

# **UNDERGROUND MINING OPERATIONS**

by

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## **INTRODUCTION**

Underground mining operations, similar to many industrial enterprises, have long recognized the potential benefits of maintenance planning. However, underground mining operations' efforts to implement maintenance planning have generally met with little success. One finds that after an initial period of enthusiastic support implemented systems and procedures fall to disuse. Most companies, upon the collapse of their maintenance planning, convince themselves that underground mining is so "unique" that to accurately plan, schedule and measure maintenance work is impractical.

Underground mining is different compared to even surface mining but management must realize that failure to successfully implement a maintenance planning system is directly attributable to management's inability to recognize what is required.

A successful maintenance planning system can be implemented if:

- The maintenance organization is structured in such a way that responsibility and accountability are clearly defined.
- A specific group is established within the maintenance organization that has responsibility for planning and controlling all maintenance activities.
- Maintenance of equipment takes into account the mine's production strategy.
- Systems and procedures are formally developed and implemented to provide a logical, disciplined approach to maintenance.
- Reliable records which show work accomplished are established and maintained and are used as a tool for improving performance.
- Periodic reports that measure the effectiveness of maintenance are submitted.
- Management exercises control when the reporting system identifies or highlights a problem area.

This paper presents a proven approach for the successful implementation of an effective maintenance planning system.

## **MAINTENANCE ORGANIZATION STRUCTURE**

Before any attempt is made to implement a maintenance planning system a logical approach to structuring the overall maintenance organization must be undertaken. Most attempts at planned maintenance that have failed have done so because of organizational problems.

Successful implementation of a maintenance planning system hinges on ensuring that the overall maintenance organization is structured in such a way that responsibility and accountability are clearly defined. A basic test for accountability is to observe if an individual can be identified as being responsible for the maintenance in a specific area, shop, or for a particular equipment type. Another key is to establish whether the appropriate individual has sufficient resources under his control to manage all the maintenance activities in his area.

### **1. Operations Versus Engineering Control of the Maintenance Organization**

Many arguments have been forcefully presented at various levels concerning the organizational control of maintenance.

Operating managers feel that maintenance effectiveness could be greatly improved "... if only we were given control" of maintenance. Engineering managers guard the control of the maintenance organization with their lives, stating that "if operators control the maintenance organization, no maintenance will ever occur".

There are pros and cons to both organizational approaches; that is central engineering control, or operating management control. However, the resolution to the argument is not the key to maintenance effectiveness. The key is to ensure organizational accountability throughout the organization, to provide for operator input on priorities, and to plan and control the work.

The correct organizational approach to maintenance management activities is a prerequisite to success. A poor organizational approach will almost certainly doom any system, no matter how good, to failure. For this reason organization is a key element, and is the factor that must be addressed first.

## **MAINTENANCE PLANNING STAFF**

Mining operations accept the need for the separation of operational planning from the actual production activity. The need for long and medium range operational planning is generally fulfilled by a separate staff organization whose primary function is to offer direction over the long term. Production supervision controls the daily and weekly output from the mine but where and how they mine is dictated by the long range mine plan developed by staff employed for the specific purpose of operational planning.

In direct contrast to this arrangement many arguments ensue when a request is made to establish a maintenance planning staff. These arguments occur in upper management circles where questions are voiced regarding the necessity of creating another "staff" group.

This age-old argument about the need for a staff or supporting function for maintenance can be quickly put into perspective. Imagine a significant mining operation without a central mine planning organization and then imagine any number of mine operating

supervisors "doing their own thing" with little, if any, regard to the long range consequences. As abhorrent as it is to imagine production

operating without a central planning organization, maintenance organizations frequently are expected to operate without centralized planning. While maintenance supervisors may do some planning they are primarily "doers".

Separate the function of planning and supervising in maintenance for the same reasons they are separated in operations. Planning and "doing" require different skills.

### 1. Selection of a Maintenance Planner

Personnel identified as maintenance planners should be an integral part of the maintenance organization. Ideally, the maintenance planner should be an experienced maintenance supervisor with good organizational ability as well as overall knowledge of the relevant equipment.

Maintenance planners must possess the skills to obtain facts, analyze them and assist in choosing the best course of action. They should not be used to do tasks that do not contribute directly in assisting management in controlling maintenance activities. A maintenance planner should not be used as a dispatcher, parts expediter or clerk. This is a complete waste of talent.

The maintenance planner will have an immense potential influence on maintenance efficiency. His actions will have more impact than any individual line supervisor and therefore he should be one of your best people. At all costs, avoid using the maintenance planning department as a "retirement village" or a place to put problem personnel.

### 2. Location of Planning Staff

Maintenance planners cannot be located away from the actual work area. A serious mistake is made by operations who establish a planning and scheduling staff that is removed from the realities of day to day problems.

Communication between planners and maintenance supervisors is essential and should be facilitated by close proximity. Isolating planners from day to day activities will guarantee that maintenance planners lose contact with the work.

### 3. Reporting Relationships

Staff or service units should make their recommendations upwards so that directives from a higher level flow down the proper channels through line managers and supervisors to the men doing the job.

As a staff or service function, maintenance planners have no direct line authority and should never transmit orders downward to men in line operations. The amount of antagonism bred by this downward communication negates any potential benefits.

However, do not have planners reporting directly to a high level manager. It is much better to have planners reporting to second level managers who are responsible for specific areas. This relationship creates a situation where the second level manager is responsible for all aspects of maintenance in this area, including planning and scheduling.

## **MAINTENANCE AND PRODUCTION STRATEGY**

It is vital that both production and maintenance departments' needs and objectives are satisfied when initiating a maintenance planning system into an underground operation. Maintenance must consider the economic affect on production of any maintenance related equipment outage and production must accept the requirement to routinely maintain production equipment.

Before routinely planning and scheduling mining equipment for maintenance some basic ground rules must be developed and accepted by both production and maintenance.

### 1. Preventive Maintenance

Most underground mines recognize that preventive maintenance is much less costly and disruptive to production cycles than breakdown maintenance. The disruption to an operation due to equipment failing during scheduled production is obvious to everyone. Conflict between maintenance and operations usually occurs when maintenance attempts to establish a routine of planned outages for preventive inspection and defect correction. If the planned outage is too short, necessary maintenance checks are not completed. If the planned outage is too long, it becomes economically unreasonable to the operator. This problem can be resolved to the satisfaction of both parties if the preventive maintenance program reduces the number of variables that have to be considered; namely the length of the maintenance outage, the interval between maintenance outages and reaction to breakdown maintenance.

Maintenance schedules should be rewritten in a form that allows attention to items of infrequent examination to be spread over a specific maintenance session cycle. This allows the matching of the work to be done with a planned outage time. The outage time should be constant be it one shift or more than one shift. Work should be planned to such a degree that the operator knows that each time a piece of equipment goes down for maintenance it will be out for a specific time frame. It puts a heavy burden on the operator if each outage is of a different duration.

The interval between maintenance outages should be constant and planned and scheduled several weeks ahead. This method allows adequate work planning time and attention to detail that is often lacking. It also allows the production personnel to pre-arrange alternate work for production crews when equipment is scheduled out. Another benefit is that this methodology enhances short range production planning.

### 2. Breakdown Maintenance

Breakdown maintenance should be approached with the attitude of correcting as rapidly as possible the cause of the equipment failure. Maintenance must look for temporary solutions that don't adversely affect the continued safe operation of equipment when equipment fails in the mining cycle. Breakdown maintenance is a basic responsibility of any maintenance department and has to have priority so as to get equipment back into service as quickly as possible. In addition, maintenance personnel should always ask, "Why did the unit break down?" Investigation should be made into the cause of the trouble in order to avoid or reduce a repetition of the problem.

A maintenance organization that takes into account the production strategy has a better than average chance of succeeding. But a

maintenance organization that disregards the production strategy is guaranteed to fail.

## **SYSTEMS AND PROCEDURES**

A maintenance procedures manual should be prepared specifically describing the necessary system procedures and work steps for which each supervisor will be held accountable. The best approach is to introduce the procedures area by area; sequentially, backed up by necessary training in their use.

This method ensures that every area supervisor has a written policy of how and what things are required.

The following systems and procedures should be developed in a written format.

### 1. Work Order System and Backlog Tracking

When it is necessary to have maintenance work performed that cannot be accomplished immediately by standby or running repair personnel a job request or work order should be prepared. The work order provides the means to both request maintenance work and to plan and control it.

The work order form should provide sufficient space for the following information:

- Date, originator, approvals, equipment identification and cost center.
- Description of the work required and any special instructions.
- Material and labor estimates.
- Actual man-hours worked, dates and major parts used.

It is imperative that all work identified as being required, unless it is standard schedule maintenance activity or emergency breakdowns of a short duration, be documented on a written work order.

Once a work order request has been submitted and the necessary work planned by the planner the job should be placed in backlog. All backlogged work should be completed whenever a piece of equipment is taken down for maintenance.

### 2. Job Card

The work order is suitable for controlling minor jobs. However, major equipment repair, overhauls or fixed plant shut-downs requiring a significant amount of work and multiple crafts require a more appropriate planning and control tool.

A Job Card is an excellent tool for controlling major repairs, either planned or unplanned. Information on equipment number, serial number, total hours run and hour meter reading (if applicable) is listed on the job card. The entire job is given a priority and all backlog work that can be accomplished is itemized in the spaces provided on the left hand portion of the form. Each task is prioritized so at lower priority tasks can be cancelled if the repair is cut short for any reason. If feasible, a thorough inspection should be made of the equipment to determine if any other work is required. On the reverse side of the job card parts associated with each job are itemized and their status tracked. Only jobs with parts on hand should be scheduled. The sequence of the job is bar charted on the job card form itself and represents the schedule. When the job is started actual hours for each task are tracked versus the scheduled hours for each task. This allows early identification of off schedule conditions. Following the completion of the repair a final inspection should be made and signed off.

The completed Job Card should be reviewed by the Foreman's supervisor and the Maintenance Planner. The Planner should use the information on the Job Card to update necessary historical records.

### 3. Daily Work Scheduling

A means to effectively and efficiently plan and schedule preventive maintenance, major breakdown repairs and backlogged work utilizing the optimum levels of manpower must be provided. A daily schedule provides this means.

A daily schedule should be prepared each work day for each shift by the Maintenance Planner with necessary input from Operations' representatives and maintenance supervisors. A short scheduling meeting should be held to determine which jobs will be scheduled and what the priorities of each job are. By involving Operations the opportunity is provided to allow production personnel to voice their concerns about priorities and progress on current work.

In addition to the previously mentioned procedures the maintenance procedures manual should include procedures and work steps for:

- Parts Removed
- Parts Procurement
- Weekly Workshop Scheduling
- Standby or Running Repair Crew Control
- Warranty and Failure Analysis

Mining operations vary in size and scope and your particular operation may require additional systems and procedures but, by developing maintenance procedures in writing and training personnel in their use, a logical and uniform approach to maintenance management can be made. Additionally, the procedures manual provides management with a control tool that ensures deviations and eventual disuse of the system does not occur.

## **RELIABLE RECORDS**

Effective maintenance record keeping is the key to controlling maintenance expenditure. Records can tell you what has to be done, when and how. They keep you abreast of costs, allow you to assign priorities and they aid in developing budgets and purchases.

The minimum records required to control maintenance and facilitate maintenance planning are:

- Major Equipment Repair record – records on major equipment repairs. These records should include operating hours, or tonnage throughput, on any major wear components at the time of repair.
- Component Record Cards – detailed information on components including warranty hours or time.
- Equipment Register – notes on all necessary specifications and lubrication data.
- Preventive maintenance and service schedule and procedures.
- Completed Job Cards and Work Orders.



- Motor Record for all electric motors.

In addition to the permanent history files, a statistical data collection record should be kept to accumulate the following information on each major piece of equipment:

- Scheduled hours
- Operated hours
- Emergency repair hours
- Major scheduled work repair hours
- Preventive maintenance hours

This information will be used to calculate availabilities and utilization.

Records are the threads that hold a maintenance planning system together. If they are "working" records, actually used by maintenance personnel and staff, then maintenance control will work. In other words, too often record systems are not usable and are of no value.

A large portion of company records are unnecessary. This of course, includes maintenance records. A close examination of all forms and recording methods must be considered to avoid the "paper" for "papers sake" syndrome often found in many maintenance planning systems. Questions must be asked to determine the value of each record type. Questions such as:

- Does the record provide a control mechanism? If yes, what does it help control?
- Is all the information gathered useful? How is it used?
- Is the record form simple enough to minimize error?
- Does the record sequence facilitate its use in conjunction with other forms and records?

A test that can be used to determine the necessity of a form or report is to take a form or report that has been submitted for completion and not fill it out, or better still return it signed but blank. If no one comes rushing in at a later date asking, "where is the requested information?", then get the form or record eradicated. It is obviously of little value.

Reliable record when maintained can be a tool for improving performance. A formalized method of record keeping, considering the value of each recorded fact, can be invaluable in controlling maintenance. However, avoid the frills and try to keep records in step with their purpose.

## **REPORTING**

Reports serve one purpose: to provide performance data for management review and action. Management can make comparisons between "actual" performance and "desired" performance only by reports submitted to them. Needless to say, any management report can be prepared from data. So data must be accurate and reliable, otherwise final reports are worthless. Any action taken on a worthless report can be disastrous.

### **1. Summary Reports**

Well organized summary reports with necessary backup detail will illuminate deviations from plans and facilitate necessary management reaction to problem areas. These reports should monitor key statistical indicators, must be easily understood and also illuminate positive and negative trends.

Summary reports should include:

- Labor distribution (by area)
  - Ordinary hours
  - Overtime hours worked
  - Overtime as a percentage of ordinary time
  - Total hours worked
  - Hours worked on scheduled jobs
  - Scheduled hours as a percentage of total hours
  - Preventive maintenance hours worked
  - Preventive maintenance hours as a percentage of total hours
- Backlog by class of equipment
  - Current and previous period
  - Percent change in backlog
- Efficiency (by area)
  - Ratio of production to maintenance manhours expended  
(production unit appropriate for group being evaluated)
- Preventive maintenance compliance (by area)
  - Ratio of preventive maintenance procedures completed to schedule
- Warranty repairs
- Utilization
- Work Index
  - Ratio of scheduled hours to calendar hours
- Mechanical availability
- Physical availability
- Cost/variance reports

These indices give a true picture of the maintenance status and utilization of resources. Most of the indices mentioned should be graphed, by class, from period to period so trends become obvious.

## **CONTROL**

Many well intentioned maintenance planning systems have failed as a result of the lack of management control. This lack of control is evident in most organizations, from the front line supervisor to the very upper levels of management.

The front line supervisor who allows a job to take twice as long as it should exercises no control. The Engineering Manager who receives summary reports that identify specific problems then tries to suppress the information, or continually changes the reporting format to something that reflects facts more favorably exercises no control. The General Manager who receives the Engineering or Maintenance Summary Reports and assumes "maintenance is too varied to systemize" exercises no control.

What must be recognized is that management is based on control. Maintenance planning systems merely help identify opportunities for improvement and measure performance.

The common failure in initiating a new maintenance planning system is to assume that the systems work and procedures are the essence of the program. This fallacy later leads to the belief that maintenance planning doesn't benefit the maintenance organization because many times maintenance appears in a worse light than prior to the implemented maintenance planning system. If the maintenance planning system is highlighting deficiencies then it is working. Management must 'zero in' on problems and take appropriate action.

### 1. Tools for Control

Many techniques are available to the manager who wants to control the events around him. As an example, the manager who asks penetrating questions and expects answers is on the road to control. The manager who insists on a plan of attack to correct identified problems and then holds the appropriate people accountable exercises control.

Use deadlines, schedules and follow-up meetings if you want to control your area of responsibility. Take action as soon as it becomes evident there is a problem. Ensure that everyone understands that their performance will be evaluated. Hold people accountable and ensure that they know that accountability applies across the field.

A good manager does not need to know all the details of his maintenance operation, but he needs to know what is going on. Once he has the means to measure what is actually happening he then must take the appropriate action to ensure the desired result.

## **RESULTS**

Dramatic results can be achieved if a maintenance planning system is successfully implemented. Reductions in maintenance costs, which have a direct effect on overall company profitability, can be realized in a relatively short time.

Not all operations are willing to address the multitude of issues that arise during the implementation phase of an effective maintenance planning system. Some operations will take partial, painless steps toward maintenance planning and then wonder why "nothing has changed". These operations face increased competition by those who approach maintenance planning in the proper way.

## **CONCLUSION**

Initialing a maintenance planning system requires planning and effort. Organizational authorities and responsibilities must be logically distributed if personnel are to be free of inconsequential tasks and be able to accomplish their objectives. Relationships between functions must be defined. The maintenance organization must be properly staffed. Specific formalized monitoring systems must be

embraced or the system of planned maintenance will deteriorate. Maintenance must interface with Production in many areas. Control measures must be taken at the appropriate level when a deviation from the desired result is highlighted by summary reports.

Maintenance can be measured and controlled just as other functions can, and its effectiveness can be improved in a systematic way with the proper planning.

Energetic and realistic management teams, willing to overcome the misconceptions about the impossibility of improving maintenance in underground mining operations, can achieve dramatic results when the effort is applied.

It is fitting to conclude this paper with a quote from Dr. Erika Steffens' and Dr. James