

AACE
INTERNATIONAL
RECOMMENDED
PRACTICE

22R-01

**DIRECT LABOR PRODUCTIVITY
MEASUREMENT - AS APPLIED IN
CONSTRUCTION AND MAJOR
MAINTENANCE PROJECTS**

SAMPLE

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IN CONSTRUCTION AND MAJOR MAINTENANCE PROJECTS**
TCM Framework: 9.2 – Progress and Performance Measurement

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Note: As AAACE International Recommended Practices evolve over time, please refer to www.aacei.org for the latest revisions.

SAMPLE

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Disclaimer: The opinions expressed by the authors and contributors to this recommended practice are their own and do not necessarily reflect those of their employers, unless otherwise stated.

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TCM Framework: 9.2 – Progress and Performance Measurement



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INTRODUCTION

This recommended practice of AACE International describes a direct method to measure, monitor and optimize construction and maintenance project labor productivity. The method described is statistical sampling of the work process, or: work sampling. The work process is made up of steps and activities that take input resources, add value, and produce the completed project. Understanding the capability of the process, or 'management system,' to produce efficiently is important for project planning and control. Sampling is a cost-effective way to provide information about the performance of the work process, i.e., about 'how' the work is done, and how to do it better. Work sampling complements conventional project management methodology, which typically tracks 'what' work is done.

Sampling provides project managers, supervisors, and the workforce with objective feedback re: the efficiency of the work process (not of individual workers, which is part of the foreman's job) and the ability to respond quickly to adjust. In addition, it provides a measure of management's ability to effectively plan, coordinate, and control project execution. Analysis of the sampling data allows for prompt removal or reduction of roadblocks, optimizing the construction work process through redesign and innovation. Streamlining the work process ensures that performing productive work is made more convenient for the workforce, ensuring that, at all times, crafts and technicians have all the necessary tools, materials, parts, supplies, information, supervisory support and personal needs readily available. Work sampling, properly applied, recognizes that productivity results from an optimal work process, i.e., from 'managing smarter,' not from people working harder.

Construction labor productivity is a measure of work process efficiency. It can be defined as the ratio of the value labor produces to the value invested in labor. Productivity increases as needed labor resources are minimized and wasted efforts eliminated from the work process. This definition and the practice covered here treats productivity as a direct, absolute measure to be optimized.

PURPOSE OF DIRECT MEASUREMENT

The purpose of construction and maintenance project work sampling is to measure and assess the work process, and provide useful, (near) real-time information about the process. It is a tool to enable more efficient, safe completion of the work scope so that fewer labor-hours will be expended than customary.

Systematic statistical observation of general work activity on the project site is useful to:

1. determine the proportion of direct labor hours being wasted in non-productive activity and delays, and productive work activity;
2. analyze factors that cause non-productive activity and delays; and
3. identify opportunities to reduce non-productive activity and delays.

As part of its discipline, work sampling enables cost management to affect productivity improvement on labor-intensive construction and maintenance projects. Work sampling on a project helps monitor the work activity to obtain an overall picture of the utilization of the workforce. With statistically sound samples, inferences can be made regarding constraints to the flow of work and resulting inefficiencies in the process. Consistent application of

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sampling over a period of time provides project managers ongoing information about the effectiveness of actions taken to continuously improve the work process.

Analysis of the (estimate-independent) data quantifies non-productive activity and identifies possible causative factors, suggesting corrective action. Work sampling provides managers and supervision quick, actionable feedback on work process performance – insight that cannot be obtained by conventional project control metrics. Conventional productivity measures tell when productivity problems occur, but work sampling also tells why – the methods complement each other.

The actual, project-specific, quantitative data obtained by work sampling ensures objective assessment of the work process. As such, the data supports benchmarking and continuous improvement of efficiency and productivity. Properly applied, it is effective in getting more construction or maintenance work done with fewer labor-hours, and with greater worker safety and satisfaction.

BACKGROUND ON PRODUCTIVITY, EFFICIENCY AND WORK SAMPLING

Construction and maintenance project performance is an important concern of project owners, constructors, and cost management professionals. Project cost and schedule performance depend largely on the quality of project planning, work area readiness preparation – and the resulting productivity of the work process made possible in project execution. Labor productivity is often the greatest risk factor and source of cost and schedule uncertainty to owners and contractors alike.

Construction and major maintenance projects are commonly managed and controlled through oversight and coordination. At intervals, progress is tracked against agreed-upon schedules and budgets – which are estimated, based largely on historical performance data. This method may be effective for highlighting when performance is not on track with plans. But it does not show why productivity is lagging or out of control, nor does it support decisions on corrective actions and improvement of the work process. As such, traditional project control measures do not fully address the objective of improving cost and schedule performance. For meaningful cost and schedule optimization, direct productivity measurement must be used to complement the indirect, relative control measures that compare performance to the estimate.

Breakthrough lessons learned by US manufacturing in the 1980s showed that managers must take responsibility for the majority of work process ('system') performance problems. It is management's job to plan, develop, and continually ensure an efficient work process – the workforce works within the boundaries of the process.

These lessons also apply to the construction industry – raising the productive use of labor-hours by applying process measurement, analysis and improvement results in better productivity, efficiency and cost effectiveness. Using statistical techniques, such as statistical process control (SPC), and Six Sigma (focus on process variation) many firms were able to radically increase productive efficiency and quality – theirs and their vendor's.

Work sampling is a statistical technique that can be effectively used for analyzing the construction and maintenance work process. Proportions of time devoted by crafts and technicians to the variety of work activities, and the variability of the work process are measured. The application has proven effective on hundreds of construction and maintenance projects, achieving labor cost savings of 20 to 30 percent, and more.

Work sampling has been widely used to periodically make studies of industrial operations. Originally used in the textile industry in the U.K., it was introduced in the US during the World War II effort to obtain information about men or machines. A fact-finding tool, it was called "snap-reading" method – referring to the instantaneous recording of observation of activities being studied. The method provides process information quickly and at less

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cost than other means. The technique has been used in one form or another by different groups for different reasons, although sometimes unfortunately misused, e.g., as a way to ‘blame’ the workforce for low productivity.

Observations must be random and free of bias, or systematic observation errors that tend to run in the same direction. Consistently carried out according to definitions and procedures, sampling results will differ from actual conditions only in a random manner and will be unbiased. The greater the number of observations, the more accurately will sampling results approximate actual conditions.

Advantages of the work sampling method are:

1. Random observations are made of overall project work activity of groups of workers, collectively observed at randomly selected areas and times, not of specific individual workers.
2. Sampling causes less anxiety and tension among workers than continuous observation (such as with a stopwatch).
3. There is no, or minimal, interference with the worker’s normal activities.
4. Observers with minimal specialized training can conduct random work sampling.
5. The number of observations can be adjusted to meet desired levels of accuracy.
6. Work sampling is an effective means of collecting useful facts during project execution that are not normally collected by other methods.
7. Work sampling is less expensive than continuous observation techniques.

WORK SAMPLING THEORY

Work sampling is based on probability theory. This means that activity samples observed at random from a large group of craft activities on a project tend to have the same pattern of distribution as that of the large group. The ratio of the number of observations (samples) on a given activity to the total number of observations of all activities approximates the percentage of time that the work process spends on that activity. If the number of observations is large enough, the percentage of time found by work sampling spent on an activity will differ little from the actual time spent on that activity in the work process developed on the project site.

A sufficient number of observations must be taken to ensure accuracy. Although the procedure is easy to learn, it is important that sampling tours are conducted randomly, without bias. Every worker on every assignment during each work period should have an equal chance of being observed on each work sampling tour.

A fundamental principle of work sampling is that the number of observations is proportional to the percentage of time the work force is engaged in an activity such as, for example, ‘working’. A sample of size N is taken to estimate the proportion P . According to elementary sampling theory, we cannot expect the proportion based on a sample (p) to be the true value of P . But we can expect the value of p to be within the range of $P \pm 2\sigma$ (‘sigma’ is the symbol for standard deviation) approximately 95 percent of the time at a (selected) 95 percent confidence level. With P as the true percentage to be determined, the p of any sample can be expected 19 times in 20 to fall within the limits of $P \pm 2\sigma$ by chance alone.

As the number of observations N increases, the sampling error diminishes, i.e., the value p gets closer to the true value of P . The absolute accuracy is the difference between the observed percentage p and the true value P (relative accuracy is this difference expressed as a percentage of the observed percentage). Absolute accuracy of resulting data can be calculated with this formula: