Evaluating the Practical Options for Implementing a Pro-active Maintenance Approach into your Maintenance Strategy

by

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Defining Pro-active Maintenance

The word "pro-active" does not appear in the Macquarie Dictionary however the word "pro-" is listed as: 1. A prefix indicating favour for some party, system, idea, etc. 2. A prefix of priority in space or time having esp. a meaning of advancing or projecting forwards or outwards, …...

In the context of maintenance one could possibly extend the above to: a prefix of priority in time projecting outwards towards the root cause. Alternatively a simpler definition could be:

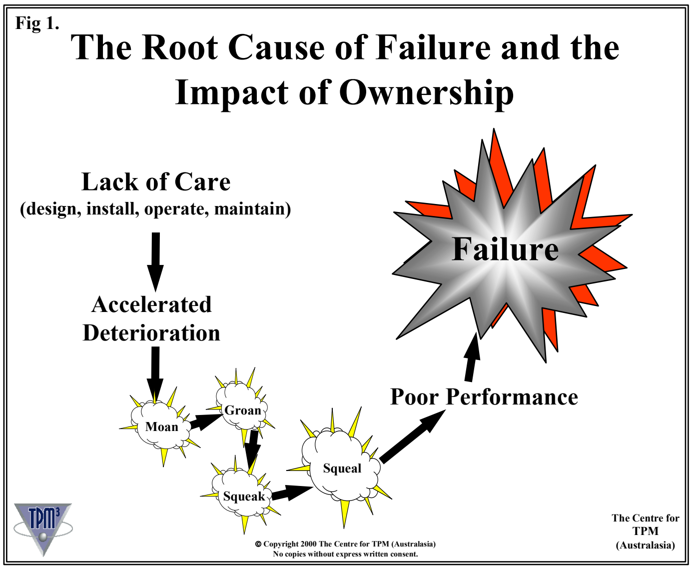
'Taking action to stop an event from occurring rather than responding to an event that has occurred'

where the key word is 'event' which could infer: Failure; Poor Performance; Moans & Groans; Accelerated Deterioration; or Lack of Care.

Given the broad definition from the Macquarie Dictionary, we will take the most 'time projecting' option of Lack of Care as shown in Figure 1.

Why be Pro-active: Understanding the Causes of Failure

Most of us have heard of the concept of the 'Root Cause of Failure' and the tool most commonly used to assist in the search for the root cause – the 5-Whys. The 5-Whys is a simple technique of asking why 5 times recognising that statistically it has been shown that after 5 whys you are most likely to be at the root cause. In the work place we rarely get to the root cause because we are too busy reacting to the symptoms of our problems. However, unless we get to the root cause we will always have problems reappearing.



What is the root cause of failure? Often, before failure we can have poor performance, prior to poor performance we may get moans and groans coming from our equipment, and before the moans and groans we will have accelerated deterioration.

What do we mean by 'Accelerated Deterioration'? This is where a piece of equipment or part of a piece of equipment wears out quicker than is expected. That is, its life is shortened because its natural deterioration is accelerated.

Let us look at the failure mechanisms of the parts that make up our plant & equipment. Most pieces of equipment in our plants can be classified into 3 broad categories: structural items; wear items; and working items. Our main interest is with the Working Items. These by far make up the majority of items that need maintenance attention and contribute most to our overall maintenance spend. So let us understand the impact of the laws of physics on our working items.

If, for example, I were to rub my hands together for the rest of the day what is going to happen? I will probably get very sore hands due to the friction, heat and wear created by the movement. I will probably also end up with several layers of skin rubbed off. To stop this from happening I would need to apply some form of lubrication to act as an interface between my hands.

Proper lubrication provides an interface between moving surfaces. A key role of lubrication is also to be a sacrificial wear element. That is, the lubrication wears out as the moving surfaces interface with it. This is why it is recommended that we replace the oil in our cars at say every 10,000 km. This is not because the oil is dirty, even though it may look dirty it is continuously filtered and clean. The reason for replacement is that the oil has worn out.

Hence, as an example, accelerated deterioration can and often does occur when:

- lubrication is not present;
- lubrication is incorrect for the application;
- lubrication between surfaces is forced out due to overload;
- lubrication wears out; or
- lubrication becomes contaminated.

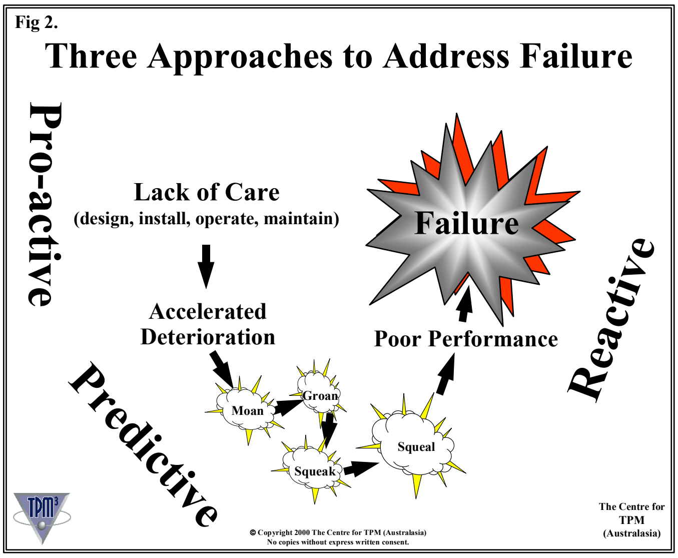
Who has ever seen an operator "blow down" machinery or equipment with compressed air, or hose it down with water? What is this process doing to the equipment? More than likely the operator is forcing contamination into the equipment without even realising it or caring about it. This contamination is a primary source of accelerated deterioration.

From the example above, we can see that to stop Accelerated Deterioration we need to be truly Pro-active and address the Lack of Care issue. Our experience indicates that unless there is a perceived sense of ownership by employees who design, install, operate and maintain equipment, the 'lack of care' issue will rarely be properly addressed. Through bitter experience many companies have now come to realise that without a sense of "ownership" employees tend not to care for equipment. Take the simple example of the company ute versus the manager's car. Both vehicles are the property of the company, yet the manager's vehicle, because of the perceived "ownership" of it by the manager is often more reliable, performs better and has lower operating / servicing costs than the company ute which is driven by everyone and owned by no-one.

In a non-caring environment our plant & equipment becomes like the company ute - performs poorly and has high operating / servicing costs.

Three Approaches to Address Failure

From Fig 2 below we can see that we have three approaches to address failure:



- ***Reactive***, where we wait for Failure or Poor Performance to occur before responding
- ***Predictive*** where we go looking for pending problems with the equipment by trying to identify Deterioration before performance is affected, or
- ***Pro-active*** where we address the root cause of failure which is the Lack of Care.

TPM: a Pro-active approach to Maintenance

TPM had its genesis in the Japanese car industry in the 1970s. It evolved at Nippon Denso, a major supplier of the Toyota Car Company, as a necessary element of the newly developed Toyota Production System. It was not until 1989, with the publication in English of the first of two authoritative texts on the subject by Seiichi Nakajima, that the western world recognised and started to understand the importance of TPM as a pro-active maintenance strategy.

It soon became obvious that TPM was a powerful new means to improving overall company performance. TPM is now having a major impact on bottom-line results along with substantially improving capacity while significantly reducing not only maintenance costs but overall operational costs. Its successful implementation has also resulted in the creation of much safer, and more environmentally sound, workplaces.

TPM has developed over the years since its first introduction in 1970. Originally there were 5 Activities of TPM that is now referred to as first generation TPM (Total Productive Maintenance). It focused on improving equipment performance or effectiveness from an equipment focus perspective. Late in the 80's it was realised that even if the shopfloor were committed fully to TPM and the elimination or minimisation of the "six big losses", there were still opportunities being lost because of poor production scheduling practices resulting in line imbalances or schedule interruptions. Hence the development of second generation TPM (Total Process Management) which focused on the whole production process and

incorporated an extra Pillar of TPM activity called Support Systems Improvement – Production Planning.

In more recent times it has been recognised that the whole company must be involved to take advantage of the significant capacity gains achieved by 3rd Generation TPM (Total Productive Manufacturing) which encompasses 8 Pillars of TPM Activity. In Australasia where our culture is quite different from the Japanese, we have developed Australasian 3rd Generation TPM which involves two extra Pillars – Work Area Management and People Support Systems Improvement.

TPM is now recognised as the secret behind the world-leading performance of companies like Toyota, Fuji, Pirelli, Volvo, Unilever, and Proctor & Gamble to name but a few. TPM is also currently being successfully adopted by companies of all sizes in industries ranging from manufacturing to mining to utilities.'

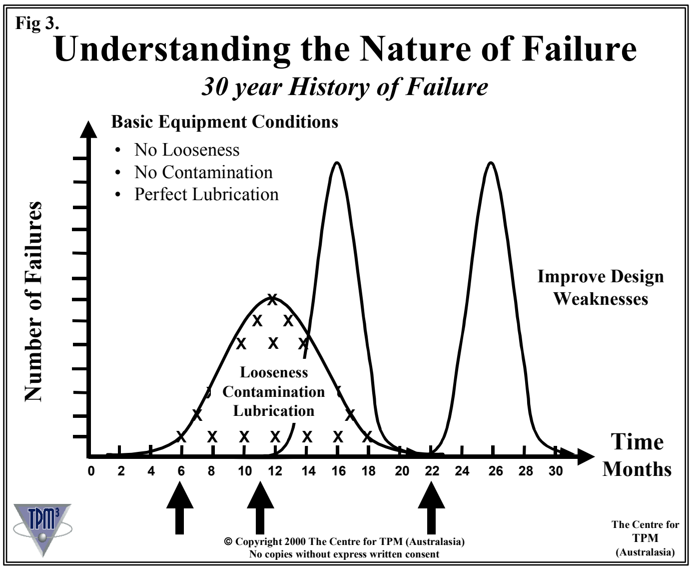
At the TPM Action '99 Forum, Nissan Casting Australia Plant at Dandenong Victoria reported since introducing TPM they have achieved:

Capacity	**Up**	**25%**
Productivity	**Up**	**60%**
Rejects	**Down**	**60%**
Maint Costs	**Down**	**50%**
Safety (LTI)	**Down**	**60 to 3**
Suggestions per employee	**Up**	**1 to 12 per year**

resulting in some $5m in savings for the company.

From the many success stories now documented, there has been a realisation by many senior managers that TPM is both strategically important for a world competitive business, and that TPM cannot be implemented by the maintenance department alone. TPM is a company-wide improvement initiative based on the principles of quality involving all employees.

Understanding the Nature of Failure



Many studies have been conducted to determine the impact of accelerated deterioration. Let us consider the situation of the working parts of your equipment. If you were to plot say the 30-year history of the actual life of a part that normally fails after 12 months would you get a straight line? In most studies the result is a normal distribution where the part fails for the majority of the time at 12 months however on other occasions it may fail early or later often with a range of some 6 months either side of the 12 month majority. If we were to introduce a periodic or preventive

maintenance plan for this part what would be our strategy. Obviously if we were to replace the part after 12 months we would still have a significant number of failures. If we were very conservative we could replace the part every 6 months. This would significantly reduce the failures however we would have very high maintenance cost. So what is the answer?

This is where TPM becomes so important. TPM is based on the precepts of:

- understand what causes the variation;
- reduce or minimise the variation; then
- look to improvement.

Under this approach the first task is to identify what is causing the variation. Studies conducted by the Japanese Institute of Plant Maintenance and companies like DuPont and Tennessee Eastman Chemical Company have shown that 3 major physical conditions make up some 80% of the variation. These physical conditions are:

- Looseness
- Contamination
- Lubrication

The elimination of these three conditions is known as “establishing Basic Equipment Conditions”. Once “basic equipment conditions” have been established we find our normal distribution curve squash up some 80% and moves to the right thus significantly increasing the life of our parts.

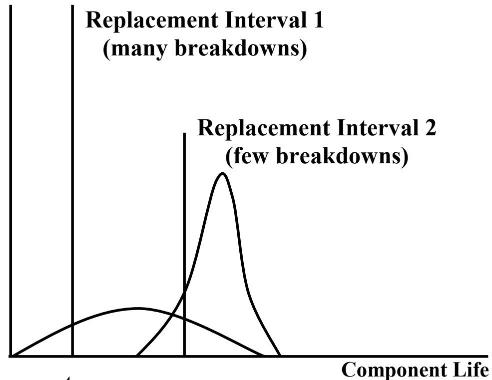
In his book, TPM in Process Industries, Suzuki raises the important issue when he states:

> ***“Implementing a periodic / preventive maintenance system before establishing basic conditions - when equipment is still dirty, nuts and bolts are loose or missing, and lubrication devices are not working properly - frequently leads to failures before the next major service is due.***
>
> ***To prevent these would require making the service interval unreasonably short, and the whole point of the preventive maintenance program would be lost.***
>
> ***Rushing into predictive maintenance is equally risky. Many companies purchase diagnostic equipment and software that monitors conditions, while neglecting basic maintenance activities.***
>
> ***It is impossible, however, to predict optimal service intervals in an environment where accelerated deterioration and operating errors are unchecked.”***

Achieving Zero Breakdowns through TPM: *The Four Phases to Zero Breakdowns*

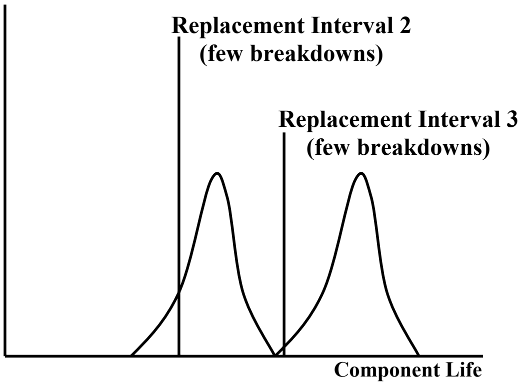
Phase 1 Reduce Variation in Failure Intervals by Stabilising Equipment / Component Life (Stage 1 Operator Equipment Management - Steps 1, 2 & 3)

- Restore deterioration
- Prevent accelerated deterioration
- Establish Basic Equipment Conditions
- Ensure proper operation
- Prepare user-friendly daily inspection and lubrication standards



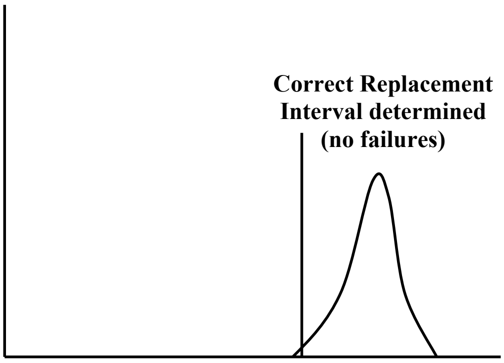
Phase 2 Lengthen Equipment Life by Identifying and Improving Design Weaknesses
(Stage 2 Operator Equipment Management - Steps 4 & 5)

- Identify design weaknesses
- Correct design weaknesses
- Prevent operating errors
- Prevent repair errors



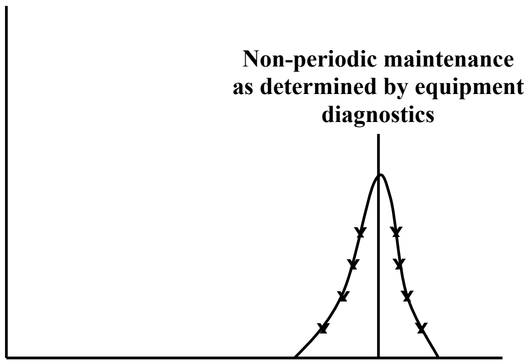
Phase 3 Periodically Restore Deterioration by Periodic Maintenance through Planned Replacement
(Stage 2 Operator Equipment Management - Steps 4 & 5)

- Perform periodic servicing and inspection
- Establish maintenance work standards
- Establish maintenance inspection standards
- Control spare parts and maintenance materials
- Recognise signs of process abnormality



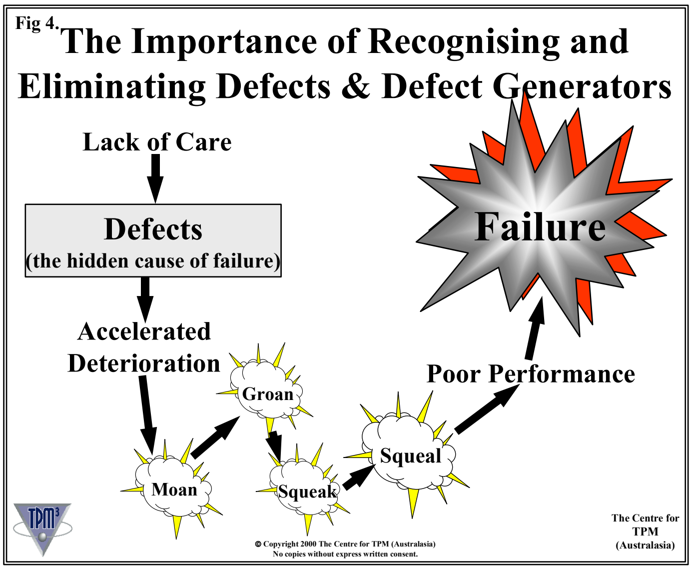
Phase 4 Predict Equipment Life by Predictive Maintenance through Condition Monitoring
(Stage 2 Operator Equipment Management - Steps 4 & 5)

Use monitoring to predict replacement
Use employees five senses
Use appropriate technology



Equipment Defects - The Hidden Cause of Failure

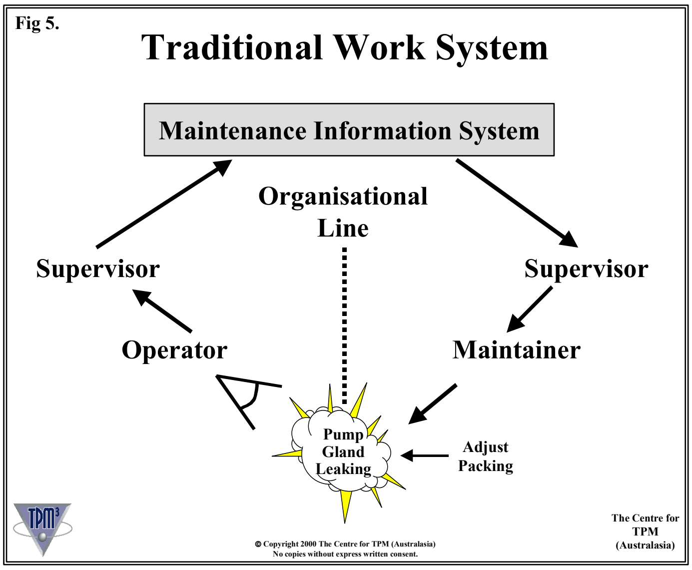
A pro-active maintenance approach is an ongoing journey to excellence that challenges our mind-sets. One such important challenge is the traditional mind-set that focuses on either actual or potential failures or breakdown and largely ignores equipment defects that can be the hidden cause of failure (see Figure 4).



Equipment defects or imperfections with our equipment are subtle and not always obvious. They "flow" into our plant & equipment due to various reasons: poor initial design or changes to the initial design requirements of our plant & equipment due to output requirement changes; the way we operate our plant & equipment and the environment we operate our plant & equipment in; imperfections in the maintenance materials we use and the way we carry out our maintenance activities; and last but not least, as a consequence of any failures which occur to our plant & equipment. They are often difficult to identify and correct because they are traditionally accepted as the norm. Equipment defects play a major part in causing "losses" in equipment performance.

Experience has shown that there is a definite relationship between failures and equipment defects in that most failures can be traced back to equipment defects. In a pro-active maintenance environment, the aim is to focus on equipment defects so as to eliminate the occurrence of failures and early deterioration. This focus on equipment defects has a large bearing on the way everyone in the company needs to become involved with pro-active maintenance. All employees need to ask the question: "are my actions focused on avoiding defects or merely addressing the issues associated with defect removal". Being able to identify and correct equipment defects and then locate their source so they can be avoided in the future is a major ingredient in the process of implementing pro-active maintenance.

Impact of Traditional Work Systems on Defect Elimination



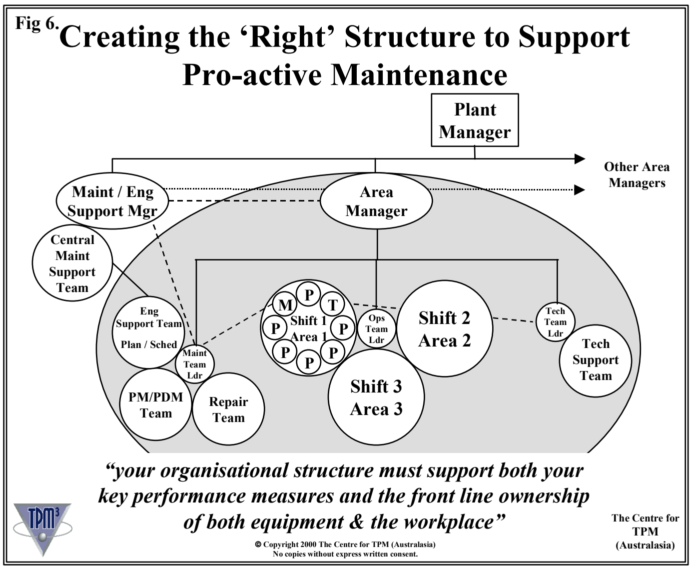
In order to control maintenance activities, work request / work order systems are often developed that require a work request be generated before any maintenance task will be actioned (see Fig 5). Unfortunately such systems, although having noble intentions, require priorities to be placed on each work request before they are transformed into a work order. Most priority systems, after recognising the safety implication of the work request, will place Failures - first, Poor Performance - second, Moans & Groans – third, Accelerated Deterioration – fourth and finally Defects – fifth or extremely low. Hence our work order systems can work against a pro-active

approach if we don't examine them in new light of the importance of early defect identification and rectification.

Creating the 'Right' Structure to Support Pro-active Maintenance

Although centralised maintenance groups provide good flexibility, experience now highlights that while employees move from equipment to equipment, or area to area, they loose the motivation to seek out basic equipment problems or defects which if left unchecked, will cause failure in the future. Employees often demonstrate a lack of care for the equipment because they know they will soon be moved to another area or piece of equipment.

An area-based team approach which promotes the development of both base-skills and mastery-skills provides a means to achieve both flexibility and ownership within the workplace. Correctly formed area-based teams create an environment where employees can come to recognise the benefits for themselves to learn both the proper way to operate their equipment as well as how best to care for their equipment by assisting operators to maintain "basic equipment conditions" and learn about the functioning of their equipment.



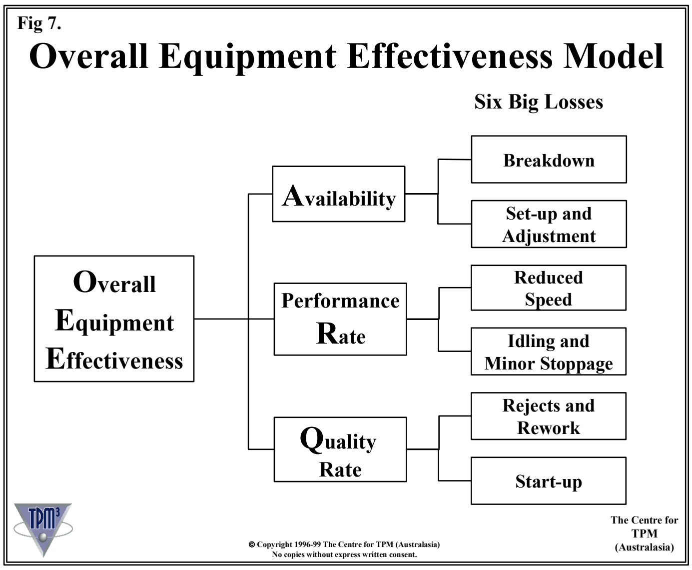
TPM implementation experience has shown that there is a definite relationship between failures and "basic equipment conditions" – no looseness, no contamination, and correct lubrication. Our experience with centralised pools of labour that are allocated according to 'reactive' workload requirements, is that it takes away ownership and the motivation for employees to ensure basic equipment conditions.

An typical example of an organisation structure that supports a pro-active approach is shown in Figure 6.

Without the framework of effective area-based teams, where team members can develop the skills to become the expert at caring for, operating and detecting any defects that might develop in their equipment, operational and maintenance costs will always be high.

Understanding the Importance of Overall Equipment Effectiveness as the TPM 'driver'

Many companies who recognise the important roll equipment and process performance have on bottom-line results are turning to the measure which drives TPM called Overall Equipment Effectiveness (OEE) which incorporates not only Availability but also Performance Rate and Quality Rate. In other words, OEE addresses all losses caused by the equipment: not being available when needed due to breakdowns or set-up and adjustment losses; not running at the optimum rate due to reduced speed or idling and minor stoppage losses; and not producing first pass A1 quality output due to rejects and rework or start-up losses. A key objective of



TPM is to cost effectively maximise Overall Equipment Effectiveness through the elimination or minimisation of all losses. A simple model outlining these losses is shown in Figure 7.

Various equations exist to help us measure OEE (see Figure 5) which is based on Availability x Performance Rate x Quality Rate, however many companies are finding the simple high level measurement of OEE:

$$\frac{\textbf{Good Output Produced}}{\textbf{Scheduled Operating Time x Optimum Rate}}$$

as a good starting point to identify whether opportunities for improvement exist. Obviously this simple measure does not identify where the losses are coming from but it does give you an accurate indication of the effectiveness or lack of effectiveness of your equipment.

When many organisations first measure Overall Equipment Effectiveness it is not uncommon to find they are only achieving around 40% - 60% (batch) or 50% - 75% (continuous process) whereas the international best practice figure is recognised to be +85% (batch) and +95% (continuous process) for Overall Equipment Effectiveness. In effect, this means there exists in most companies the opportunity to increase capacity / productivity by 25% - 100%.

Conclusion

The original precepts for a manufacturing based pro-active maintenance approach were developed by Toyota where they soon realised that ‘basic equipment conditions’ (no looseness, contamination or lubrication problems) and operators skill levels and behaviour is of a high standard are mandatory. Unfortunately in most manufacturing and mining operations these ‘basic equipment conditions’ and operator skill and behaviour levels do not exist thus undermining the basis of many maintenance initiatives.

For this reason, any pro-active maintenance strategy needs to ensure:

‘basic equipment conditions’ are established; and
‘equipment-competent’ operators are developed

before attempting to achieve world class equipment performance. Failure to do this in an environment where basic equipment conditions and operator error are causing significant variation in the life of your equipment parts will block your ability to achieve your reliability goals.

TPM recognises that the maintenance function alone cannot improve reliability. Factors such as operator ‘lack of care’ and poor operational practices, poor ‘basic equipment conditions’, and adverse equipment loading due to changes in processing requirements (introduction of different products, raw materials, process variables etc) all impact on equipment reliability. Unless all employees become actively involved in recognising the need to eliminate or reduce all “losses” and to focus on ‘defect avoidance’ or ‘early defect identification and elimination’ failures will never be cost effectively eliminated in a manufacturing or mining environment.

It should be acknowledged that a TPM implementation is not a short-term fix. It is a continuous journey based on changing the work-area then the equipment so as to achieve a clean, neat, safe workplace through a “PULL” as opposed to a “PUSH” culture change process. Significant improvement should be evident within six months, however full implementation can take several years to allow for the full benefits of the new culture created by TPM to be sustaining. This time frame obviously depends upon where a company is in relation to its quality and maintenance activities and the resources being allocated to introduce this new mind-set of equipment management.

The Centre for TPM (Australasia)
In January of 1996, the Centre for TPM (Australasia) - a membership based organisation was created with the mission to "promote and advance the knowledge and practice of Australasian 3rd Generation TPM and conduct, promote and advance the public education of TPM[3] throughout Australasia." The Centre which has it's Head Office and NSW regional office in Wollongong along with regional offices in Melbourne, Sydney, Perth, Adelaide, Brisbane and New Zealand, provides networking, information exchange, training and consulting support and has a strong Research Division in co-operation with the University of Wollongong.

For further information please contact the Centre for TPM (Australasia) on (02) 4226 6184 or visit our web site at: www.ctpm.org.au

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A fitter and turner by trade, Ross has a Mechanical Engineering degree from the University of New South Wales and a Management degree from the University of Wollongong. He has more than 25 years of manufacturing and operational experience covering maintenance, production, operations and executive roles followed by 5 years of international consulting experience. In January 1996, along with several colleagues, he founded the Centre for TPM (Australasia). Ross has been actively involved with TPM since 1990 and has delivered publicly over 100 papers and workshops on the subject both within Australia and overseas. He, along with his colleagues from the CTPM, is presently assisting a number of companies both in Australia and New Zealand to embark on TPM.