GOOD MAINTENANCE MANAGEMENT

by

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Every mining and mineral processing operation strives to achieve good maintenance results in the form of high equipment availability and reliability coupled with low maintenance costs. In the past it was widely believed that good maintenance results required the proper balancing of these two results. It was assumed that maintenance cost must necessarily be high in order to achieve high equipment availability.

We now know that this is not so. The two results are not mutually exclusive. Consider the factors that most commonly cause low availability. The first is frequent equipment failures and breakdowns. Breakdowns are expensive to repair both in terms of labor and material costs. If the number of breakdowns can be reduced, it follows that maintenance costs will also go down and availability will go up.

Another common cause of low availability is the lack of the correct spare parts when they are required for repairs. This situation results in inefficient use of the maintenance work force, since it must continually drop repair projects in progress pending receipt of the required repair parts and move to other jobs. Lack of spares also lead to excessive expenditures for air freight shipments and other accelerated purchasing and delivery practices.

The achievement of good maintenance results from the application of certain basic concepts that have been well tested and proven in the minerals industry. These elements, which are essential to good results, include:

- *Selection of the correct equipment for the job* – obviously, the equipment must be reasonably well suited to the application in which it is working.
- *Good operating practices* – equipment operators must operate the equipment with reasonable care, avoiding abuse and neglect of the equipment.
- *Adequate spare parts supply* – this does not imply carrying excessive stock in the warehouse. It does require good anticipation of requirements and good materials management and control practices.
- *Preventive maintenance*
- *Good maintenance planning and control*
- *A qualified workforce*

The first three elements listed above are beyond the scope of this discussion. Each of them are extensive topics and could be the subject of separate articles in their own right. The last three elements, however, make up good maintenance management practices and are the primary subjects of this article.

Preventive Maintenance

The ultimate purpose of performing preventive maintenance (PM) is to prevent equipment failures by conducting proper and timely lubrication and inspections. The inspections should identify faults that can be corrected while they are still small problems and before they develop into major equipment or component failures, which are more costly and time-consuming to repair.

Equipment manufacturers recommend appropriate intervals between PM lubrication services and inspections. These usually represent a good starting point for establishing appropriate intervals. Each individual operation, however, should monitor its equipment breakdown results and adjust these recommended intervals accordingly. For example, if a high rate of breakdowns is continually experienced, it may be appropriate to reduce the interval between services. On the other hand, if almost no breakdowns are encountered, it may be appropriate to lengthen the interval between services. Generally, we recommend a conservative approach, which is to err on the side of shorter intervals.

We recommend, wherever feasible, to use a system of scheduling intervals on the basis of a 52-week schedule. In other words, the intervals are expressed in calendar days. The schedule, of course, must be set so that actual operating time between services closely approximates the desired interval in terms of hours of operation. If the normal operating schedule changes significantly, it is necessary to modify the PM schedule to achieve that result.

The 52-week schedule facilitates better distribution overall in the scheduling of work in the maintenance department. Intervals based on operating hours tend to cause equipment PM due dates to accumulate into clusters, causing peaks and valleys in the work load. The use of a 52-week schedule also helps to correct problem units, which get fewer operating hours because of recurring downtime. By scheduling them on a fixed 52-week schedule, they receive more frequent attention in terms of operating hours, which helps to bring their overall performance back to normal.

We are aware of at least one major mining company that operates a fleet of haul trucks 21 shifts per week. They schedule trucks for PM service every other week, always on the same day of the week. During the alternate week, the truck is scheduled in for corrective maintenance on the same day of the week. Consequently, each truck visits the shop on the same day of every week. Scheduling for both the operations and maintenance departments is simplified.

It is essential for the maintenance technician who performs the PM service to use a detailed checklist that itemizes each task that must be performed. This checklist minimizes the chance that any tasks might be missed or forgotten. The checklist should have space for the mechanic to make notations where he can report equipment faults that should be corrected in the future. He can also use this space to report adjustments and minor repairs that were performed during the service.

We recommend a policy of correcting faults found during the PM service on the spot only if they can be corrected during the scheduled service duration. Otherwise, they should be noted for the future, to be performed during a scheduled corrective maintenance period. Of course, exceptions to this rule are faults that would endanger the safety of equipment or personnel if the equipment were operated further.

Our reasons for recommending this policy are twofold. Firstly it is important that maintenance return the equipment to operations as scheduled, if at all possible, to improve maintenance department credibility. Secondly, corrective maintenance can be performed more efficiently if the work has been previously planned and scheduled.

Above all, it is vital that a mining organization consistently adhere to PM schedules. PM services should not be bypassed due to press of production requirements. This simply results in greater equipment downtime at a later date and a general degradation of productive capacity.

Maintenance Planning and Control

The primary objective of maintenance planning and control are to:

- Perform maintenance and repair work at times that are convenient to operations and when maintenance has the necessary manpower, parts, tools, and workshop space available; that is, to effectively use the maintenance labor force, equipment downtime, and maintenance facilities.
- Ensure that required work is performed on a timely basis and is not forgotten or neglected.
- Minimize costs

  There are a number of essential elements inherent in optimizing the planning process.

  Work identification is the first step in the planning process. Work that needs to be performed can be identified from four primary sources:

  - PM inspections
  - Daily fueling service reports
  - Equipment operator shift reports
  - Reports from operators during the shift

These four sources report equipment faults that require correction. They should pass on a timely basis to the planning and scheduling system so that corrective work can be performed at the appropriate time.

Work planning, as we use the term, includes defining the work to be done, identifying parts and materials that are likely to be required, estimating the number of workmen and time required to complete the work, identifying tools and shop space required and confirming that all of these resources are available. For this purpose, virtually all corrective and repair work should be assigned to work orders, which form the basis on which planning is performed.

It is essential to utilize a comprehensive work order system. Without such a system, maintenance work cannot be brought under control. The work order is a means of identifying the work to be done, a basis for planning the work, a tool for collecting costs, and a means to record work history on each equipment unit.

We normally recommend establishing maintenance planners to do work planning before work is scheduled. The planner estimates the parts and materials that will be required for the work order, the number of workmen and time required to do the work, and any special tools and equipment required. He ensures that the necessary parts and materials are available. If they are not, he initiates procurement action. When a work order has been planned, it is considered to be available for scheduling once the necessary resources are available. No work, except emergencies, should be

started until the planning had been completed. This procedure makes it possible to use equipment downtime, shop space, and manpower efficiently.

Planners should be personnel who have hands-on experience in supervising maintenance work. It is essential that they understand the work and how it is performed. The planners' role is to assist the maintenance foreman in planning and scheduling work, thereby giving the foreman more time to spend actually supervising work.

The work order system can be facilitated by the use of job standards. Ideally jobs that normally recur have a job standard that can be called up by the planner to speed up the process. A file of job standards can be built up gradually by saving actual work orders for repetitive jobs. Then, when a specific job requirement resurfaces, the standard can be recalled and edited to the extent necessary for the current work order.

Work orders are utilized to communicate the job assignment to the tradesmen, to collect costs and work history, and to communicate work completed to the original work requester. Workmen's time and material costs are also charged to the work order. Since work order costs are linked directly to the equipment unit on which the work was performed, they allow cost by equipment unit to be tracked accurately.

A work backlog is simply a record of all work that has been identified but has not yet been completed. A formal system of recording and monitoring the equipment work backlog is essential. If reliance is placed on each foreman to use his own methods of tracking outstanding work, there is high probability (almost a certainty) that some work will be overlooked or forgotten.

The main function of a well-structured backlog system is to provide a ready list of all work that has been planned and is ready to be performed. To be effective, it is essential to segregate backlog lists by individual equipment units so that work can be scheduled when the unit will be in the shop or down for maintenance. It is also useful to be able to sort the backlog by foreman or by trade, so that it can be determined whether a crew has either excess or insufficient manpower.

At Performance Associates, we strongly recommended a two-tiered **work scheduling** system. The first level of this is a weekly forecast of work to be performed the following week, including repairs and PM services. The forecast should be in balance with manpower and shop space availability. It identifies the equipment to be worked on and details the work orders for each equipment unit, including manhour estimates, selected from the backlog.

The second level of this scheduling system is the actual work schedule for each shift. Recognizing that there will necessarily be some deviations form the weekly forecast, this schedule should be prepared the previous work day. One schedule should be prepared for each foreman. The schedule should detail each work order and identify the workmen assigned to each work order and the approximate time period during which the work would be performed. Before the start of the shift, perhaps during a short meeting, maintenance supervision may find it necessary to adjust the schedule to respond to emergencies that have arisen overnight.

Workmen are made aware, prior to the start of the shift, of the jobs that they are expected to work on and the sequence for completing these jobs. In this way, when they complete the first job, they move directly to the second. This method improves manpower efficiency, since it eliminates time spent waiting to be told what to do next.

During the course of the shift, the foreman records the work progress of each assigned job. This step serves as a work control tool, the details of which are submitted to the foreman's supervisor at the end of the shift. In effect, the foreman accounts for the day's activities and results.

Weekly forecasts and daily schedules are developed jointly by the maintenance planner and the foreman in consultation with operating management.

Coordination with operations – we believe that it is important to have a formal method of coordinating maintenance and operations activities. One effective way is through weekly scheduling meetings between the maintenance and operations departments. Both departments should have a preliminary weekly plan or forecast of work whey they arrive at the meeting. The operating plan should use forecast tons of output as a basis to forecast the number of production equipment units it will require. The maintenance department then selects the units to be worked on, recognizing the constraints of the operating plan. The objective of joint meetings is to arrive at forecasts that are both compatible with and serve the interests of both departments' requirements. The meeting should produce an operating plan and a weekly maintenance forecast, as discussed above, that are acceptable to both departments. During the meeting, it may be necessary for one or both of the departments to make modifications to their forecasts to achieve the best result for the operation as a whole.

With regard to the daily maintenance schedule, the maintenance foreman consults with the operations foreman when he and the planner are preparing the next day's schedule. In addition, the two should speak prior to the beginning of the shift and throughout the shift as required.

The ultimate objective of interdepartmental communication is to allow both departments to work against forecasts and schedules that the other department can and will support.

Utilizing a database to achieve optimum results – while it is possible to operate a sound maintenance management program without a computerized database system, most operations find that a computer-based system is inexpensive and highly effective toward achieving optimum results. There are many maintenance management computer-based systems available for purchase. When selecting one, care should be taken to ensure that the chosen system provides the features needed in the minerals industry. We believe that the following features are an integral part of any computer-based maintenance management system:

- The ability to track operating hours of both equipment and components.
- The ability to create a work order and automatically post it on the backlog.
- Dynamic scheduling of work from the backlog to a schedule for a specific date and shift.
- Automatic maintenance of the backlog (that is, jobs are removed automatically when work orders are completed).
- The ability to retain a work history of equipment, components and tires.
- The ability to retain a history of the costs and man-hours associated with the work performed. This history should be retrievable by work order, equipment item, cost center and functional areas.
- Dynamic creation of a weekly forecast from the backlog that shows the effect on manpower distribution.
- Automatic scheduling of PM services based on calendar day, operating hours, operating tons, or week of the years.
- The ability to track purchase orders associated with each work order.
- The ability to create PM checklists.
- The ability to monitor equipment availability and utilization.

- The ability to provide job standards.
- Multi-user capability.

Component tracking – components that rotate from one equipment unit to another should be tracked by serial number. In this way, a complete history of the number of hours it operated and the work performed on each component unit can be maintained. The tracking system should also maintain an inventory of components that show the location of each unit, whether it is installed on an equipment unit, stored in the warehouse, or in the component rebuilder's shop.

Failure analysis and warranty control – normally, failure analysis is used primarily to determine the cause of recurring equipment or component failures and to identify methods of avoiding future failures. Failure analysis also, however, impacts warranty claims. Reimbursement for warranty repairs can be difficult without analytical documentation of the failure. The burden of proof is normally on the operating company, not the equipment supplier. Therefore, a useful tracking system should also document failure analysis.

Work history and costs – recording maintenance history on a daily basis is an important aspect of managing the maintenance effort. Control is most effective when equipment repair history is available for reference. Noticeable trends within a unit's repair history can assist in identifying and solving specific problems.

Policy and procedures documentation – a maintenance policy and procedures manual is useful for assisting maintenance employees with understanding specific maintenance management practices. It facilitates the implementation of standard procedures and helps to standardize maintenance results. A good maintenance and procedures manual includes the following elements.

- The company's goals and policies relating to maintenance management.
- An overview of the company's maintenance procedures and how they relate to each other.
- A description of the organization structure and reporting relationships including organization charts.
- A description of how maintenance and operations personnel should interactively participate in managing the maintenance effort.
- Procedures covering maintenance planning, scheduling, PM, work control, reports, and the interface with the computer system.
- Responsibility and accountability statements for each position involved with maintenance management.

In addition, the manual should be presented to the maintenance staff in a brief training program. Our experience indicates that a clear understanding of these matters by all personnel is essential for an effectively functioning maintenance department.

Maintenance Workforce Training

It is not uncommon, in both mature and young maintenance organizations, to find that the workforce lacks some of the skills that their assigned work requires. Sometimes, this occurs because the workforce has never had a good grounding in fundamental maintenance skills. More often, however, the skill deficiency develops over a number of years as new equipment is acquired and care is not taken to provide an opportunity for the workforce to learn the procedures and techniques required to maintain specific equipment.

An organization that has a skill deficiency is faced first with identifying specific deficiencies. A procedure we often use is to analyze in detail the various tasks normally assigned to the maintenance workforce. The specific skills required to perform these tasks are then identified both as to basic maintenance skills and equipment-specific skills.

The next task is then to assess the capabilities of the workforce and determine whether the required skills are available in sufficient quantity to accomplish the work required. This process results in an identification of the specific skills which are deficient.

This assessment then sets the stage for correcting the problem. Training of the workforce, or segments of it, is usually required. The list of deficient skills is analyzed, which results in specification of the required training curriculum. A plan is then prepared for carrying out the program, and the curriculum is organized into training modules. For each module, the following information is defined.

- A **module name** identifies the module
- **Training hours** are estimated to determine the time duration of the training. These hours are divided into three categories; hours to be spent on in-house formal classroom training; hours spent on local technical training institution classes, and finally, hours spent in on-the-job training. On-the-job hours are those in which the employee is assigned to tasks that relate directly to the skills being taught in the module, not simply hours spent working in the department.
- The **source of training** designates who will develop or provide the source of the module.
- The **training material** that will be used as a reference during instruction of the module. In many cases this material is already published and commercially available. In other cases, it may represent material that must be created, or a combination of published material supplemented by newly created material. Normally, reference material consists of written text. In some cases, however, other media, such as video tapes, may be utilized.
- **Development hours** represent an estimate of the manhours required to develop each module. Development of the module includes establishing the learning objectives, preparing the training reference material to be used, preparing an instruction outline, developing a student workbook, developing a skill assessment test, and developing an on-the-job qualification demonstration checklist.
- A **workbook** that consists of a series of questions is used by the student during the instruction to reinforce learning. The workbook questions are completed with open access to the training reference material. The skill assessment test is taken on a closed-book basis to confirm that the required learning has in fact taken place. The qualifications checklist is utilized by the trainee’s supervisor to confirm that the skills have been demonstrated through performance of actually assigned work.
- The **number of trainees** who will require training in each module is estimated.
- A **scope** of the module provides a brief description of the skills covered in the module.

Finally, a customized curriculum is established for each employee, based on the requirement of work assignments and the assessment of possessed skills. The intention is that employees who already possess the skills that are taught in a specific module should not be required to receive instruction in that.

Since each employee receives a customized curriculum, it is essential to have a method of tracking and controlling employee progress through the program. A computer-based employee tracking system is extremely useful and should follow each employee’s progress through classroom and on-the-job training.

On-the-job training provides employees with the opportunity to work on tasks that require the specific skills being learnt, and demonstrates whether an employee has actually mastered the new skill. Daily on-the-job work assignments therefore are vitally important to the effectiveness of on-the-job training. A good tracking system must also be readily available to maintenance planners and foremen to assist them in making daily work assignments that will facilitate completion of the on-the-job training for each module.

Such a tracking system provides management with the necessary information to ensure completion of the training program on schedule. It also provides a means of ensuring that each employee is given the opportunity to learn the necessary skills. What remains, then, is to develop and procure the defined training modules and implement the training.

We have concluded over the years that no maintenance organization produces its best possible results without the essentials listed at the beginning of this article. We have also concluded that virtually any maintenance organization that has the will to commit the effort and resources can acquire these elements and produce satisfactory and even outstanding maintenance results.

We also, however, offer one word of caution. Our industrial society is afloat with quick fixes such as new management techniques that include equipment condition monitoring, operations/maintenance integration, total productive maintenance, etc. These approaches are all good and valid concepts. However, they are of no avail unless essential basic elements are present. We might liken these approaches to equipping a novice athlete with the latest equipment and expecting to produce an Olympic medallist. Obviously, the athlete must master the basics of this sport first. So it is with the maintenance of facilities and equipment.