Work measurement

Time Study

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Work measurement or Time Study

DEFINITION BY BRITISH STANDARD INSTITUTION:

- "The application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."

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OBJECTIVES OF WORK MEASUREMENT

The objectives of work measurement are to provide a sound basis for:

- Comparing alternative methods.
- Assessing the correct initial manning (manpower requirement planning).
- Planning and control.
- Realistic costing.
- Financial incentive schemes.
- Delivery date of goods.
- Cost reduction and cost control.
- Identifying substandard workers.
- Training new employees.

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TECHNIQUES OF WORK MEASUREMENT

For the purpose of work measurement, work can be regarded as:

1. Repetitive work: The type of work in which the main operation or group of operations repeat continuously during the time spent at the job. These apply to work cycles of ex-tremely short duration.

2. Non-repetitive work: It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

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Various techniques of work measurement

- Time study (Stop Watch Technique),
- Synthesis,
- Work sampling,
- Analytical estimating,
- Predetermined motion and time study.

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Techniques of work measurement
Time study

Time study:

A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analyzing the data so as to determine the time necessary for carrying out the job at the defined level of performance.

Techniques of work measurement
Synthetic data

Synthetic data:

A work measurement technique for building up the time for a job or parts of the job at a defined level of performance by totaling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.

Techniques of work measurement

Work sampling

- **Work sampling** is a technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers.
- Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.

Predetermined motion time study (PMTS)

- It is a work measurement technique whereby *times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job* at the defined level of performance. The most commonly used PMTS is known as Methods Time Measurement (MTM).

Analytical Estimating

It is a work measurement technique, being a development of estimating, whereby the time required to carry out *elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.*

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Work Measurement Techniques
and their Application

Techniques	*Applications*	*Unit of Measurement*
1. Time study	Short cycle repetitive jobs. Widely used for direct work	Centi minute (0.01 min)
2. Working sampling	Long cycle jobs/heterogeneous operations.	Minutes
3. Synthetic Data	Short cycle repetitive jobs	Centi minutes
4. MTM	Manual operations cor fined to one work centre	TMU (1 TMU = 0.006 min)
5. Analytical estimating	Short cycle non-repetitive job	Minutes

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Steps in Making Time Study

- Stop watch time is the basic technique for determining accurate time standards. They are economical for repetitive type of work.

Steps in Making Time Study

Steps in Making the time study:

1) Select the work to be studied.

2) Obtain and record all the information available about the job, the operator and the working conditions likely to affect the time study work.

3) Breakdown the operation into elements. An element is a distinct part of a specified activity composed of one or more fundamental motions selected for convenience of observation and timing.

4) Measure the time by means of a stop watch, taken by the operator to perform each element of the operation. Either continuous method or snap back method of timing could be used.

5) At the same time, assess the operators effective speed of work relative to the observer's concept of 'Normal' speed. This is called performance rating.

Steps in Making Time Study

6) Adjust the observed time by rating factor to obtain normal time for each element

Normal time = (Observed time x Rating) / 100

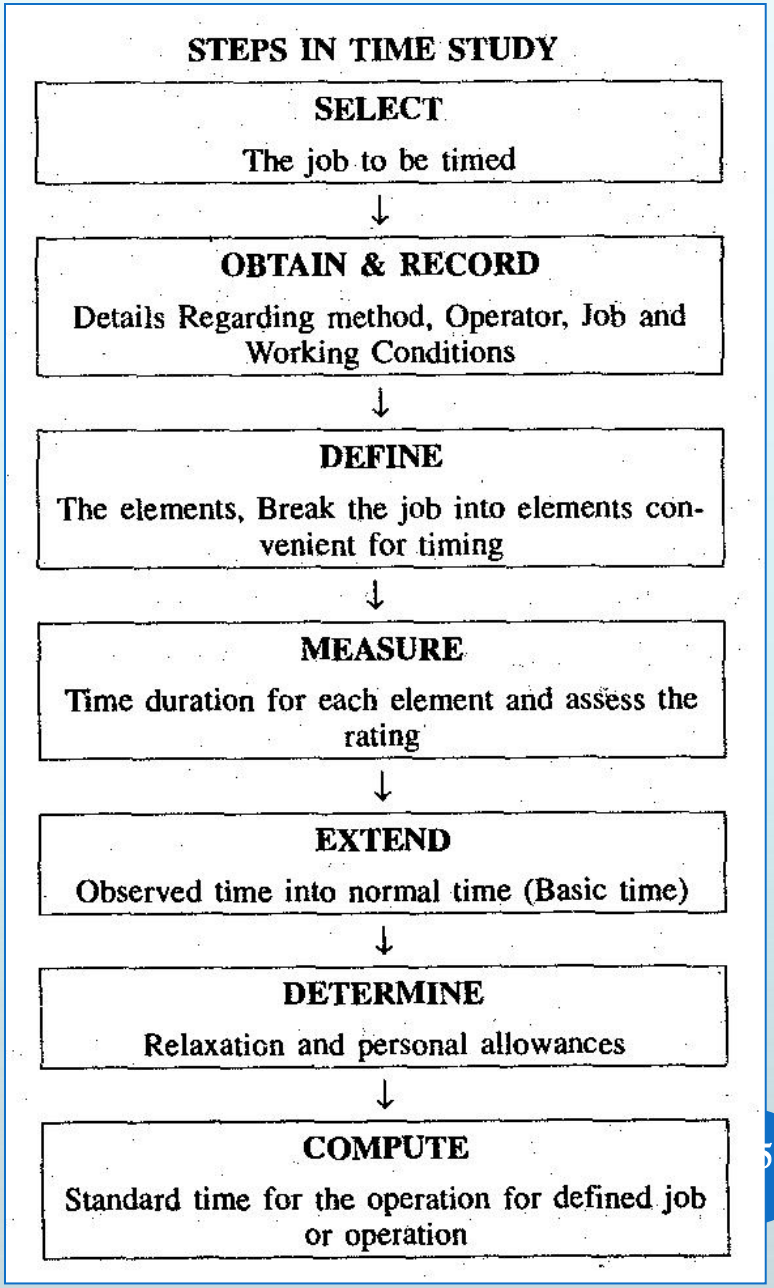
7) Add the suitable allowances to compensate for fatigue, personal needs, contingencies, etc., to give standard time for each element.

8) Compute allowed time for the entire job by adding elemental standard times considering frequency of occurrence of each element.

9) Make a detailed job description describing the method for which the standard time is established.

10) Test and review standards where necessary.

Steps in time study



Steps In Time Study

Select (**Selecting Job for Time Study**)

The reasons for which time study may be done:

- The job in question is new one or not previously carried out.
- Change in the method of existing time standard.
- Complaint received from workers or unions regarding the time standard.
- *A* particular operation becomes bottle-neck operation which holds up number of sub-sequent activities.
- Change in the management policy regarding how time standards are used, i.e., General purpose or wage incentive plans.

The general guidelines for selecting the job for time study:

- Bottle–neck operations.
- Repetitive jobs.
- Jobs using a greater deal of manual labour.
- Jobs with longer cycle time.
- (Sections/department frequently working overtime.

Steps In Time Study
Obtaining and Recording Information

During this step, all the relevant and necessary information regarding the method, operator and details of working conditions are recorded:

- The accuracy of time standards depends upon the correctness of the method employed by the operators. So wrong methods should not be timed. The method is to be standard and the time required to carry out the job as per the standard method is to be timed.
- The selection of an operator refers to choosing an operator amongst many operators doing the same job. He should be a representative worker with a normal pace neither too fast nor too slow. So the details of the operator is essential to be recorded before starting actual time

- Information to enable the identification details such as. Part number and name, machine No. speed and feed, materials, operator details, etc.
- Working conditions under which an operator carries out the job like temperature, dust, smoke, vibrations, noise, etc.
- Working position such as standing, sitting, bending, etc., and weights handled, protective clothing, etc.

Steps In Time Study
Obtaining and Recording Information

Breaking the Jobs into Elements

- Once the recording of the basic information regarding the job and, operator are done, the next step is breaking job into elements.
- Element is a distinct part of a specified job selected for convenience of observation, measurement and analysis.
- Work cycle is a complete sequence of elements necessary to perform a specified activity or job to yield one unit of production. It may also include the elements which do not occur with every cycle.

Steps In Time Study
Obtaining and Recording Information

Reasons for Breaking the Jobs into Elements

- To ensure that productive time is separated from unproductive activities (separating effec-tive time and ineffective time).
- To permit the rate of performance to be assessed more accurately than would be possible if the assessment were made over a complete cycle.
- To enable different types of elements to be identified and distinguished so that each ele-ment is given an appropriate treatment.
- To ensure elements involving a high degree of fatigue to be isolated and to make the allo-cation of fatigue allowances more accurately.
- To enable the detailed work specification to be produced.
- To enable machine elements to be distinguished from 'human' elements.
- To enable time standards to be checked or modified at later date, omissions and errors to be rectified.
- For accuracy of rating.
- To enable time values for frequently recurring elements, such as

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Steps In Time Study
Obtaining and Recording Information

TYPES OF ELEMENTS

- A repetitive element is an element which occurs in every work cycle of the job. *Examples,* Picking up part for assembly, element of locating a work piece in a holding device.

- An occasional element is one that does nor occur in every work cycle of the job or which may occur at regular intervals. *Examples,* tool changing after sometime, adjusting tension or machine setting, instruction from supervisor. Occasional element is useful work to be included in standard time.

- A **constant element** is an element for which the basic time remains constant whenever it is performed. *Examples,* Switch on machine, measure diameter, insert cutting tools.

- A **variable element** is an element for which the basic time varies in relation to some basic characteristics of the product, equipment or process. *Examples,* Dimensions, weight, qual-ity, etc.

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Steps In Time Study
Obtaining and Recording Information

- A **manual element** is an element performed by a worker.
- A **machine element** is an element automatically performed by a power driven machine. *Examples,* Press working parts, annealing tubes.
- **Governing element** is an element occupying a longer time than that of any other element which is being performed concurrently example Gauge dimensions while turning diameter (turning diameter will be a governing element).
- **A foreign** element is one that is observed during study but do not form part of the given activity of the cycle. *Example,* Dropping work on the floor, operator talking to his col-league.

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Steps In Time Study
Obtaining and Recording Information

Guidelines for Breaking Jobs into Elements

- Elements should be easily identified.
- Each element should have a definite beginning and end.
- Manual elements should be separated from variable elements.
- Occasional elements should be timed separately.
- Elements should be as short as can be conveniently timed by a trained observer.
- Elements should be chosen so that they represent naturally unified and recognizably distinct segments of the **operation.**

Example of Standardized Element Breakdown

DRILLING WITH TWIST DRILL IN BENCH TYPE MACHINE

Element	*Break Point (end)*	*Remarks*
Pick up piece, place in jig	Moving jig towards spindle start	
Place under spindle, Advance drill	Machine feed engages Tool starts cutting	Machine feed Manual feed
Drill	Tool finishes cutting	–
Lift up spindle	Hand leaves lever handle	–
Take out of jig place aside	Noise when piece reaches bottom of container	Small pieces
Take out of jig	The moment when the piece is separated from jig	Pieces which cannot be thrown away
Place aside	(*a*) Piece released from hand grip (*b*) Crane hook released after reaching floor container	Pieces which cannot be thrown away

Steps In Time Study
Obtaining and Recording Information

How Many Cycles to be Timed ?

- The number of cycles through which any particular job should be observed varies directly as the amount of variations in the times of the elements of the job.
- The number of cycles to be observed will depend on the degree of accuracy desired. This in turn will depend on the length of run of the job and the number of people engaged on it.
- The study should be continued through a sufficient number of cycles to ensure that occa-sional elements such as handling boxes of finished parts, periodical cleaning of machines, etc., can be observed several times.
- Where more than one operator is engaged on the same job it is preferable to take a short study on each of several operators rather than timing too long on a single operator.
- The number of observations at 95% confidence level and accuracy of ± 5

$$n = \left[40 \frac{\sqrt{n' \Sigma x^2 - (\Sigma X^2)}}{\Sigma x} \right]^2$$

n' = number of preliminary readings,

n = sample size (number of observations)

Σx = sum of preliminary set of observations

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Steps In Time Study

MEASURE

(Measure) Duration of Each Element

- When elements have been selected, the next step is starting the timing of operations. There are two principal methods of timing with the stop watch: (a) Cumulative timing, and (b) Fly back timing.
- In cumulative, the watch runs continuously throughout the study. It is started at the beginning of the first element of the first cycle to be timed and is not stopped until the whole study is completed. At the end of each element the watch reading is recorded and individual element times are obtained by successive subtractions after the study is completed.
- In fly back timing, the hands of the stop watch are returned to zero at the end of each element and allowed to start immediately, the time for each element is obtained directly.
- While recording the time of the elements, operators speed of working is assessed and recorded on the observation sheet. Rating is the time study engineers assessment of the operator's pace of working in relation to the concept of standard or normal. Rating is used to convert observed time into normal time.

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Steps In Time Study

EXTEND

Extend Observed Time into Normal Time

- The representative time established from the observation data is the time which an operator has taken while working at a certain pace.
- The observed time is converted into basic or normal time by multiplying it by rating factor.

$$\text{Normal time} = \frac{\text{Observed time} \times \text{performance rating (\%)}}{100}$$

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Steps In Time Study
determine

Determine relaxation and other allowances

- Normal times of elements added together give normal time for the operation. But this will not
- be equal to standard time as the operators cannot work continuously. Some additional time is added to normal time to arrive at the standard time. The additional time is needed to:
- To provide the operator to attend to his personal needs (relaxation allowances).
- Interference allowances.
- Contingency allowance.

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Steps In Time Study

compute

Calculate Standard Time for the Job

- The various allowances are added to the normal time as applicable to get the standard time. Thus basic constituents of standard time are:
- Elemental (observed time).
- Performance rating to compensate for difference in pace of working.
- Relaxation allowance.
- Interference and contingency allowance.
- Policy allowance.

TIME STUDY EQUIPMENTS

Basic time study equipment required to make the time study are: (I) Time study board, (2) Stop watch, and (3) Time study forms.

- Time study board: Time study board is simply a flat board, usually of plywood or of any suitable plastic sheet and it should have fittings to hold a stop watch and time study forms. The use of board provides support and resting face while writing observations on the shop-floor and makes the hands free to write and operate stop watch.

- Stop watch: Stop is the measuring instrument to observe the elemental timings and usually a decimal watch is used.

- Time study forms: Time study forms are usually printed forms of standard size. The use of standard forms is desirable as the constant information, such as part number and part name, operation description, observers name and other description are pre-printed on the top of the form which eliminates the possibility of any details being missed. As the size of, the forms are standardized they can be easily filed for future referencing.

Selection of Worker for Time Study

- The worker selected should be skilled and should have a good temperament. His pace of performance should be close to the average so that observed times are near to the normal times.
- When a large number of workers are working on the job, it is a good policy to take studies on more than one qualified worker.
- The distinction is made between a qualified worker and representative worker. A representative worker is one whose skill and performance is the average of the group under consideration. A representative worker may not be necessarily be a qualified worker.

Selection of Worker for Time Study

A Qualified Worker as Defined by ILO

- A qualified worker is one who is accepted as having the necessary physical attributes, who possesses the required intelligence and education; and who has acquired necessary skill and knowledge to carry out the work in hand to satisfactory standards of safety quantity and quality.
- The time study man should not make any attempt to time the operative without his knowledge from a concealed position or with the watch in the pocket.

PERFORMANCE RATING

- Performance rating is the process of adjusting the actual pace of working of an operator by comparing it with the mental picture of pace of an operator working at normal speed.

TIME STUDY SHEET

TIME STUDY TOP SHEET

Department:	Study No: Sheet No.: Of
Operation: M.S. No.: Plant/Machine: No.: Tools and Gauges:	Time Off: Time On: Elapsed Time: Operative: Clock No.:
Product/Part: No. Dwg. No.: Meterial Quality:	Studies By: Date Checked:

N.B. Sketch the WORKPLACE LAYOUT/SET-UP/PART on the reverse or on a separate sheet and attach

Element Description	*R.*	*W.R.*	*S.T.*	*B.T.*	*Element Description*	*R.*	*W.R.*	*S.T.*	*B.T.*

N.B. R. = Rating. W.R. = Watch Reading. S.T. = Subtracted Time. B.T. = Basic Time.

Performance Rating

$$\text{Performance rating} = \frac{\text{Observed Time}}{\text{Normal Time}} \times 100$$

Factors Affecting Performance Rating

There exists a variation from element to element and even among the elements in the same operation. This is due to the inconsistency in the speed of the working of the operator.

Each worker by nature has different temperament and attitudes towards the work. Some workers by their nature are fast (above the speed of the average worker) and some are by nature slow. Both these workers will not represent a normal worker.

- The variation in actual times for a particular element may be due to the factors both internal and external. The external factors which are not in control of work study man are:
- Variation in the quality or other characteristics of the material used even though it is in prescribed tolerance limit.
- Changes in the operating efficiency of tools and equipment within their useful life. • Unavoidable changes in methods or conditions of operations.
- Change in working conditions like heat, light, dust, etc.

Factors which are within control (Internal Factors)

Acceptable variation, in the quality of the product.

- Variation due to operators ability.
- Variation due to his attitude of mind.

The various methods of performance rating are:

(1) Speed rating,
(2) Westing house system of rating,
(3) Synthetic rating, and
(4) Objective rating.

(1) Speed rating: In this technique the speed of the movements of the operator is the only factor considered for performance rating. The speed rating is found by the observer by comparing pace of operators working with his own concept of normal pace. An average worker is rated at 100%, better than average worker is rated at a figure higher than 100 and below average worker will be rated below 100. If a worker is rated at 125% it means that the speed is 25% higher than the observers concept of normal and rating of 80% means the worker is working 20% below the observers concept of a normal worker.

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WESTING HOUSE METHOD OF RATING

(2) Westing house system utilises a set of criteria to measure the performance of the operators.

The factors are:

1. Skill 2. Effort 3. Consistency, 4. Conditions

- **I. Skill:** Measures the workers proficiency in adhering to a given method, coordination of proper hand and eye movements, rhythm of the movements. The skill has been classified into six degrees, each degree indicating a specified class of skill within which an operator performs the task.
- **2. Effort:** Measures the speed with which the skill is applied. The effort is also divided into six degrees.
- **3. Consistency:** Measures factors which affect the consistency of the operator to perform the work cycle repeatedly within the same time. Elements which affect the consistency are—variations in materials, hard spots, presence of foreign elements. Consistency is subdi-vided into six classes.
- **4. Conditions:** Measure the extent to which the conditions like temperature, vibrations, light and noise affect the operator's

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WESTING HOUSE METHOD OF RATING

- The Westing house system of classification of skill, effort, consistency and conditions are shown in Table.
- As per this system, the time study observer assign rating for a criteria of particular. task. Numerical values are than obtained from Table and establishes the performance rating by adding the four values and adding the levelling factor to normalise the observed time.
- It is applied to the cycle time in case of a manual time rather than to the individual elemental times.

Performance Rating Table. (Westing house method)

Skill			*Effort*		
+ 0.15	A1	Superskill	+ 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

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EXAMPLE OF WESTING HOUSE METHOD

***Illustration of Westing House Method*:** An observed time for an operation is 0.05 minutes and the ratings are as follows:

Skill (Excellent) B2
Effort (Good) C2
Condition (Good) C
Consistency (Good) C
The values for the ratings are assigned from Table 5.2.

Criteria	*Rating*	*Numerical Value*
Skill	B2	+ 0.08
Effort	C2	+ 0.02
Condition	C	+ 0.02
Consistency	C	+ 0.01
	Total	+ 0.13

(*a*) Performance rating factor = 1 + 0.13 = 1.13 = 113% = 113%

(*b*) Normal time of operation = Observed time × performance rating

= 0.05 × 1.13
= 0.0565 minutes

SYNTHETIC RATING:

Synthetic rating: The performance rating under this method is established by comparing observed time of some of the manual elements with those of known time values of the elements from predetermined motion and time studies (PMTS).

- The procedure is to make the time study in a usual manner and then compare the actual time for the elements with predetermined time values for the same elements.
- A ratio is computed between predetermined time value for the element and actual time value for the element.
- This ratio is the performance index or rating factor for the operator for the particular element. Performance rating factor, *(R)* is given by

$$R = \frac{P}{A}$$

P = Predetermined time for elements (minutes)

A = Average actual time value (selected time) for the same element 'P' (minutes)

OBJECTIVE RATING:

In this method, 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 activity, paying no attention to job itself. After the pace rating is made, an allowance or a secondary adjustment is added to the pace rating to take care of job difficulty.

- Job difficulty is divided into six classes, and percentage is provided for each of these factors. The job difficulties as per the founder of this system—M.E. Mundel have been categorized into six classes as follows:

1) Amount of body used.
2) Foot pedals.
3) Bi-manual-ness.
4) Eye-hand coordination.
5) Handling requirements.
6) Weight.

ALLOWANCES

- The normal time for an operation does not contain any allowances for the worker. *It is impossible to work throughout the day even though the most practicable*, effective method has been developed.

- Even under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation.

Allowances must also be made to enable the worker to attend to his personal needs. The allowances are categorized as:

(1) Relaxation allowance,
(2) Interference allowance, and
(3) Contingency allowance.

ALLOWANCES

Relaxation Allowance

Allow the worker to recover from fatigue.

- Relaxation allowance is a addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on nature of the job.

Relaxation allowances are of two types—

- FIXED ALLOWANCES and
- VARIABLE ALLOWANCES.

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ALLOWANCES

FIXED ALLOWANCES:

(a) Personal needs allowance. It is intended to compensate the operator for the time necessary to leave, the workplace to attend to personal needs like drinking water, smoking, washing hands. Women require longer personal allowance than men. A fair personal allowance is 5% for men-and 7% for women.

(b) Allowances for basic fatigue. This allowance is given to compensate for energy expended
during working. A common figure considered as allowance is 4% of the basic time.

VARIABLE ALLOWANCE

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job.

The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organisation to organisation.

ALLOWANCES

INTERFERENCE ALLOWANCE

It is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him.

This allowance is applicable for machine or process controlled jobs.

- Interference allowance varies in proportion to number of machines assigned to the operator. The interference of the machine increase the work content.

CONTINGENCY ALLOWANCE

- A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays, the precise measurement of which is uneconomical because of their in frequent or irregular occurrence.
- This allowance provides for small unavoidable delays as well as for occasional minor, extra work.

Some of the examples calling for contingency allowance are:

- Tool breakage involving removal of tool from the holder and all other activities to insert new tool into the tool holder.
- Power failures of small duration.
- Obtaining the necessary tools and gauges from central tool store.

Contingency allowance should not exceed 5%.

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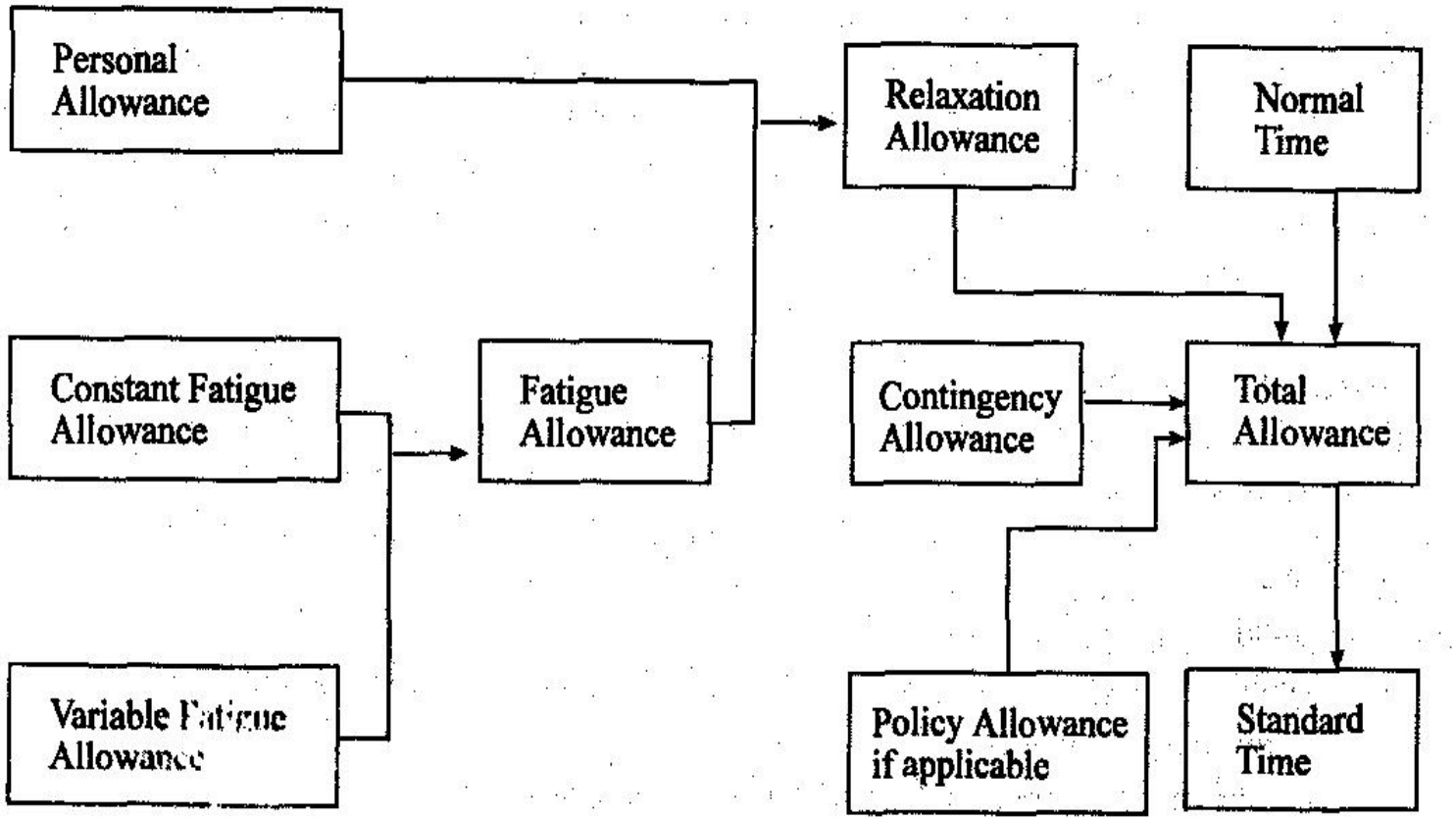
ALLOWANCES



Various allowances to build standard time.

ALLOWANCES

Policy Allowance

- Policy allowances are not the genuine part of the time study.
- The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions.

The policy allowance as defined by ILO:

- "A policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, e.g., work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances. Policy allowance are sometimes made as imperfect functioning of a division or part of a plant."

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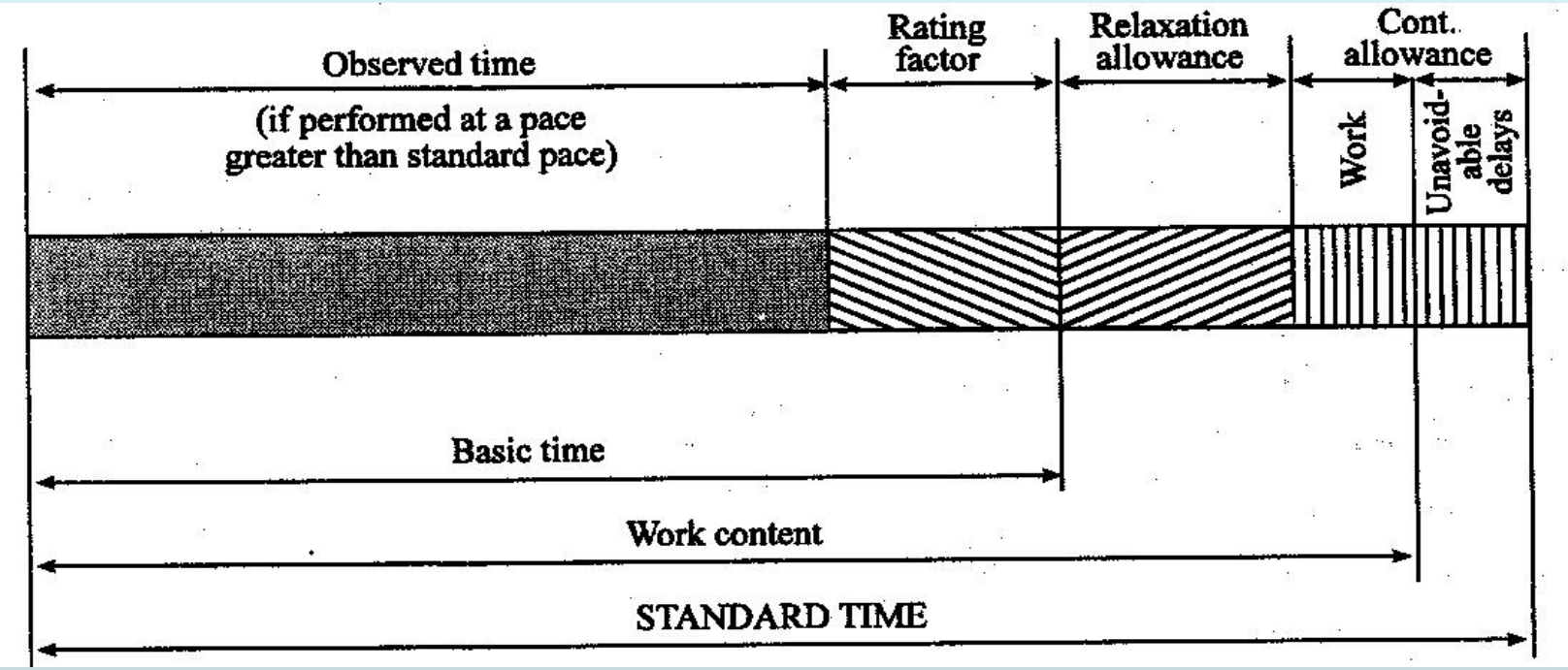
COMPUTATION OF STANDARD TIME

- Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance.
- The basic constituents of standard time are as shown.



WORK SAMPLING

- Work sampling is a fact finding tool.

Work sampling is defined as:

- "A technique in which a statistically competent number of instantaneous observations are taken, over a period of time, of a group of machines, processes or workers.
- Each observations recorded for a particular activity or delay is a measure of the percentage of time observed by the occurrence."

WORK SAMPLING

Work sampling has three main applications

- **Activity and delay sampling**: To measure the activities and delays of workers or machine. e.g., the percentage of time in a day, a person is working and the percentage that a person is not working.

- **Performance sampling**: To measure working time and non-working time of a person on a manual work, and to establish a performance index or performance level for a person during his working time.

- **Work measurement**: Under certain circumstances, to measure a manual task, that is, to establish a time standard for an operation.

Procedure for Conducting a Work Sampling Study

Steps involved in making sampling study:

- **Decide on the objective of the study**: It is very important to first set the objectives of study as the duration of the study, number of observations, the design study sheet and elemental breakdown depends upon the objective.
- Obtain the approval of the supervisor of the department in which work study is to be con-ducted. Make sure that the operators to be studied and the other people in the department understand the purpose of the study. Obtain their cooperation.
- **Decide upon work and delay elements**: Work and delay elements represent the headings under which the observations are to be recorded. The nature of the work and delay ele-ments differ from company to company depending upon the objective of the study and the work.
- **Decide upon the** duration of the *study:* The duration of study depends upon the objec-tive, number of observers, the accuracy desired and the frequency of occurrence of the activity.
- **Determine** the desired accuracy of results: This may be stated as the standard error of a percentage or desired accuracy. The confidence level is also to he stated.
- Make a preliminary estimate of the percentage occurrence *of* the activity or delay to be measured.

Design of Work Sampling Study

- 1. Determination of Required Number of Observations
- The number of observations depends upon:
  - Activity percentage (P)
  - Limits of accuracy (A)
  - Confidence level (C)
- *Number of observations at a confidence level of 95% is given by*

$$N = \frac{4\,(1-P)}{A^2, P}$$

Setting Performance Standards with Work Sampling

Procedure to develop performance standards:

- **Taking the study:** A work sampling study is carried out for the operation whose standard time is to be determined. Observations are made at random intervals of time and are noted. Whether subject under study is working or idle are noted. Reasons for delays *and* interrup-tion are recorded.
- The observations of production activity (working) are divided into **machine working** and **hand working**. Operators pace of performance is noted down when manual working is observed.
- **Rating index:** Individual performance ratings are averaged out to obtain an overall rating index.
- **Production quantity:** Number of pieces produced during the period of study are deter-mined from production reports.
- **Overall time per unit(T_a):** It is calculated by dividing production time (duration of study) by number of pieces produced.
- **Effective time per unit (T_e):** Overall time per piece includes even the time spent on un-productive activities. Overall time is multiplied by percentage of productive activities to get the effective time per piece.

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PROCEDURE TO DEVELOP PERFORMANCE STANDARDS:

Let T_o = Overall time per piece
N = Total number of observations.
N_p = Observations of Production activity.
$= N_m + N_h$
N_m = Observations of machine controlled work.
N_h = Observations of hand controlled work.

∴ Effective time per piece (T_e) = Overall time / unit × production activity %

$$= T_o \frac{\times N_p}{N}$$

The effective time per piece (T_e) can be compared to observed time of stop watch study. To get the normal time, effective time is broken down into manual and machine controlled time.

Machine controlled effective time $(T_m) = T_e \times \frac{N_m}{N_p}$

$$= T_e \times \frac{N_m}{N_m + N_h}$$

and Manual (hand) controlled time $(T_h) = T_e \times \frac{N_h}{N_m + N_h}$

or $(T_e - T_m)$

Normal time per piece

Let R be the performance rating index

T_h = Hand controlled portion of effective time
T_m = Machine controlled effective time

$$\text{Normal time} = \frac{T_h \times R}{100} + T_m$$

Rating is applied to only manual (hand controlled) elements

Standard time per piece

Standard time is calculated by adding relevant allowances to the normal time.

EXAMPLE OF CALCULATION OF STANDARD TIME

Problem The following data refers to a sampling study of production of one component.

1. Duration of data collection 5 days @ 8 hours per day
2. Number of operators = 10
3. Allowances given for the process = 15%
4. Production quantity in 5 days = 6000 components
5. Sampling data collected

Days	1	2	3	4	5
No. of observations	230	240	200	180	225
Occurrence of activity	200	190	170	150	210

Calculate standard time of production of the component if average performance rating of the operator is 120% and the entire operation is manual.

Solution : No. of observations (N) = 1075

No. of observations (N_p) = 920

(working)

$$\text{Overall time per piece} = T_o = \frac{\text{Total time worked}}{\text{No. of units produced}}$$

$$= \frac{5 \times 8 \times 10 \times 60}{6000} \text{ min.}$$

$$= 40 \text{ min.}$$

$$\text{Effective time per piece } (T_e) = T_o \times \frac{N_p}{N}$$

$$= 40 \times \frac{920}{1075}$$

$$= 34.23$$

$$\text{Normal time} = \text{Observed time} \times \text{Rating}$$

$$= 34.23 \times 1.2$$

$$= 41.07 \text{ min.}$$

$$\text{Standard time} = \text{Normal time } (1 + \text{allowances})$$

$$= 41.07\ (1 + 0.15)$$

$$= \mathbf{47.24} \text{ min.}$$

Control Charts in Work Sampling

- Control charts are used in work sampling to continuously keep track of particular activity.
- A chart is employed where the proportions of activities obtained from work sampling are represented as a function of time. The points in the chart gives the idea of the trend and the presence of out of control condition if exist.
- An investigation is made if the point falls outside the control limits. Control chart is useful aid to a work sampling man.

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Advantages of Work Sampling Compared to Time Study

- Many operations or activities which are impractical or costly to measure by time study can be measured by work sampling.
- A simultaneous work sampling study of several operators or machines may be made by a single observer.
- It usually requires lesser man-hours and costs less to make a work sampling study instead of making a continuous time study.
- Observations may be taken over a period of days or weeks thus reducing the chances of day-to-day variations affecting results.
- Any interruption during study will not affect the results.
- Work sampling measurements may be made with a pre-assigned degree of reliability.
- Work sampling studies are preferred to continuous time studies by the operators being studied.
- C A stop watch is not needed for work sampling studies
- Work sampling studies cause less fatigue and are less tedious.

Disadvantages of Work Sampling

- Work sampling is uneconomical for short *cycle* jobs.
- It is also uneconomical for studying a single workman or even small group of workmen or machines.
- Time study permits a finer breakdown of activities and delays than is possible with work sampling study.
- Workman may change their normal pattern of working on seeing the observer, making the sampling study of very little value.
- Insufficient observations are likely to produce inaccurate results.
- It does not normally account for speed of the operator.

SYNTHETIC DATA

- A work measurement technique for building up time for the job at a defined level of performance by totaling elemental times obtained previously from time studies on other jobs containing the elements concerned, form synthetic data.

SYNTHETIC DATA

The steps involved in synthetic data:

- Collect all the details about the job (dimensions, tools, methods, conditions).
- Analyse jobs into constituent elements (activity grouping to enable synthetic elements to be applied if relevant).
- Select appropriate basic times from synthetic data covering contingent factors.
- Select and apply synthetic data covering contingent factors.
- Verify details of elemental analysis for job method and condition.
- Total the basic times, rating and allowances to compute standard time for the job.

Advantages

- Although synthesis was originally developed to establish the work content for short batch production and jobbing work, it can be used in place of time study to determine times for many other types of work including repetitive work provided necessary data is available.
- The main advantage of synthesis is the reduced cost of application. By means of synthesis it is possible to establish times, which are equally satisfactory for planning and production control purpose.

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PREDETERMINED MOTION TIME ANALYSIS (PMTS)

- A standard time for a job or an operation may be established by time study, by work sampling or by the use of predetermined times.
- A predetermined time system consists of a set of time data and a systematic procedure which analyses and subdivides any manual operation of human task into motions, body motions, or other elements of human performance, and assigns to each the appropriate time value.
- This system of time data was originally developed from extensive studies of all aspects of human performance through measurement, evaluation and validation procedures.
- Predetermined times are the tabulated values of normal times required to perform individual movements such as moving an arm from one position to another, etc.
- The total times needed to perform the operation is the sum of the times needed for basic motions. By arranging the basic motions and

  aggregating associated times, an existing task can be analysed or a proposed operation can be timed without actually performing it.

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PREDETERMINED MOTION TIME ANALYSIS (PMTS)

Factors to be Considered While Using PMTS

- Application of PMTS requires that an operation which is to be measured is divided into basic motions as per the system selected.
- Each system has its own specific rules and procedures which must be followed exactly.
- Most PMTS do not include allowances, so these are added as in stop watch study.
- At the time of application of PMTS for the first time in a company the adjustment should be made if necessary, in order to match company's performance level which is one time activity.
- PMTS can be classified as to accuracy level, time required for application and the extent of method description.

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PREDETERMINED MOTION TIME ANALYSIS (PMTS); TYPES OF PMTS

- **Methods time analysis (MTA):** A. B. Segur stated that the method must be well defined before an attempt is made to time-analyse the motions involved.
- He developed a table of improvement principles involving many of his basic motions such as hold, grasp, preposition, position, avoidable delay and balance delay.
- The improvement principle involved here is in the elimination of the left hand as a holding device.
- In MTA, motion values are given up to fifth decimal.

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Types of PMTS

Work factor system (WE):

- This is first system of PMTS to have a general use with the work factor system it is possible to determine the work factor time for manual tasks by the use of predetermined data.
- A detailed analysis of each of the task is made based upon the identification of major variables of work and the use of work factor as a unit of measure.
- Then the standard time from the table of motion values is applied to each motion.

Four major variables of work factor system are:

Body member.

Distance.

Manual control.

Weight or resistance.

This system is applicable to highly repetitive system.

Methods Time Measurement (MTM)

Methods Time Measurement procedure is defined as:

- 'A procedure which analysis any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it was made."

- The primary objective of MTM is to improve methods of operation and it establishes methods accurately before production starts by determining correct times and operations.

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Basic Motion Time study (BMT)

- Basic motion time study was developed and is thought by J.P. Woods and Gordon Limited, Toronto, Canada. Like other predetermined motion time system, all manual activity has been divided into basic motions.
- A basic motion, according to Woods and Gordon, is defined as" Any motion which starts from rest, moves through space, and ends at rest"
- (Type 1) Reach
- (Type 2) Move
- (Type 3) Turn
- The body motion and symbols are very similar to the body motions employed by MTM. The only difference lies in the step, where the distance measured is the distance the foot travels.

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Advantages of PMTS

- Short cycle jobs can be timed accurately.
- Rating, the most difficult part of time study is not necessary.
- The results obtained are consistent.
- A reasonable estimate of work content can be obtained before the task is actually carried out.

METHOD TIME MEASUREMENT (MTM)

The objective of MTM is the establishment of tangible, understandable and acceptable data for the scientific measurement of human effort.

Method Time Measurement is defined as:

- ‘A **procedure which analyses any manual operation or method into the basic motions required to perform it and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made.**‘

USES OF MTM

- Developing effective methods and plans in advance of beginning production.
- Improving existing methods.
- Establishing time standards.
- Cost estimating.
- Training supervisors to become method conscious.
- Research in the areas like operating methods, performance rating.

METHOD TIME MEASUREMENT (MTM)

- MTM procedure recognizes:
  - Eight manual movements.
  - Nine pedal and trunk movements.
  - Two ocular movements.
- Thus there are nineteen fundamental motions to be considered in the establishment of any motion pattern. The time for each of these motions are determined not only by the physical conditions involved in the motions performance but also by the nature of the conditions under which it is made. Thus, the time for a given motion is affected by a combination of physical and mental conditions.
- Unit of MTM is TMU. One TMU $= 0.0006$ minutes.

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METHOD TIME MEASUREMENT (MTM)

CONVENTIONS FOR RECORDING MTM DATA

- To simplify recording individual MTM methods, a system of MTM. conventions has been developed. By using this system, every detail of the motion can be easily recorded. For example:
- **Reach**: Reach is the basic element when the predominant purpose is to move the hand or finger to a destination. The time for making a reach varies with (1) condition (nature of destination), (2) length of the destination, (3) type of reach.
- **Classes of reach**: There are five classes of reach. The time to perform a reach is affected by the nature of the object towards the reach is made.
- **Case** A **Reach**: to object in fixed location or to object in other hand or on which other hand rests.
- **Case B Reach**: to object whose general location known. Location may vary slightly from cycle to cycle.
- **Case** C **Reach**: to object jumbled with other objects in group.
- Case **D Reach**: to very small object or where accurate grasp required.
- **Case E Reach**: to indefinite location to get hand into position for body balance or next move or out of the way.
- The length of a motion is the true path, not just the straight line distance between the two terminal points.
- For example, R 8 C represent Reach 8 inches, case C.
- R 12 A represent Reach 12 inches, case A.
- The values of TMUS for these symbols are obtained from MTM tables.
- Similarly, the details for other symbols:
- Move, Turn, Apply pressure, Grasp, Position, Release, Disengage.
- Eye motions, Body leg and foot motions are obtained from the MTM tables (published).

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METHOD TIME MEASUREMENT (MTM)

MTM VERSIONS

- **MTM–1** is the most accurate. Provides the most detailed method detailed description but requires the longest time for analysis.
- MTM–2 was developed by constructing motion combinations from basic motion of MTM–l. The analysis can be done more quickly than MTM–l.
- MTM–3 is the simplest of the MTM systems and is intended for use with long cycle short run operations.
- Speed of analysis is seven times faster than MTM–1.
- **MTM–3** should not be used for analysing manual motions with a frequency higher than 10 or sequence of eye motions.
- The MTM should be used with caution. A sufficient training is essential to take up the MTM measurement.

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‘MAYNARD OPERATION SEQUENCE TECHNIQUE‘ (MOST)

- **INTRODUCTION TO ‘MAYNARD OPERATION SEQUENCE TECHNIQUE‘ (MOST)**
- H.B. Maynard and Company has introduced MOST system and this new system– was brought into practice in the United States in 1975. It has gained a wide recognition as a major contribution to the body of Industrial Engineering.
- This techniques has a wide application and can be successfully applied in all industries ranging from ship building to electronics, automobile, textile. Application have been made in offices, assembly shops, materials handling, maintenance and other such operations.

Levels of MOST and their Applications:

- **Maxi MOST**: At the highest level, maxi–MOST is used to analyse operations that are likely to be performed lesser than 150 times per week. An operation in this category is less than 2 minutes to more than several hours in length.
- **Basic MOST**: At the intermediate level, operations that are likely to be performed more than 150 times but lesser than 150 times per week should be analysed with basic MOST.
- **Mini MOST**: At the lowest level, mini–MOST provides the most detailed and precise methods analysis. In general, this level of detail and precise is required to analyse any operation likely to be repeated more than 1500 times per week.

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‘MAYNARD OPERATION SEQUENCE TECHNIQUE‘ (MOST)

DEFINITIONS:

- **Operation**: It is a job task consisting of one or more work element usually done essentially in one location or the performance of any planned work.
- **Sub–operation**: A sub operation is desecrate, logical and measurable part of an operation. The content of such a sub–operation may vary depending on type of operation requirements and application area.
- **Time standard**: It is the total allowed time including manual time, process time and allowance that it should take to perform a task or do a job.
- **Activity**: It is defined as the series of logical events that take place when an object is moved, observed or treated by hand, a tool or transportation device.
- **Method step**: A method step is a descriptive formulation of an activity one or more steps organised in sequence according to the applied method will constitute an operation or sub–operation.
- **Sequence model**: A sequence model is a multi–character representation of a single activity.
- **Sub**–activity: It is defined as discrete sub–division of an activity or sequence model.
- **Parameters**: It is a character representation of a sub–activity.

‘MAYNARD OPERATION SEQUENCE TECHNIQUE‘ (MOST)

- **Most analysis** Most analysis is a computer study of an operation consisting of one or several methods steps and corresponding sequence models as well as appropriate parame-ters time values and total normal time for the operation or sub-operation.

- Consequently only three Basic, Most activity sequence are needed for describing manual work plus a fourth for measuring the movements of object with manual cranes.

  The GENERAL MOVE SEQUENCE (for spatial movement of an object freely through air).

  The CONTROLLED MOVE SEQUENCE (for the movement of an object when it remains in control with a surface or it is attached to another object during the movement). • The TOOL USE SEQUENCE (for the use of common hand tools).

Application of MOST

- This technique finds its application for method improvement. It helps to established the standards and also for determining the production delays and labour performance index.

QUESTION BANK

1. Define time study and explain its objectives.
2. Explain the various steps involved in time study.
3. What is performance rating? Why it is required to rate the worker? What are different rating methods?
4. Explain the Westinghouse method of performance rating.
5. Explain the various types of elements with examples for each.
6. Explain the principle techniques of work measurement and their applications.

QUESTION BANK

7. Explain various timing methods in stop watch study.
8. Explain the effect of following on standard time:
    a) Skill of the operator,
    b) Variation in work,
    c) Pace of performance,
    d) Working conditions.
9. Why it is necessary to give allowances? What are different types of allowances? How standard time is computed?
10. What is the relationship between observed time, normal time and the standard time?
11. What is work sampling? What are its merits and limitations? Where work sampling can be useful in the area of production?
12. Explain briefly the steps in work sampling study.
13. How do you determine number of observation to be taken?
14. Write short notes on:
    a) Synthetic rating and analytical estimating,
    b) Data and analytical estimating,
    c) Predetermined motion time study (PMTS),
    d) Methods time measurement (MTM),

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