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How to Use Work Measurement for High-Productivity Maintenance Operations

Nowhere is the application of work measurement likely to generate more productivity improvement and cost reduction than in maintenance. Maintenance represents the largest single variable operating cost in most enterprises when you include physical plant value, maintenance labor, materials and overhead. And yet, maintenance does not receive a proportionate amount of higher management attention. High productivity maintenance contributes to better customer service, higher quality, on-time delivery and ultimately, satisfied customers. They will not only keep coming back but will spread the word to other potential customers.

This article reveals how the Maintenance, Engineering or Industrial Engineering Manager spearheads the achievement of dramatic productivity impact by implementing work measurement to manage and control maintenance. Work measurement and method improvement have been the focus of Industrial Engineering since its inception as a separately recognized engineering discipline.

Essential Principles for a High-Productivity Maintenance Program

Any program that focuses on lasting results is based on sound principles. Productivity in maintenance is no exception. There are several principles that, if followed, lead to spectacular results that not only last but also grow in value far into the future. Industrial engineers are very familiar with some of these because they apply to measuring direct operations. Some serve the special needs of maintenance work. These principles are as follows:

Scientific principle. Best productivity result when each worker has a definite job to do in a definite way and a definite time. Frederick Taylor's principle applies to all work; maintenance is no exception.

Measurement before control. The measurement of an activity is basic to its control. Lord Kelvin saw this in the 1700's as applied to his scientific investigation of the laws of physics. It is universal.

Activity responsibility. The responsibility for each activity in the life of a work order is necessary to ensure that the work order continues to move toward resolution without delay.

Delegate, educate. If you delegate responsibility for an activity or function, you must educate the staff in means to carry out that responsibility.

Customer/service relationship. A customer/service relationship exists between the beneficiaries of the work—customers--and those who perform maintenance work—service providers. The customer decides what is needed from an operational viewpoint, and maintenance decides how the service is provided. Together the customer and maintenance decide when--the priority—based on resources available and urgency of each specific task compared to other current work.

Crew size. The optimum crew size for a maintenance job is the smallest that can perform the work using a good method in a safe, efficient manner. The standard crew size is one. Other crew sizes are applied as exceptions to this general rule.

Timeliness. Large maintenance jobs or projects are divided into smaller work orders. Smaller work orders are easier to plan accurately. They highlight problems or roadblocks early enough to enable making adjustments that result in on-time completion of the project.

These principles are the basis for the application of work measurement in maintenance described below.

The nature of maintenance work

An examination of the nature of maintenance work reveals some unique characteristics. It is low volume work. A maintenance technician often does many different jobs in a single day unlike the production counterpart who does high volume work. The maintenance technician does longer cycle work while the production worker does shorter cycle work. These significant differences led to major problems in early attempts to measure maintenance work. Breaking long jobs down into elements resulted in a large number of elements because the job duration was so long. Each element required further study followed by application of detailed stopwatch time study or a predetermined time system analysis to determine the time for each element from the method identified. Furthermore, if the same application technique applied to high volume production were used, the industrial engineer had to study each job in each skill. There are at least four or five hundred different jobs, or tasks, in each of 14 skills—mechanical, carpenter, paint, masonry, pipe, electrical, sheetmetal, weld, labor, custodial, HVAC, automotive, instrument, machining. The combination of many elements, many different maintenance tasks and many skills results in the need to develop, apply and maintain a library of over 7000 standards. One of the most difficult activities the industrial engineer faced was applying the standards to the daily maintenance workload. Which task standards would be required on a given day? Where is the standard for that task filed? Is it realistic to measure this kind of work with the same precision as high volume work? In short, the attempts failed. Another approach was needed.

Universal Maintenance Standards.

In the early 1950's, after repeated attempts to use conventional work measurement failed, industrial engineers sought new methods for assigning standards to maintenance work. The resulting standards were called Universal Maintenance Standards (UMS) because they could be applied not just in one location, industry or service enterprise, or one country, they could be applied everywhere maintenance work was performed—manufacturing, service, government, utilities, commercial, finance, education or healthcare. It could be applied to conventional building and equipment maintenance and also to the huge and rapidly growing information technology assets of an enterprise. It could be applied to IT project management as well as trouble call management at the help desk.

The UMS system is based on two important techniques: range-of-time and work-content-comparison. These techniques are described below:

Range-of-time. The range-of-time technique recognizes the variable nature of maintenance work. A simple task such as removing and replacing a part may take more or less time depending on how tight the bolts are, how many coats of paint or much rust is present on them. The range of time is that variation in time that will cover 95 out of 100 situations. For example, the standard time of 1.2 hours represents a range from over 0.9 hours up to and including 1.5 hours. The industrial engineer or planner applies a standard time of 1.2 hours to any job that falls in that range.

Work content comparison. Even though the parts are different, the motion pattern for two tasks may be much the same, and therefore, the time to perform them is the same. For example, hand threading a one-inch nut on a bolt is like screwing in a light bulb. Or replacing a wall light switch receptacle is the same as replacing a wall plug receptacle. If the time to perform one of the similar tasks is known, that time can be applied to the other task using the work content comparison technique.

In large samples of data, task times applied using the range-of-time and work-content-comparison techniques were found to compare favorably with task times dutifully applied using direct work measurement techniques. The UMS data was found to be within +/-5% of the true standard with 95% confidence. If one hundred UMS samples of forty hours of work each were taken, in 95 out of the 100 samples, the UMS times would be within the accepted industrial engineering accuracy range of +/-5%.

Organizing the data

The industrial engineer organizes UMS data in a building block fashion similar to direct labor standard data. Five levels of data make up the UMS library: basic motions, basic operations, craft operations, bench marks and spread sheets.

Basic motions. The foundation of UMS data is predetermined time system basic motions. A predetermined time system analyzes and classifies method data into basic motions and establishes a relationship between the motions and the time required to perform them. Two very widely used predetermined time systems are Methods-Time Measurement (MTM) and Maynard Operation Sequence Technique (MOST).

These techniques measure work by dividing it into basic motions such as reach, grasp, move, position and release. They document the motions, sequence of motions and time. The time for each motion is picked from tables of predetermined times.

Basic Operations. The basic motions are grouped together to form basic operations, common to all crafts. For example, one of the basic operations is part handling. All crafts use part handling motions so basic operations includes a table of part handling operations. The variables included in the table are weight of the part, distance moved, whether the part is located on a workbench or on the floor. From this table, already developed, all part handling values are selected. Consistency, speed of application and accuracy are enhanced with this approach.

Craft Operations. Some operation times are unique to a certain craft. For instance, welding operations are made up of manual handling, body motions, machine settings and arc times. The latter times are a function of the joint configuration, metal characteristics, rod or wire size and length of the weld. Special data, called weld craft operations data, is organized for application to this welding of work. Similar craft data is available for other skilled craft operations such as painting, carpentry, electrical, pipefitting and machining.

Bench Marks. The industrial engineer selects table values from the basic operations and craft operations standard data to develop typical jobs—called bench marks—for each craft in the facility's maintenance department. The bench mark contains the method steps and the time for each step. It does several things: it provides a process for method engineering as the bench mark is created; then it acts as a method instruction once approved and applied to a work order. It is the first data level that documents a complete maintenance task.

Examples of electrical bench marks are "replace a control switch", "wire a motor to a fused switch", or "troubleshoot a control panel".

Examples of mechanical bench marks are "replace a set of 4-C90 V-belts", replace a conveyor roller", or "install a handrail". Tasks are selected for bench marks because they represent the work most frequently performed by a craft. If they are properly selected, a small number of bench marks, usually around 100, can be used to apply standards to all the work in a craft. The planner uses the work content comparison technique to apply standards to work orders for which no bench mark exists.

Using UMS, the industrial engineer can typically apply standards to all maintenance work with 1200-1500 bench marks covering all fourteen crafts, substantially reducing the data library required compared to the direct standard method requiring over 7000.

Spread Sheets. Even with the advantages described above, there is still the challenge of managing 1500 bench marks, quickly finding the appropriate one for an application, or finding the right bench mark for comparison with a work order for which no bench mark exists. The spread sheet fills these additional needs admirably.

The industrial engineer sorts the bench marks first by craft, then by task area within craft, depending on the division of maintenance responsibility for that facility. Finally, the bench marks are sorted by range of time.

Examples of typical electrical task areas are as follows: lighting, controls, wiring, motors and generators.

Examples of typical mechanical task areas are as follows: Belt drives, reducers and gear boxes, material handling equipment, compressors, clutches and brakes, and lubrication and service.

The bench mark titles are listed on spread sheets in groupings as sorted above. The spread sheets are the only data required for the actual day-to-day application of UMS times to work orders. The other levels provide valuable backup that gives credibility to the times and can be used for periodic audits to ensure that the times are still valid and are being applied properly.

All work order times consist of four components: job preparation time, area travel time, job site time and allowances for personal, rest and minor unavoidable delays. The job preparation and area travel times are developed for each facility during bench mark development. The job site time comes from the spread sheets. The three components are added together, and the allowance is applied as a percentage of all three. Allowances are set by management policy and may be apart of the management-labor agreement. All four components are arranged on a single UMS time calculation table. Once the table is developed, the whole application process takes only seconds for work orders that are several hours long.

Organizing for Maintenance Work Measurement.

In most maintenance organizations, both the maintenance technicians and supervision do planning. There are several reasons why this does not work. First, several trips are made to the job site, first to plan the job, then to go back to the shop and get tools and parts and possible assistance from other skill workers. Second, the parts might not be in stores so the technician has to find another job to do until the parts arrive. If the supervisor checks the job, it takes time away from the main supervisory responsibilities—utilization and development of the workforce. If a supervisor spends half the shift checking jobs and finding parts, and has a crew of ten, the real ratio of supervisor to workers is really 20:1. Little supervision or training gets done.

The best organization for maintenance work measurement is a small formal, dedicated planning function. The planner role is to maintain a backlog of ready-to-work jobs for each maintenance technician. Close communication with supervision is an important part of the process. The planner field checks jobs when needed, plans work content, verifies priority, identifies special tools, materials, requisitions non-stock or out-of-stock items, plans safety requirements, crew size, crafts needed, and time to do the work. The planner also develops bench marks and maintains the data library. After the initial library is developed the industrial engineer serves as in-house auditor, performing an audit yearly to determine that the data and its application are accurate. The audit also verifies that time reporting is done properly—essential to accurate performance calculation as well as accurate and complete equipment cost.

Benefits of a planner function in maintenance

Dozens of audits in many manufacturing, service and government maintenance departments have shown that a planner function and UMS can have substantial impact when applied properly and audited yearly. The proper ratio of planners to technicians is 20-30:1. The more proactive the maintenance department, the more technicians a planners can support. Table 1 shows typical maintenance department sizes, appropriate number of planners, and the equivalent number of technicians the planner function will add to the workforce through higher productivity. Most departments, without planners, are about 50-60% productive. Productivity is raised to at least 80% with a planning function and UMS times. This productivity improvement is very significant but only a part of the total savings. There are additional downtime reduction savings, life cycle cost reductions and on-time completion benefits. Whether the facility is in information technology, heavy industry or public works, the principles and application are much the same. The continuous improvement opportunities revealed enable the enterprise to gain a competitive advantage, improve service to customers, or contribute to meeting other goals and objectives in the strategic plan.

Getting Started

The high priority startup tasks for a maintenance work measurement program fall into organization and process categories as described below.

Organization. Organization involves selecting planners using the ratios above. Planner selection is one of the most important management decisions and has great impact on the success of the program. The planners must have good maintenance skills and experience. In short, the selected planners are the ones you can least afford to lose from the technician group. If they meet this test, you have made a good selection. The benefit is this. Working as a technician, they apply their unique skills and experience to only the jobs they work on. As planners, they will transfer their capabilities to everyone in the maintenance workforce on every work order they plan. This planner function is the ultimate expert system. It is a continuous on-the-job training program. Moreover, it can be used as a career path to supervision.

Processes. Processes involve data development and work order planning. Most of the data development has been completed already. All the levels of data have been developed or validated before, so the industrial engineer can save many IE-years of development time simply by purchasing the data and validating it for the facility in which it will be used. A cautionary word. As with any technique, mastery of the system through training and practice is a prerequisite. Another option is to hire a consultant to do the planner training, supervisor training and to make available a set of basic operations, craft operations and bench marks. The new planners validate these data. They can do this one-time development project in two to three months and, in the process, become familiar with the data before they start applying it to the workload.

Depending on the age of the work order and stores processes, this may be an ideal time to update them. If you haven't done this in the last five years, you can take advantage of the new technology to get a high-productivity computerized maintenance management system. Andrew Carnegie was noted for his penchant for judiciously tossing out brand new equipment before the installation was even finished if something better came along. Sometimes, management is short of cash or just short-sighted and keeps old technology too long. Computer technology gets obsolete in months, not years, so it pays to look closely at opportunities here.

At a minimum, the work order should be examined to see how the UMS times would be applied. The times should appear on each work order so the technician knows the goal. This is great motivational tool. The work order should also be checked to see how the time reporting is done. You may need to add or update performance and delay reporting or other work reporting to ensure that your performance and equipment history records are accurate.

The stores process should be checked to see if you could get a quick read on the inventory value at any time. Also the issue process should not take more than a few minutes. If cost is high, service takes too long, or there are too many stock-outs, unrealized opportunity lurks there waiting to be revealed.

One might ask, "What has this to do with work measurement?" The answer is that, if the standard says the job should take one hour, and it takes two hours, not unusual in maintenance work because of material delays, then you will increase productivity and reduce cost when the delay cause is fixed.

For an enterprise that earns 5% on sales, a $50,000 cost reduction is equivalent to a $1,000,000 sales increase. You may not know where your next million in sales will come from, but a one-week industrial engineering work sampling study can show you where the cost reduction is. It will provide information to determine the savings potential and justify your maintenance work measurement program, based on a formal planning function and Universal Maintenance Standards.

For further reading

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Bio Sketch

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Table 1. The proper size planner function achieves additional, predictable amounts of work without adding staff.

Number of Maintenance Employees	Number of Planners	Number of Equivalent Workers Added
150	5	30 to 45
100	4	20 to 30
75	3	15 to 22
50	2	10 to 15
30	1	6 to 9
20	1	4 to 6
10	1/2	2 to 3