ICOMS98, Adelaide, 1998

Maintenance Improvement Strategies

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A maintenance improvement strategy is presented in this paper which has been applied in a number of companies, with each of its elements tested for individual effectiveness and for its contribution to the whole program. It focuses on two key issues: the operations/maintenance interface, and the need for detailed technical information on the condition of equipment to optimise maintenance decision making. The strategy has three early elements: an audit, a workshop for combined operations and maintenance personnel and a preliminary roll-out of tasks. The strategy fits within a cohesive model which has three principal lobes: condition-based maintenance, strategic planning and optimisation for operations scheduling.

1. Introduction

Maintenance is a life time of sustained effort to ensure that the assets of a company continue to provide a service which will ensure that the organisation can provide its designated service. The key goals for improved maintenance delivery include [1]:

1. There is no end point to the achievement which can be marked as the completion of the service. The effort must be sustained over the life of the company.
2. The effort must be sustained in the sense that the integrity of the plant is only as good as its weakest part. If the outcome of the service is reliability of the assets, then the quality of work must be uniform and sustained to avoid a few weak areas which will undo the good work completed elsewhere.
3. The outcomes of the services should be measured in terms of the productivity of the assets. Maintenance success is intimately concerned with the business outcomes of the effective utilisation of the equipment.
4. Sustained introduction of refined or original techniques to improve the surveillance of the equipment or facility to detect life threatening damage mechanisms.
5. Continuously improve the skill in both technical undertakings and organisation/decision making of the maintenance staff. This will reduce the risk of failure introduced by maintenance activity and ensure that resources may be minimised but remain effective.
6. Continuously improve the clarity of communication between production and maintenance staff to ensure that decision making for both task groups is optimised. This has been achieved in some sites by the operator/maintainer being one person or co-working in one team. However such approaches will most likely not assist the objective in item 5.

It is with these five objectives that we have developed a maintenance improvement strategy, which seeks to bring about long term improvements, particularly in an environment where the original gains associated with planning, improved work practices and management awareness of maintenance have already been made.

A three part process has been designed including an original audit to assess the weaknesses of the current maintenance strategy, a workshop to raise company-wide awareness and set commitments on people, and a long term improvement program whereby companies improve themselves. The speed with which the last item is undertaken is in direct proportion of two factors: management vigour and the health of the operations/maintenance interface. The second factor is more subtle and not as widely recognised as the need for management support. The whole approach is based on a simple model set out in this paper.

2. Improvement Model

A program for the improvement of maintenance within a company is set out in Figure 1. The objective of this program is to provide a means by which the assets of the company are operated and maintained with the knowledge of their current and expected future capability, [2]. There are three lobes to the process: condition-based maintenance, strategic planning for the assets and optimisation of maintenance to suit production. Ideally one would like to do everything at once, but no company can sustain more than about four or five improvement tasks at any one time. As a consequence, a company needs to move to elements of condition-based maintenance first, then to adopt improvements in each of the other two lobes, and then to take stock of their future management of their assets. There is no clear advantage in whether to progress the strategic lobe or the production optimisation lobe before the other.

The condition-based maintenance lobe has two paths incorporated in it. The left hand path following downtime tracking and inspection strategies are primarily focused on operations staff better understanding the capability of the equipment which they control. The right hand path is for the maintenance staff to analyse their performance and to improve their planning. Reliability-centred maintenance is a powerful, risk-based technique which we employ in the right hand path to reduce the total amount of maintenance undertaken. But we also recognise that it is only possible to achieve this by improving the surveillance of the plant so that problems which would normally be prevented by a greater preventative maintenance program, are anticipated and corrected before downtime arises.

The strategy behind Figure 1 is that it shows the dependency of activities. For example, condition-based maintenance cannot be imposed on a site which practices reactive maintenance without first setting up a comprehensive, cyclic preventative maintenance program. In addition, maintenance performance improvement is only possible when a mechanism which is the equivalent of a work order allows effective information capture. An inspection system should not be rolled out prior to the establishment of a downtime

tracking system, without running the risk of creating unnecessary inspections and missing others which would prevent failures such as have arisen in the past.

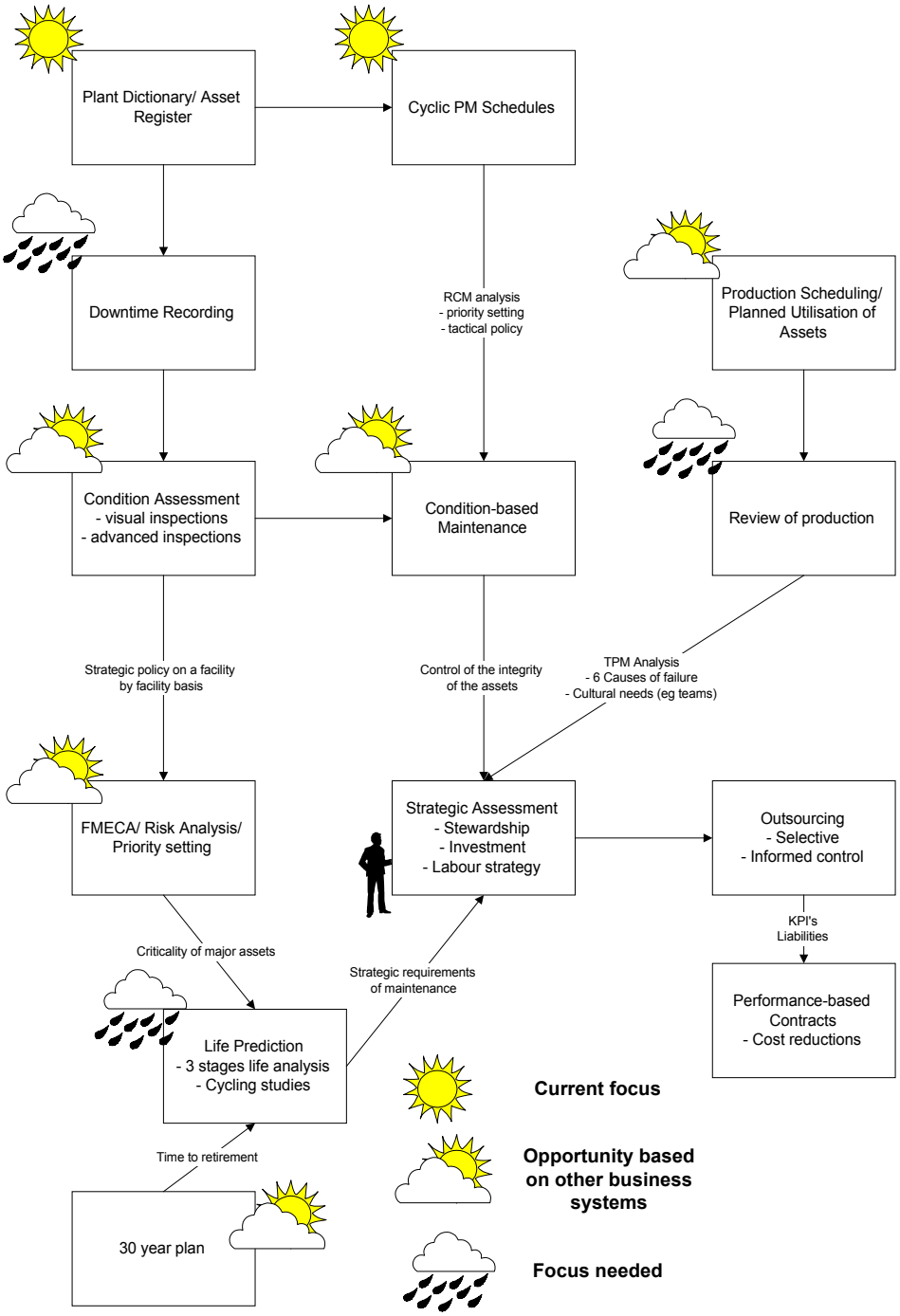


Figure 1 Maintenance Improvement Strategy

3. Audit

The audit developed as part of this work had two primary sources of influence. The first was the proprietary seven part audit used by the Maintenance Engineering Society of Australia for their maintenance excellence awards, [3]. The second was the need to capture signs of the presence of techniques associated with the first lobe of the maintenance improvement strategy. It was conducted in an informal manner at first, attempting to establish how informed people were, the quality of their planning and communication, and so forth. It has now been refined into a six part strategy which is free to the public domain, and may be used by any company or practitioner.

The strategy consists of the following:

1. Management - policy, vision, financial approval, accountability
2. Asset Specification - hierarchical plant dictionary, documentation, adding/subtracting/editing assets, registration of design capability, spare parts
3. Work management - work order completeness, capture and use of history, work flow systems, skills matching, performance tracking, contracts, planning
4. Ability to Provide - stoppage tracking, equipment failure tracking, criteria of equipment failure, reliability analysis, service lives, operations/maintenance interface
5. Asset Condition - inspection program, skills levels, analysis, technology
6. Maintenance Improvement - strategy, reduction of waste, culture, knowledge, information systems, procedures management

The audit is not used so much for benchmarking purposes but to identify critical areas which should be amenable to improvement using the model shown in Figure 1.

The normal experience is for people to report that the audit findings match what people have been saying for years. Of course, being part of an improvement process, the model and its underlying task base is designed to address the specific weaknesses shown up by the audit.

A summary finding from one such audit is listed below:

- Formulate broad maintenance principles and policy.
- Assign Performance Goals which are linked to business objectives and reinforce staff roles and responsibilities.
- Introduce maintenance criteria in the asset specification/selection process.
- Implement simple strategies to gather maintenance information for improving planning and scheduling.
- Finally and most importantly, develop a maintenance culture throughout the company.

While these represent open statements and the audit report has to match action items under these categories, the statements are indicative of the areas of weakness to be found in a long established, substantial manufacturing company.

4. Workshop - Operations/Maintenance Interface

There is a need in any improvement process to bring items of formality to the attention of the entire company. This leaves an imprimatur that the process is blessed by the management and time devoted to it is justified, even at the expense of other work. Without such an imprimatur, the maintenance improvement process can only be grafted and its rate of introducing change will be much slower. There are two primary issues which a company must face, [4]:

- What are the expectations that operations and maintenance staff have of each other? This is not just a set of concepts but rather the blue print for activities each party expects the other to join in.
- How do both parties combine in a variety of circumstances so that the effectiveness of their joint effort is greater than would normally reward the sum of the hours they both put into it?

A sample outcome from conducting joint discussions on these points is included as Table 1.

WHO→ WHAT↓	Company Management	Maintenance Provider	Production Team
PEOPLE - training, issues, work place	Lead operators to undertake simple maintenance Identify ownership of asset Education of individuals about the importance of data Policy on computers Education needed for maintenance staff to refresh technical know how of each trades person Improve the understanding of Maintenance and Production in what the other group require →improve awareness of planned improvements →facilitate communication between the groups	Education of operators - better utilisation of tools - allow operators to undertake simple maintenance tasks Train maintenance fitters on all rotables Training of operators in how to identify a maintenance task Partnership teams - continuous improvement Customer focus - what do customers feel about maintenance Interaction with Production over PM effectiveness Identification of necessary operators' skills needed	Determine who will perform maintenance →maintenance, operator, external, mix/match Partnership teams - continuous improvement Interaction with Maintenance over PM effectiveness Daily/weekly check sheets for inspections plus pass information on to maintenance Skills matrix needed for all operators' knowledge of PM Shop floor training - all operators to understands the do's and don'ts of various machines - avoid unnecessary downtime
FINANCIAL - financial plan, capital, agreements	Develop and communicate a company maintenance business system	Inputs on capital requisition Reports to contain: • reaction time • trouble report generation • completion of tasks	Tool turnover recorded for future investment Quarterly review of plant and equipment Reports to contain: • $breakdown

		Identify existing equipment life expectancy versus use/production requirements plus improvements in technology - facilitate future capital expenditure →Record related statistical information and plot trends	• $preventative • $loss of production Identify existing equipment life expectancy versus use/production requirements plus improvements in technology - facilitate future capital expenditure →Record related statistical information and plot trends
PLANT - equipment, services, tools, spare parts	Initiate a special project group to consider special improvements →trouble reports, metrics of performance, reporting	Standardised checking procedures for tools - better utilisation of tools Maintain a register of all of their tasks - optimise period of maintenance Retain a store of critical tools → 24 hour turnaround on replacement tools Check wear and tear for cables in lifting mechanisms plus other items of specific work listed by syndicate Formal reviews with Production Determine standard method for assessing criticality - machine is suitably prioritised Oil charts are placed above machines again - avoid incorrect lubrication Develop a PM plan for each area	Record maintenance history by operators - better utilisation of tooling ABC check sheets for simple inspections Operator swipes personal ID and enters information on call out details Trouble reports will be issued Formal reviews with Maintenance Trouble reports written by only designated people - track progress and priority Determine standard method for assessing criticality - machine is suitably prioritised
PROCUREMENT - purchases, suppliers	Tender to be set up for providing rotables - assist standardisation - greater control over spares, supply, downtime Information services to support new addition to CMMS	Log work undertaken by contractor Purchase special purpose tooling to monitor performance of air tools Identify outsourcing of work →maintenance of plant →heat treatment facility →structured agreements PM program set up prior to machine's arrival - attain maximum machine life	Standardisation of tools - minimum number of suppliers Consult Maintenance about future machine purchases - determine necessary PM program - identify availability of spares - reduce costs of maintenance - improve reliability
TIMING - of work, decisions	Implement structured meetings to monitor the PM plan and associated improvements	Timing of PMs sensitive to production needs Response time will be monitored PM schedule will be maintained →New tasks identified by group will be added to the list Maintenance plan for each	Visibility meetings organised - Maintenance understands Production's needs

		item will be developed Maintenance needs a white board listing jobs and priority Expand and develop CMMS for risk assessment - improve management of critical equipment	
INFORMATION - library data, design, manuals, systems, reports	Monitor performance of suppliers Network system to raise work orders automatically - eradicate wasted time associated with raising work Network system to link with CMMS to allow automatic data transmission Analyse feed back on measures Ensure compatibility of trouble report with CMMS - replace paper system →centralised automated trouble report system →redesign trouble report for easier use Develop comprehensive set of analysis codes - turn data into information	Manage tool manuals Write ABC check sheets for operators Report performance Develop a bar codes to identify maintenance activities indicators of suppliers Maintenance manuals will be maintained CMMS will be supported - MTBR reported - History will be analysed →Useage, frequency of breakdown, cost of maintenance Feed back on measures to management - Top ten killers Trouble report needs simple description of work Tracking needed for trouble reports Produce KPI's from trouble reports analysis Monthly/quarterly report on all breakdowns - how well is the Maintenance section performing - concise reports on major issues Use friendly reports on maintenance of critical equipment - seek methods of cost reduction Inform Production of wants/needs - ensure they can make it easier to conduct maintenance	Register of critical tools - Identify possible replacements Provide copy of manuals to maintenance Lost time tracking system will be supported - MTBF identified Notification of all downtime to be compiled →Pro forma designed by Maintenance - reduce future downtime Provide a wants or needs life to Maintenance - gives focus to maintenance tasks

The delegates typically address a wide range of issues and demonstrate the considered opinion of a wide range of key people's thoughts on the policy areas of who, what, why and how. These four areas are encapsulated in the matrices set out in the table. Who and what are identified as columns and rows respectively. The What are titles listed on each row. Why are items which list below a What title but commence with a "-" whereas How are similarly items below a What title but commence with a "→". It should be

noticed that there were few How items listed which is normal for the first write-up from a seminar session.

5. Improvement Program

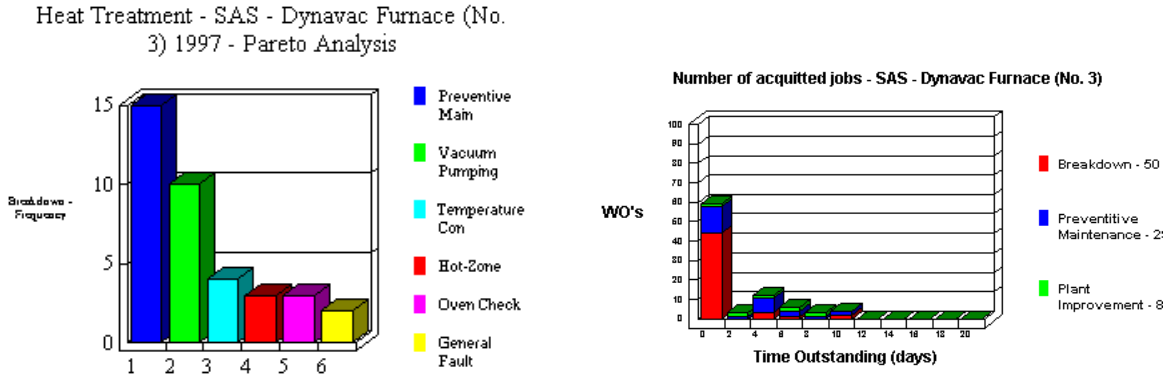
Improvement processes combine both a field or plant activity and a back-up information activity, typically conducted through the computerised maintenance management system (CMMS). The second item is as important as the first in order to ensure that improvements are documented, information flows and decision making is informed. This ensures a cultural improvement plus the success of improved communications. If people expect to have certain information supplied to them, breakdowns in the communication flow will generate attention on trouble spots which are indicative of more fundamental problems such as neglect or waste through repetitive work.

It should be appreciated that the fundamental source for maintenance improvement is the eradication of repetitive work. Not only should a breakdown be repeated in the future, but any work done should have a lasting and permanent effect. A typical improvement program which assist this objective has the following strategy:

Strategy Area	Plant Activity	CMMS Activity
Plant dictionary	Production client nominated to work with maintenance in correct specification of plant equipment. Walk down of the plant using pro forma sheets, setting out the hierarchy of the plant.	Confirmation of hierarchical structure logged into the data base.
Downtime recording	Agreement with senior production personnel on downtime codes. Tuition conducted for production personnel as to accuracy and purpose of the system.	Downtime sheets issued, tracked and entered into the data base. Pareto and time trend reports issued to wide audience.
RCM Audit	Use RCM check sheets to audit work order procedures and inspections.	Agree on a company-wide scale for levels of risk which has meaning for both operations and maintenance. Update work orders and procedures in the CMMS.
ABC Check sheet generation	Develop check sheets in word processor files. Educate staff in the use of check sheets.	Enter revised PM's to control inspections. Enter ABC check sheet details for capture of data and allow analysis of trends.

Initial equipment condition audit	Use check sheets to provide a base line of plant condition.	Establish KPI's on inspection.
Cross check of information	Review PM program - prevent downtime - minimise PM's - address condition issues	Compare breakdown and PM work order trends with downtime trends. Compare inspection results with downtime trends.

The type of data which can be addressed in the final stage is shown in



Downtime analysis *Work order response performance*

Figure 2 Analysis of SAS Dynavac furnace

There are some clear mismatches between the data: for example, 35 downtime incidents were recorded but 50 breakdown work orders were logged. We expect that the downtime data is reasonably correct but we may be missing some very brief incidents, or equally likely we are seeing evidence of repeat visits to the same failure. The data is providing us with a basis for further investigation.

The balance of PM to breakdown work order is not satisfactory, but the scheduling of PM's is also poor with 15 PM's being blamed by operators as preventing the use of the asset. The downtime analysis is owned by production staff and gives substance to their observations in a meeting with maintenance staff. On the other hand, the work order performance analysis put forward by maintenance shows how they are providing resources and an analysis of the details of each work order will demonstrate how they are currently addressing the downtime problems recorded by production.

6. Conclusion

Maintenance improvement is not achieved by setting up a dedicated team who are required to establish new procedures, commission a CMMS and generally accomplish a set of tasks in relative isolation. It is achieved by a company-wide effort which brings in many people, sets obligations upon management and requires commitment from both operations and maintenance staff. In addition, the maintenance and operations roles cannot be smeared together; they are distinct due to their differing objectives and

expertise. Maintenance improvement strategy has to appreciate these differences and embrace a wide range of people and issues.

We have also found that while improvement is feasible is a specific area or business unit of the company, it cannot target just a key machine. Maintenance improvement relates to policy, anticipation of problems, responsiveness of people and monitoring outcomes. The data associated with the exercise is intended to provide a focus and some credibility to people's discussions and collaboration with other groups.

Before embarking on such a program, it is critical that people appreciate where they are in respect to what constitutes good practice. A meticulous audit, embracing the principles listed in this paper will provide a foundation from which to plan an improvement process. While the significance of culture, people's attitudes and day-to-day labour issues is appreciated, the primary threat to maintenance improvement is a lack of technical expertise and an unwillingness to analyse the detailed indicators about a business and the manner in which it conducts asset management/utilisation.

Acknowledgments

The author acknowledges the partnership with Mr. G. Chapman who has shared in much of the developments described in this paper. Plus the author thanks the many companies who have participated in the research and development program.

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