle of the afternoon. The length of these periods ordinarily varies from 5 to 15 minutes each.
If no wage incentive plan is used, employees are paid for the rest periods at their regular hourly base rate.
If a wage incentive plan is used and if fatigue allowances have been incorporated in the time standard, employees are not paid for the rest periods as such. Workers merely take their fatigue allowance during the specified rest period rather than at intervals during the day at their own choosing.
Fatigue allowance does not need to be made for much light factory work and organized rest periods, during the day, provide sufficient rest for another group of factory operations.

Delay Allowance:

Delays may be avoidable or unavoidable.
Intentional delays will not be considered in determining the time standard.
Unavoidable delays do occur from time to time, caused by the machine, the operator, or some outside force.
It is expected that machine and equipment will be kept in good repair. When there is a **breakdown** or when repairs are necessary, the operator is usually taken off the job and such delays **do not enter into the time standard**. In such cases the operator is usually paid for waiting time at the hourly base rate.
Sometimes, there are **minor adjustments**, breakage of tools such as drills and taps, or lost time due to occasional variation in material and interruptions by supervisors, and there **must be included in the time standard**.
The analyst, and the supervisor should consider each unavoidable delay as a challenge, and every effort should be made to eliminate these delays.

The kind and amount of delays for a given class of work can best be determined from all-day time studies or work-sampling studies made over a sufficient period of time to give reliable data.

<u>Applying the Allowances</u>:

Personal allowance is applied as a percentage of the normal time, and effects both handling time and machine time alike. For convenience, fatigue allowance is sometimes applied in the same way, although some believe that this allowance should apply only to those elements during which the operator works, and not to the machine time during which the machine works.

Delays are applied as a percentage of the normal time, or if entirely a machine-delay allowance, then on the machine elements only.

If these three allowances are applied uniformly to all elements, they may be added together and applied together, necessitating but a single computation.

Although, allowances have traditionally been applied as a percentage of the normal time to be added to the normal time to obtain the standard time, there is a trend toward considering allowances in terms of minutes allowed per working day. Thus, instead of referring to personal allowances as 5 percent, it would be referred to as 24 minutes per 8-hour day (480x0.05=24). If this were the only allowance made, the working time in this case would be 456 minutes per day (480-24=456).

Standard Time = Normal time +(Normal time x Allowance in %)
= Normal time x [(100 + Allowance in %)/100]

Although **this equation** is used, it **is not absolutely correct**.

A **better equation**:

Standard Time = Normal time x [(100)/(100 – Allowances in %)]

<u>Example</u>:

See your textbook, pages 308-309.