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 REQUIRE 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.

<table>
<thead>
<tr>
<th>How an Effective Predictive Maintenance Strategy can Improve Plant Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in Lost Production</td>
</tr>
<tr>
<td>Reduced Cost of Maintenance</td>
</tr>
<tr>
<td>Less Likelihood of Secondary Damage</td>
</tr>
<tr>
<td>Reduced Inventory</td>
</tr>
<tr>
<td>Extending the Life of Plant Equipment</td>
</tr>
<tr>
<td>Improved Product Quality</td>
</tr>
</tbody>
</table>
# 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:

\[
\text{Annual Benefits} = \text{Probability of successful early detection} \times \text{Benefit due to decrease in forced outage time} + \text{Benefit due to some forced outage time becoming scheduled outage time}
\]

Benefit due to decrease in forced outage time is equal to: \( cf \cdot f_1 \)

Benefit due to some forced outage time becoming scheduled outage time is equal to:

\[
c_s t_s + c_f f_1 (1 - f_1) - \{ c_s \{ t_s + f_2 (1 - f_1) t_f \} + c_f \{ t_f (1 - f_1) (1 - f_2) \} \}
\]

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. 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.
COSTS

Computers & Instrumentation

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.

Software

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.

Staff (Rough Guide)

<table>
<thead>
<tr>
<th># points measured &amp; analyzed per month</th>
<th>Staff required</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

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.

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.

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