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British Standard

Work study and organization and methods (O & M)

Part 3. Guide to work measurement

Etude de travail, organisation et méthodes (O et M)
Partie 3. Guide de la mesure du travail

Arbeitsstudien, Organisation und Verfahren (O und M)
Teil 3. Leitfaden für Arbeitszeitstudien

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Foreword

In 1959 the first edition of BS 3138 'Glossary of terms used in work study' was published which was revised in 1969. In 1979, the second revision was published as 'Glossary of terms used in work study and organization and methods (O & M)'.

As BS 3138 has become increasingly used throughout the private and public sectors of British industry and throughout the world (the ILO* use it as a reference standard), BSI and some of the cooperating organizations for BS 3138 have received numerous enquiries as to how the various terms and disciplines interrelate with each other.

Accordingly it was decided to prepare under the direction of the Quality, Management and Statistics Standards Committee a new series of guides as BS 3375 to meet this need, and to reflect the four main sections of BS 3138.

To date, BS 3375 comprises the following Parts:

Part 1. Guide to organization study
Part 2. Guide to method study
Part 3. Guide to work measurement
Part 4. Guide to work performance control

In this Part, in addition to the conventional use of italic type for subclause heading, etc., defined terms (see clause 2) have been printed in italic type for ease of identification.

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Guide

0 Introduction

0.1 Purpose of the guide

This guide supplements the information in the *work measurement* section of BS 3138 by noting and explaining the uses of *work measurement* in organizing, controlling, and monitoring work. This was not thought earlier to be necessary, but the many enquiries received from senior managements, *management services* practitioners, and specialists in other disciplines, suggested that many of the definitions and their uses are imperfectly understood. Accordingly it was felt that further clarification of the basic techniques, their application and use should be provided.

Recognizing that the balance of terms in the *work measurement* section is weighted heavily towards *time study*, some more recent developments in other techniques are noted and explained, and guidance is given in broad terms on the factors affecting choice of techniques. It was thought helpful also to supplement the information in BS 3138 about development of time standards, and to offer guidance on the maintenance of standards and on the *work measurement* aspects of *management services* training. The objective has been to demonstrate the contribution of *work measurement* to the whole field of operations management. Consequently although BS 3375 has been based on BS 3138, it also reflects current thinking.

The increasing use of *work measurement* in service and administrative areas has resulted in a number of the traditional descriptions taking on broader and at times slightly different meanings. Consequently a single document with examples for all areas of application might confuse or mislead. Given that the purpose and principles of *work measurement* remain the same wherever it is used, the traditional terminology has been retained.

0.2 Objectives of work measurement

In order to survive, all commercial, industrial and public service organizations have to exercise vigilance in controlling their costs and in ensuring that they get the best return from their expenditure. Profit is one measure of organizational efficiency: but it can be an unreliable yardstick in conditions of imperfect competition. Competition provides a spur to economic vigilance and continued improvement; but it cannot by itself provide an absolute criterion against which to judge effectiveness. Even techniques such as budgetary control can only work effectively on the basis of sound predetermined targets for achievement.

Work measurement aims to provide this reliable and consistent basis for comparing what has been achieved against what should have been achieved from a given expenditure of resources. It seeks to determine the resources needed, at all levels of activity, to achieve defined objectives.

Starting from the basis of the time required to carry out a *task*, the physical requirements of manpower, plant, and equipment can be calculated. Those requirements will determine also the space required and, from the running times of the plant and equipment, the manpower requirements and the shift patterns, the energy needs can be assessed.

0.3 Dependence on method and design

It is clear from the definition of *work measurement* that it is the measurement of a *task* in terms of time. The definition of a *task* implies that both the design of the product or service and the method used to carry it out are specified. So *work measurement* is strictly the measurement of a given working method for a specific design in terms of the time needed for a *qualified worker* to carry it out at a defined rate of working. This clarification is important because it emphasises that the objective time required for a *task* depends upon the method and the design that are followed. Therefore the concept of work *measurement* is meaningless in isolation. *Method study* should always be carried out before attempts are made to determine time standards, and there is often need for *work measurement* to be conducted on existing methods as part of data collection and for comparisons when developing improvements (see figure 2 of BS 3138 : 1979 and **3.2.1** to **3.2.3**).

0.4 Basis for output and productivity

Increasingly *work measurement* is being seen also as a basis for monitoring the productivity of an undertaking at different levels of activity, the comparison at each level being between the output and the resources expended. The productivity measure is the index of output/input where output is the number of work units (standard hours) produced and input is the expenditure of the man hours involved.

0.5 The nature of work measurement

Changes in work organization and employment patterns since the 1979 edition of BS 3138, have brought acceptance that for valid planning all work should be measured in some way. This has led to changes both in the frequency of use and methods of application of the established *work measurement* techniques, and the range of some of them has been widened. With the increased numbers employed in administrative and service functions there have been some changes of emphasis in the way measurement is applied and a greater dependence on synthetic data in conjunction with statistical methods of data processing and various forms of *activity sampling.* The use of *predetermined motion time systems (PMTS)* for measuring short-run and non-repetitive work has been facilitated by developments in microcomputing equipment, and modern recording devices have simplified direct observation studies. But it is important to recognize that although the manpower element of all work is measurable by an appropriate technique, this can be done only on the basis of an average whose limits of accuracy can be determined statistically, as in *category estimating;* (see **4.4.6** and **4.6**). Even *time study,* the earliest formal technique, uses what is essentially a sampling procedure in that the use of *rating* makes possible a smaller sample. Detailed *PMTS* were derived from statistically validated samples, and the higher order of most *PMTS* were developed by *statistical analysis* of motion frequencies.

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1 Scope

This Part of BS 3375 clarifies the objectives and outlines the benefits that can be gained by the use of *work measurement* procedures in the field of operations management. The degree of difficulty and the advantages and disadvantages of applying the various techniques are set out in tabular form for ease of comparison by senior managements, *management services* practitioners and specialists in other related disciplines.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 3375 the definitions given in BS 3138 apply.

NOTE. See paragraph 5 of the foreword.

3 Uses of work measurement

3.1 Introduction

The primary purpose of *work measurement* as traditionally established is to derive times for human work. This gives a basis for determining manning levels for a given level of output, and helps to determine shift patterns, plant requirements and the energy demands of the work programme.

In this guide a general view is taken that relates to the overall needs of an organization rather than just the traditional view of *work measurement* as the measurement of a *task*, or a group of *tasks*, in terms of time.

3.2 Resource organization and utilization

3.2.1 *Product design.* A 'product' may be a mechanical, electronic, or structural artefact or it may be a service or an administrative control system. In each case the need can be

(a) for ease of manufacture (e.g. material and design);

(b) for ease of use (e.g. comprehensibility of a claim form to an applicant and subsequent ease of checking to an assessor); or

(c) for ease of maintenance (e.g. accessibility of mechanisms or of basic data in a control system).

There is often a need to decide between competing demands, for example between the relative importance to be ascribed to ease of use, manufacture or maintenance. *Work measurement* can aid these decisions by providing comparative time implications for the alternatives and thus for finding the most economic compromise. See also term 33006 of BS 3138 : 1979.

3.2.2 *Workplace layout. Ergonomics* and the *characteristics of easy movement* are the techniques and principles that govern workplace design. *Work measurement* is necessary as an aid to analysis and in deciding upon the best of the alternatives presented. The detailed motion analyses offered by *PMTS* are particularly appropriate when designing assembly facilities for repetitive work.

3.2.3 *Method.* The *characteristics of easy movement* are relevant to the development of easier and more effective working methods. Other factors that have a bearing on this, e.g. in assembly work, are the presentation of components or documents to the worker, use of chutes and conveyors for passing completed work to the following stage, and the development of holding devices so that both hands are free for assembly or other work. In each case *work measurement* can guide development of the most appropriate alternative.

3.2.4 *Design and method improvement. Work measurement* data are used to work out preferred changes in product or system design, *workplace layout* and working methods.

3.2.5 *Work balancing.* In *team working,* particularly in short cycle work, close *work balancing* between individual groups and departments is essential if high utilization is to be achieved. The output of the whole team working at *standard performance* can be no greater than the output of the operation with the highest *task* time, e.g. in a team of six the labour utilization would be only 86 % if one station had a six-second cycle and each of the other five had a five-second cycle. *Work balancing* under those conditions usually entails very close attention to motion patterns and handling arrangements in order that the work may be distributed equally as far as is possible between the *work stations*, so very detailed measurement of *element* times for operators and plant is necessary. There is a need also to select and train operators to maintain *standard performance. Work balancing* also has a significant role as between individual departments and processes in a total production system, where the final output is governed by 'the department or the process with' the smallest capacity.

3.2.6 *Scheduling.* Production schedules, delivery times and dates and other information for production or work control (see BS 5191) are developed by relating *task* times to capacity.

3.2.7 *Work sequencing.* Where work necessarily follows a given route through several processes, the most advantageous economic order in which each *task* is loaded to each process can be determined by minimizing work in progress and delays, and by maximizing resource utilization within the programmed time scale. Owing to the great number of variables involved, optimization of sequencing is complicated, and is most easily done by electronic data processing (EDP), although rule of thumb manual methods have been developed for that purpose. But however the calculation is made, the operating, setting and maintenance times for each item at each stage are critical: *work measurement* provides this information.

3.3 Productivity and performance

3.3.1 *Productivity.* Manpower productivity is the relation between input and output where the output is the manpower content (*standard hours*) of the resultant products and the input is the attendance hours of the workers concerned. *Work measurement* is needed to quantify the manpower content of the products, whether those be an artefact, a service, or an administrative system.

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3.3.2 *Performance. Labour performance index* is the relation between the hours allowed (i.e. by measurement plus any *estimated work*) for the work done, and the number of hours (attendance hours) spent on it. (See **3.4** and **3.5** of BS 3375 : Part 4 : 1985). The basic distinction between productivity and performance is that performance relates to the work that is actually carried out, whether or not it is part of the standard method, and *operator performance* excludes the time during which the operator is unoccupied.

3.4 Financial calculations

3.4.1 *Costing.* For accurate manpower costing it is necessary to know the direct labour costs for all the *tasks* that comprise a product. *Standard times* are the basis of these calculations, and of any ratios, *variances,* and budgets used in cost accounting.

3.4.2 *Financial incentives.* Time standards can be used in *financial incentive schemes* that are based upon measured achievement within a defined period. See **5.4** of BS 3375 : Part 4 : 1985.

4 Techniques and procedures

4.1 Introduction

When BS 3138 was first prepared, the main *work measurement* technique was *time study,* and the main areas of application were the man/machine *tasks* in manufacturing industry, as shown by the range of definitions in section four. But technological development and economic pressures since the 1979 revision have brought changes in work organization, employee attitudes and the pattern of employment generally. These have affected both the frequency of use and the methods of application of the established techniques.

For example, the growth in the proportion of workers employed in the administrative and service functions has led to greater emphasis on techniques such as *synthesis* that are more suitable for measuring those functions. The definitions in section four of BS 3138 : 1979 are still valid in their proper context, but because of this changing emphasis many of them are less relevant for practitioners working predominantly with other techniques in other areas.

There has been, therefore, a widening of the range of techniques that the trained practitioner regards as necessary for complete coverage of the work which he is required to measure, so, as well as amplification of many of the previous definitions, some new terms have been introduced in **4.2** to **4.6**. The techniques and procedures have been classified under five headings in order more clearly to compare and contrast.

4.2 Direct observation

4.2.1 *General.* Most of the techniques in this group are designed to produce a *standard time* for a specified *task*, though they may also be used to record the *basic times* for defined *elements*, for future use in *synthesis* or in design and methods improvement (see **3.2.4**). They differ primarily in the ways of recording *observed times*, methods, *workplace layout* and working conditions.

4.2.2 *Rating.* Those techniques involving observation require adjustment of *observed times* so that they represent the rate of output expected from an average *qualified worker.* This is achieved through the use of a *British Standard rating scale* where the observer makes a judgment on actual performance against the scale. Through the process of *extension* the *observed time* is converted to *basic time.*

4.2.3 *Time study. Time study* normally involves manual recordings of the *elements* as they are performed, and the use of a stop-watch to measure their actual duration. *Rating* is applied to convert *observed times* to *basic times* and *relaxation allowances* are then added to produce a *standard time* for the *task* studied. This method is most conveniently used to cover predictable *work cycles* of short to medium duration, involving a mixture of manual and process times for which synthetic data are not readily available. The concept of *selected basic time* is relevant where each *element* is timed and rated on several occasions during a study, as in *time study* (see **6.2.1**).

4.2.4 *Activity sampling. Activity sampling* measures the proportions of time spent on different activities, or states of inactivity, by an individual or group of persons and/or machines. *Rating* can be applied to the manual work observed; the results may then be related to the volume of work produced during the study to derive *standard times* for the *tasks* or operations studied.

4.2.5 *Production studies. Production studies* cover a relatively long duration; their purpose is fully described in the definition. A subcategory, known as frequency studies are undertaken when *element* times for a *task* or range of *tasks* are already available (from *PMTS* or other data), but where frequencies cannot readily be deduced by visualization or analysis of available records.

4.2.6 *Film, video and audio recording*

4.2.6.1 *Film analysis. Film analysis* is a method by which times for individual motions or complete *elements* are derived from a ciné film, by counting the number of frames occupied by that motion or *element.* Time-lapse or normal photography may be used and the film speed has to be controlled accurately. *Rating* may be applied, and *observed times* adjusted accordingly.

4.2.6.2 *Video recording.* Video recording is a method of obtaining a visual record of people at work, which can be displayed for subsequent analysis. Both film and video tapes have the advantage of providing a complete, permanent and repeatable record of the observed methods.

4.2.6.3 *Tape data analysis.* Tape data analysis is a method by which the analyst makes a verbal record of the work being observed (usually in the form of *PMTS codes* augmented by brief descriptive material) using a tape recorder. The record is subsequently transcribed to provide a written *PMTS* analysis of the *tasks* studied.

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4.3 Synthesis

4.3.1 *General. Synthesis* is the derivation of *task* time standards from previously studied and validated *element* times without recourse to direct observation. It can be accomplished in various ways, using *standard time* data arranged at appropriate levels of detail.

4.3.2 *Data collection.* Where the same *element,* with the same *basic time* is common to more than one *task,* it is prudent to build up a library of *elements* and their associated times for use in calculating future standards. Where groups of *elements* recur in the same sequence and frequency they can be marshalled into higher order data blocks; that approach has been used in developing second and subsequent generations of some *PMTS.* In all cases it is desirable to establish formal patterns for data collection so that common and logical *break points* are used.

4.3.3 *Synthetic data*

4.3.3.1 *General.* The term synthetic data describes *task* time standards or their component *element* times which have been systematically collected and published in a form to facilitate their rapid application. Examples of some classes of synthetic data are given in **4.3.3.2** to **4.3.3.6**. Note that a number of standard proprietary packages are available at each level. Some incorporate statistical validation processes and others make use of electronic data processing facilities.

4.3.3.2 *Predetermined motion time systems (PMTS).* The definition of *PMTS* covers both the basic level of times and the successive generations of data that have been developed by combining the basic motions into sequences that occur frequently. Above the basic level the averaging necessary to derive the times for those sequences gives short-term positive and negative deviations. The length of the *work cycle* in which these deviations balance out is known as the balance time for the generation. Application of all *PMTS* requires analysis of *tasks* in terms of the activity patterns, using codes to identify the motions used in performing them. This analysis is a useful basis for method and design improvement (see **3.2.3** and **3.2.4** and definitions 32022 and 32023 of BS 3138 : 1979). As *PMTS* relate to basic movements and to people's mental and visual processes, they are applicable universally in all types of work or environment.

4.3.3.3 *Special purpose data (or 'trade data').* Special purpose data are times for *elements* which regularly occur within particular types of work, e.g. clerical work. They may be performed manually or by a machine. The times may be obtained by *PMTS* analysis of typical motion patterns for the *elements* or by analysis of *time studies* or films of the work.

4.3.3.4 *Higher-level data.* Higher-level data are times for broadly-defined *elements* of relatively long duration or for commonly-occurring *operations.* They are normally developed for, and specifically applicable to, the work of a particular organization or the *operations* carried out on a particular type of machine. The data may sometimes be expressed as a time formula, consisting of a mathematical expression that takes account of both the fixed and variable *elements* within the *operation* or *task.*

4.3.3.5 *Modular time standards.* Some sets of data are arranged so that instead of each *element* having its own specific time standard, groups of *elements* are allocated to a series of modules, with a common time standard for each module.

The times usually follow a mathematical progression to minimize the potential errors thus induced. The method is said to facilitate the rapid application of the data.

4.3.3.6 *Operation sequence times. Operation* sequence times is a method of applying *PMTS* in which the macro *elements* of a *task* are expressed in terms of predetermined *element* sequences, to which modular standards are applied. The approach is designed for fast application where precision is not the main consideration.

4.4 Estimating techniques

4.4.1 *General. Estimating* techniques cover methods used for assessing the time likely to be taken by 'one-off' or infrequently-recurring long-cycle *tasks* (e.g. construction work, major assemblies or repairs).

4.4.2 *Estimating. Estimating* provides a subjective assessment of the total *work content,* on the basis of experience and historical data. By implication (see **4.4.4**) it is non-analytical.

4.4.3 *Analysis of historical records.* Analysis of historical records covers the extraction of time or frequency data from records of work which may or may not have been kept specifically for the purpose. *Task* times derived in this manner are of doubtful reliability, since they may include, e.g. *ineffective time* or *waiting time.* They may however provide a guide for estimates of the *work content* of new *jobs.* Useful information on *element* frequencies can also be obtained from such analyses, for use in *synthesis.*

4.4.4 *Analytical estimating. Analytical estimating* differs from the method described in **4.4.2**, in that the *task* is first analysed into its component *operations* or *elements;* if *standard times* are available for any of these *elements* they are applied, and the *work content* of the remainder is assessed on the basis of experience.

4.4.5 *Comparative estimating. Comparative estimating* is a method of arriving at the time for a *task,* sometimes to within statistically-calculated limits of accuracy, by relating its *work content* to that of *tasks* which have previously been measured by one of the objective techniques of direct observation or *synthesis.* It therefore incorporates the concept of a defined rate of working. *Tasks* are usually grouped into time ranges or time-slots to which nominal time values are assigned.

4.4.6 *Category estimating. Category estimating* is similar in concept to *comparative estimating* except that it involves the allocation of *tasks* to predefined work categories rather than time-slots.

The system incorporates a method of monitoring the *task* times by statistical measurement which has the benefit of providing statistical limits of accuracy.

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