Technical Paper

Justifying Predictive Maintenance

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This paper describes, in brief, the issues involved in justifying a computer-based predictive maintenance program. A general formula for cost-benefit analysis is proposed, which can be tailored to your particular process. There are many issues involved in deciding whether to initiate a predictive maintenance program. Even if a program is already in place, it is often difficult to quantify the benefits of implementing a computer based system such as Azima DLI's ALERT Reliability Software. The intention is to clarify the extent to which ALERT can have your process running more safely and efficiently, and is to be used as a rough guide only.

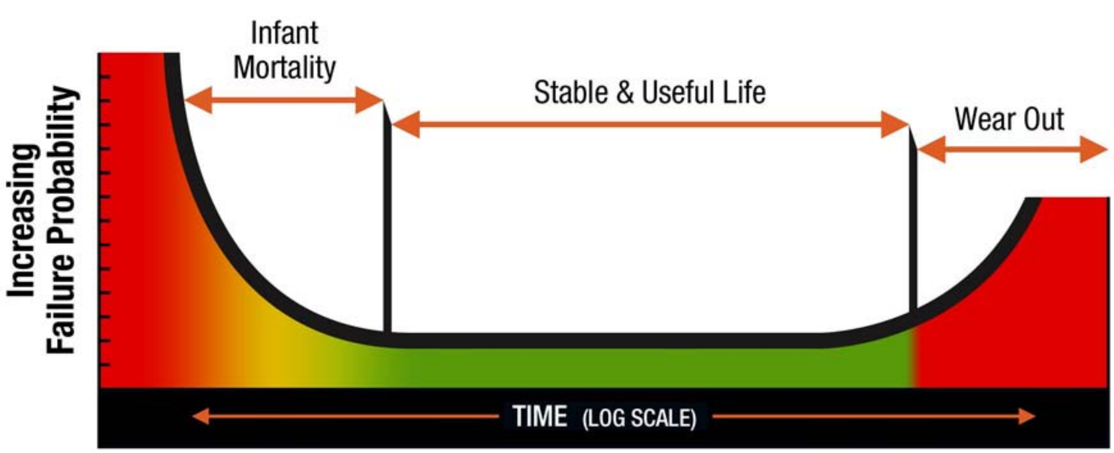
PREDICTIVE MAINTENANCE

The basic principle of predictive maintenance is to take such measurements that allow your organization to predict when plant machinery will break down. These measurements include machine vibration and plant operating data such as temperature, pressure and oil metal concentrations.

PREVENTATIVE MAINTENANCE

Preventative maintenance schedules regular machine/plant shutdowns, irrespective of whether repairs are required. There are many problems associated with this maintenance strategy including:

- Increased maintenance costs as parts are replaced when they are not necessarily required.
- Risk of infant mortality due, for example, to human error during dismantling work. The component life cycle chart shown here identifies that, by far, the greatest probability of assembly failure is at start-up.



BENEFITS OF PREDICTIVE MAINTENANCE

Predictive maintenance, on the other hand, determines when the machine REQUIRES repair. Plant machinery is therefore only repaired WHEN REQUIRED. The benefits of predictive maintenance can be separated into two main categories.

INCREASED SAFETY: Predictive maintenance provides the reassurance of safe, continued plant operation. By reducing the likelihood of unexpected equipment breakdown, the safety of employees is improved. Although difficult to quantify, there is a definite economic benefit in improved employee and union relationships.

IMPROVED OPERATING EFFICIENCY: There are many areas in which a predictive maintenance program can increase the efficiency of your process. Please see chart below.

How an Effective Predictive Maintenance Strategy can Improve Plant Efficiency	
Reduction in Lost Production	Predictive maintenance aims to identify problems in equipment so that necessary downtime can be scheduled. By identifying problems in their initial stages, the predictive maintenance system gives notice of impending failure, so downtime can be schedules for the most convenient and inexpensive time. Predictive maintenance minimizes the probability of unexpected failures, which would result in lost production. This is always important, particularly so if your plant uses 'just in-time' manufacturing techniques, as the lost production and credibility to the customer may NEVER be regained.
Reduced Cost of Maintenance	As equipment is only repaired when needed (as opposed to routine disassembly), maintenance staff have more satisfying and worthwhile work and the costs of maintaining the machinery are reduced as resources (labor, equipment and parts) are only used when needed.
Less Likelihood of Secondary Damage	By identifying potential failures in advance, the severity of these failures can be substantially diminished by reducing or preventing secondary damage. For example, a failing bearing in a motor can be identified and replaced before the winding and shaft are also damaged.
Reduced Inventory	Predictive maintenance reduces inventory costs because, as substantial warning of impeding failures is provided, parts can be ordered as required, rather than keeping a large backup inventory.
Extending the Life of Plant Equipment	Using a predictive maintenance program, machines are only dismantled when necessary, so the frequency of equipment disassembly is minimized, and thus the probability of 'infant mortality' is reduced.
Improved Product Quality	Predictive maintenance requires data to be taken from the plant. That process, coupled with the collection of additional plant performance data (performed by many predictive maintenance groups), means that the efficiency of plant equipment is scrutinized constantly. By increasing the efficiency of your process, the quality of your product will be improved. With an improved product, and a renewed confidence in product supply, customer relations will also be improved.

DETERMINING THE BENEFITS / COSTS OF PREDICTIVE MAINTENANCE IN YOUR PLANT

BENEFITS	
Reduced Forced Outage Time	Annual Benefits ($ per unit per year), can be estimated as: Probability of successful early detection X [Benefit due to decrease in forced outage time + Benefit due to some forced outage time becoming scheduled outage time] Benefit due to decrease in forced outage time is equal to: $c_f\ t_f\ f_1$ Benefit due to some forced outage time becoming scheduled outage time is equal to: $c_s t_s + c_f t_f (1-f_1) - \{c_s [\ t_s + f_2 (1-f_1)\ t_f\ ] + c_f [\ t_f (1-f_1)\ (1-f_2)\ ]\ \}$ where: c_s = Cost of scheduled outage ($ per unit hour) c_f = Cost of forced outage ($ per unit hour) f_1 = Fraction of forced outage time which is eliminated - assume 0.2 (conservative) f_2 = Fraction of remaining outage time which becomes scheduled outage time - assume 0.2 (conservative) t_s = Current scheduled outage time (hours per unit per year) t_f = Current forced outage time (hours per unit per year) A conservative estimate for the probability of successful early detection is a minimum of 0.5
Secondary Damage	It is difficult to develop a general rule for the savings due to reduced secondary damage. An estimate of a factor of ten has been suggested[2]. That is, the repair bill will be ten times higher if a machine is allowed to fail, rather than repairing it before failure.
Other Benefits	The benefits of increased product quality, improved employee relationships due to increased safety and job satisfaction, reduced inventory and extended plant life can only be assessed in your plant.
Thus, the benefits of using ALERT to manage your predictive maintenance program can be readily estimated. ALERT allows you to optimize on these savings.	

<table>
<tr><th colspan="2">COSTS</th></tr>
<tr><td>Computers & Instrumentation</td><td>The equipment necessary will depend on your requirements, but should be in the range of $20,000 to 30,000, including instrumentation. Annual equipment cost in depreciation and interest on capital can be conservatively estimated of 30% of its capital cost. Maintenance cost can be estimated as 10%-15% of the capital cost.</td></tr>
<tr><td>Software</td><td>The cost of the ALERT System ranges from $7,900 - $15,000 depending on the features required for your application. An additional benefit is that the cost of the ALERT System, as software, is completely tax deductible.</td></tr>
<tr><td>Staff (Rough Guide)</td><td>
<table>
<tr><th># points measured & analyzed per month</th><th>Staff required</th></tr>
<tr><td>0 – 50 points</td><td>Readily done by maintenance engineer along with other work</td></tr>
<tr><td>50-1500 points</td><td>1 technician doing field work, sharing with 1 engineer</td></tr>
<tr><td>1500-3000 points</td><td>1 technician doing field work, 1 engineer to analyze, 1 to evaluate, depending on the degree of automated analysis equipment used.</td></tr>
<tr><td>Over 3000 points</td><td>More technicians for field measurements, again varying with automation, but keeping engineer staffing at 2.</td></tr>
<tr><td colspan="2">As you can see, the more automation features available, the fewer people will be required to implement your predictive maintenance program. This highlights the need for ALERT’s many automation features.</td></tr>
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<tr><td colspan="2">It is possible, therefore, to determine a rough estimate as to the savings ALERT can provide your plant. We are confident that, even using this conservative analysis, the payback period you determine for the investment in our system will be minimal.</td></tr>
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References

1. BEEBE, Ray, Evaluating the Cost Benefits of Machine Condition Monitoring , paper delivered at the Machine Condition Monitoring and Fault Diagnosis Conference, University of Adelaide, June 1987.

2. BOWD, Les, Private Correspondence , Tomago Aluminum.

3. DENNIS, Stephen, Some Developments in Condition Monitoring of a Power Plant, paper delivered at Condition Monitoring Seminar, N.S.W. Institute of Technology, 1986.

4. EPRI Report CS 1896, On-Line Acoustic Emission Monitoring of Fossil Power Plants, A Critical Assessment , June 1981.

5. SACHS, Neville W., Predictive Maintenance Cuts Costs, Power Transmission Design, November 1986.