Calculating Oil Analysis Return on Investment

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Starting, Expanding or Even Keeping an Oil Analysis Program Depends Upon Your Ability to Create Value and Express it in the Language of Management.

More than any single factor, growth in the oil analysis industry has been limited by the inability of its professionals to effectively propose projects and report results to management using conventional financial language. This is not uncommon in technical disciplines like oil analysis where technicians and engineers have received little or no training on the use of the financial project evaluation methods typically employed. The reliability professional of the future must possess the skills to express his or her value to the organization using language to which management is accustomed.

Too often the oil analysis technician or engineer complains about the lack of support from management for sophisticated oil analysis programs, claiming management says “there’s no money for oil analysis” or words to that effect. The fact is, in our economy there is always money available for investments that produce a healthy profit. The failure more often lies in the presentation. For example, if management is asked for the money to buy filters and oil analysis services for the purpose of lowering ISO cleanliness codes and monitor progress, the proposal is in oil analysis language. Few managers speak oil analysis. Managers speak the language of the dollar, pound, franc, yen . . . you get the picture. It is incumbent upon the oil analysis or reliability professional to translate from the language of ISO codes, mg KOH/gm, cSt, etc., to the manager’s native language . . . money. If left up to the manager to perform the translation, the response to the proposal is an almost certain no.

Here, methods for quantifying the benefits of oil analysis and the tools used to present the findings to management are discussed in the context of oil analysis to begin to equip the oil analysis professional with the tools required for success.

Quantifying the Benefits of Oil Analysis

The application of oil analysis and other precision maintenance activities produces real benefit to the organization. Often, oil analysts think only in terms of the savings associated with extended or condition-based oil changes. They often fail to capture value contributions related to equipment reliability or risk reduction. Effective management of lubrication builds reliability into the system, and oil analysis produces tremendous value when it provides advance warning of a failure event. The early warning system allows management to schedule the activity to avoid interruption of business, and to have parts and labor lined up. Likewise, oil analysis provides information about the event itself so the right “fix” is implemented, preferably removing the root cause of the problem. Below is a summary of some of the costs that can be controlled when decisions are made with the benefit of oil analysis.

- Repair Costs - If a machine presently fails once every year, one can estimate the average costs for parts and labor to restore the machine and present that as an annualized value to ease analysis. For instance, if a machine fails once a year and, on average, requires $5,000 for restoration, the average annual repair cost is $5,000

- Downtime Costs - When a mission critical machine is not running, the cash register is not ringing. One can estimate the typical downtime cost associated with a machine’s failure and multiply it by
the average duration of the lost production time. It is important to look only at the profit of the production in the financial analysis (production loss minus cost of goods sold).

- **Lubricant Costs** - Often, changes in lubrication management and oil analysis reduce the consumption of lubricants. Savings estimates should include lubricant costs, labor and disposal costs.

- **Energy Consumption Costs** - Usually, improving lubrication involves reducing friction. By comparing energy consumption during normal operation before and after the changes with an amp meter, these savings can be effectively estimated.

- **Quality Costs** - Often, percent defect is reduced through good management of lubrication quality. This is especially true in applications like molding, machining, rolling and casting where the precision of hydraulic control is affected by the lubricant’s quality. But it is true elsewhere too. Simply stated, good running machines seem to make better products over the long haul.

- **Increased Production** - In some cases, properly lubricated machines can produce more. For example, contamination or varnish can slow the cycle time of a molding machine, reducing its output. Likewise, proactive and predictive lubrication analysis and management may enable management to turn production up a notch or two with greater confidence that reliability will be assured.

- **Risk-based Costs** - Insurance, safety risk, environmental damage and other risk-based costs should be assessed on a case-by-case basis and included in the evaluation.

In essence, oil analysis affects the Overall Equipment Effectiveness (OEE) which measures an asset’s production quantity and quality relative to a theorized around-the-clock production level with no interruptions of output (planned or otherwise) or quality level.

**Proactive and Predictive Benefits**

Financial benefits generated by oil analysis and lubrication management projects come in two forms, proactive benefits and predictive benefits. Proactive activities like reducing particle and moisture contamination, changing or reclaiming oil and upgrading a lubricant’s quality specification actively extend the life of components. By controlling the forcing function, or root cause, that leads to a failure, one can preemptively reduce the failure rate for a component or system.

For example, the relationship between particle or moisture contamination level and mechanical integrity has been widely researched. Reducing the particle contamination level of the oil lubricating a rolling element bearing from ISO 19/16 to ISO 15/12 will, on average, double the life of the bearing. Likewise, reducing the moisture contamination level in the same rolling element bearing system from 1000 ppm to 250 ppm would double the life of the bearings in the same system. If one elects to control both moisture and particles simultaneously, an additive effect is said to exist, meaning the total life extension is the sum of the parts (see Figure 1).

![Table showing life extension](image)

*Figure 1. Proactive maintenance produces a quantifiable life extension. This life extension factor can be translated into dollars.*

Quantifying the proactive benefits is a simple division of the current failure costs due to wear and failure by the life extension factor. In other words, in the bearing system example, every dollar currently lost per year due to failure would be reduced by 75% if the proposed particle and moisture targets are achieved. Proactive maintenance makes money because it effectively reduces the number of failure events that occur for a given time period.
There is inherent complexity in the valuation of predictive maintenance activities. The objective for predictive maintenance is to produce a non-event or reduce the relative impact or severity of a failure event. Quantifying this can prove difficult. The value of predictive maintenance lies in its ability to provide advance warning so that unscheduled outages are avoided, parts and labor can be scheduled, run-time compensatory actions can be taken to “limp” the machine along until the scheduled outage, costly chain-reaction failures can be avoided, etc. In their article “Predictive Maintenance - The Effect on a Company’s Bottom Line”, Johnson, Maxwell and Hautala provide a robust framework for assessing this value.

The Johnson et al approach to assigning a value to a “save” is a logical risk-based approach that compares the relative severity of a failure event with the intervention of condition-based monitoring techniques like oil analysis to the probable severity in the absence of these tools. Stated simply, the premise is that one can’t assume the worst possible outcome when assessing the value of a “save” using oil analysis and other condition monitoring tools. The presence of the tools merely alters the probability of each outcome.

For example, the simple failure event described in Figure 2 has three possible outcomes - Severe, Moderate and Minor; and three cost components - Downtime, Parts and Labor. In the example in Figure 2, the worst case scenario carries a $115,000 cost. The best case with early detection results in a $3,000 repair bill. It would be inaccurate and unbelievable to assume the value of each save produced by the addition of oil analysis is $112,000 per event ($115,000 - $3,000). This is because the worst case simply doesn’t always occur. Failures don’t always occur at peak operating time and they don’t always go unnoticed. Keen operators and mechanics often see or hear changes in the operation of machines under their charge long before a catastrophic failure. Likewise, it is unreasonable to expect oil analysis or any other condition-monitoring tool to effectively detect all the failures in the very early stages.

However, it is believable to assume that the addition of oil analysis and other condition-monitoring tools will affect the probability that each of the scenarios will occur. In our example, the risk-based, weighted total cost of a failure event before oil analysis intervention is $32,600. The early warning system provided by oil analysis reduces the likelihood of the failure event being severe or moderate, increasing the likelihood of escaping with a minor failure. This reduces the weighted-average cost of a
failure to $7,385 per event, producing, on average, savings of $24,765 per event generated with the intervention of oil analysis. Then, one merely multiplies the average number of failures per year by the savings attributable to the early warning system to determine the annualized predictive maintenance value of oil analysis for that piece of equipment.

Proactive maintenance saves money by reducing the number of failure events per year and predictive maintenance reduces the impact of each event that remains. You will find that this logical method for assessing the financial benefit of oil analysis and lubrication management will be well received by management. Clearly, numerous assumptions must be made, but managers are accustomed to dealing with estimates and calculated values. Assuming one’s approach is reasonable, logical and systematic, and presented in a format to which they are accustomed, the response from management is usually very positive.

**Building the Business Proposal**

To many reliability professionals, the idea of developing a business proposal is daunting. However, it is critical to achieving success. Once you have effectively translated from oil analysis and lubrication engineering units to dollar signs (the engineering unit of management) by developing an estimate of the value of implementing your project, the business proposal must be developed in a form to which management is accustomed. To be effective, the proposal should contain the following elements:

- Technical summary of the project you wish to implement.
- Case histories of similar organizations that have successfully implemented such programs.
- A brief description of how you expect the proposed project to deliver value to the organization with a breakdown of cash inflows, or benefits, expected from the project.
- A brief description of the expected costs to implement the project with a breakdown of the cash outflows (up-front and ongoing).
- A tabulated review of the financial impact the project will have on the organization with the expected DPP, IRR and NPV clearly identified.
- A list of the assumptions you made in evaluating the business aspects of the project.

**Technical Project Summary**

Generally, managers who make financial decisions like reports that are light on technical details and heavy on financial details. It is the natural inclination of most technical people to produce just the opposite in a report they present to management. Engineers and technologists tend to develop specific detail in describing the technical nature of a project, then present a very casual financial argument. Reverse this and you will see more projects approved, and done so more quickly. In the summary, you need to generally describe the technical change you wish to implement, but do so in plain language, unencumbered by technical jargon. For example:

Mechanical unreliability of XYZ company’s paper machines has been the source of tremendous maintenance and lost production costs. On average, four (4) bearing failures occur per year per machine. An investigation into the root causes of failure has the led the reliability team to conclude that extremely high levels of abrasive contamination and moisture contamination in the oil is causing abnormal wear in the bearings, leading to failure. We believe that we can substantially reduce the contamination levels in these gearboxes by employing vent breathers, upgraded seals, state-of-the-art lubricant conditioning techniques and regular monitoring to ensure that our target levels are met. Research in the area suggests that cleaning the oil from our current contamination levels to the new target cleanliness levels will reduce bearing failure frequency by 75%. Oil analysis will ensure that these new targets remain in control. Likewise, the early warning system provided by oil analysis is predicted to substantially reduce the severity of the remaining failure events and enable efficient planning of repairs.
The above statement is clear, concise, non-technical and adequately summarizes the nature of the proposed contamination control program. Frankly, most managers don’t desire any more information than what was stated above. However, you must be prepared to answer technical questions of this nature, so be sure to have your ducks in a row. Just because the technical aspects of the project are not detailed in the business proposal to management, technical staff should not take a casual approach toward the project’s technical validity.

**A Business Case for Oil Analysis**

**Quantify the Benefits**
1. Proactive Benefits
   A. Reduce Failure Rate
   B. Reduce Operating Costs

2. Predictive Benefits
   A. Reduce the Severity of Failure
   B. Plan Activities

**Building the Business Proposal**
1. Create a brief technical summary in plain language.

2. Compare benefits of the proposed project against the implementation costs over the life of the project.
   A. Upfront Costs
   B. Ongoing Costs

3. Provide case history validation of other companies who have succeeded.

4. Compute the project’s return on investment in language managers are accustomed to.

5. Define the assumptions in preparing the project and prepare to defend them.

**Quantifying the Overall Benefits**
Once the general statement has been made describing the technical proposal, summarize the value proposition. Borrowing from the numbers previously generated in the predictive and proactive valuation process, create a simple summary table like the one is Figure 3.
Currently, the weighted-cost of each of the four failure events that occur annually is $32,600, or $130,400 per year per paper machine. Employing proactive maintenance reduces the number of failure events per year from four to one, as previously discussed. The early warning system of predictive maintenance decreases the cost of each remaining failure from $32,600 to $7,835 by reducing the likelihood of a severe or moderate failure in favor of the less costly minor failure. Include your life extension and event severity worksheets in the proposal’s appendix for reference in the event management wishes to check your work in more detail.

In this case, value was produced both by the proactive maintenance and predictive maintenance elements of the program. In some cases, one or the other delivers the bulk of the value. Proactive maintenance delivers value where the failure rate can be effectively reduced and is most productive when we can easily and inexpensively improve control over the root causes of failure, like contamination. Predictive maintenance delivers value when the early warning system can substantively impact the severity of the failure event. Predictive maintenance is most productive when high-resolution warning systems are available at a reasonable cost. It is sensible to implement the complimentary proactive and predictive measures simultaneously.

**Case History Validation**

When it comes to new technology and change, many managers are risk-averse and don’t want to be the test case for their industry. Fortunately, there are many case histories of companies that have successfully applied these concepts. Seeking out these case studies and summarizing them for management will greatly increase the likelihood of approval. Check periodicals like Practicing Oil Analysis Magazine to find these case studies (refer to the case study section of the learning center on Noria’s web-site at www.oilanalysis.com), but also call individuals within your industry or other industries who you know have developed successful programs but haven’t published their results. Conferences and meetings provide an excellent venue for meeting and learning about these successful individuals and teams.

**Breaking Down the Costs**

Usually, this is simple . . . what is it going to cost per machine to implement the program? In this case, funds are required for the following:

- Employ an outside consultant to help develop the master plan
- Deploy the use of multiple devices to manage contamination
- Create a manual of lubrication best practices to ensure consistency and uniformity among all staff members across time
- Train the staff properly to deploy the new program of lubrication excellence
- Substantially upgrade the oil analysis program

Some of the costs will be directly related to a machine while others, like training, consulting and development of the best practices manual, will be apportioned across a number of machines. So, as Figure 4 illustrates, the costs should be collected and assigned on a per machine basis. You may want to build a

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<table>
<thead>
<tr>
<th></th>
<th>Cost Per Failure Event*</th>
<th>Events Per Year Per Machine**</th>
<th>Annual Failure Cost Per Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Oil Analysis - Current Situation</td>
<td>$32,600</td>
<td>4</td>
<td>$130,400</td>
</tr>
<tr>
<td>With Oil Analysis - Proposed Situation</td>
<td>$7,835</td>
<td>1</td>
<td>$7,835</td>
</tr>
</tbody>
</table>

**Annual Savings Per Machine** $122,565

*This cost is affected by reducing the severity of each failure event using predictive maintenance.

**This cost is affected by reducing the number of failure events per year by deploying proactive maintenance.
table summarizing the costs for all the machines you wish to address with the program. Likewise, for the purpose of the proposal, it is necessary to separate up-front costs from recurring costs that are ongoing.

<table>
<thead>
<tr>
<th>Cost/Unit</th>
<th>Up-Front</th>
<th>On-Going/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Design Consulting</td>
<td>$1,000</td>
<td></td>
</tr>
<tr>
<td>Filtration System Upgrades</td>
<td>$25,000</td>
<td></td>
</tr>
<tr>
<td>Breather, Seal and Tank Upgrades</td>
<td>$5,000</td>
<td></td>
</tr>
<tr>
<td>Best Practices Manual Development</td>
<td>$1,000</td>
<td></td>
</tr>
<tr>
<td>Staff Training and Development</td>
<td>$1,000</td>
<td></td>
</tr>
<tr>
<td>Installation and Startup Labor</td>
<td>$5,000</td>
<td></td>
</tr>
<tr>
<td>Filter Elements</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>Breather Elements</td>
<td></td>
<td>$100</td>
</tr>
<tr>
<td>System Repair Parts</td>
<td></td>
<td>$250</td>
</tr>
<tr>
<td>PM Labor</td>
<td></td>
<td>$2,000</td>
</tr>
<tr>
<td>System Repair Labor</td>
<td></td>
<td>$400</td>
</tr>
<tr>
<td>Oil Analysis</td>
<td></td>
<td>$600</td>
</tr>
<tr>
<td>Best Practices Manual Updates</td>
<td></td>
<td>$300</td>
</tr>
<tr>
<td>Continuing Staff Development</td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td><strong>Total Costs/Unit</strong></td>
<td><strong>$38,000</strong></td>
<td><strong>$4,650</strong></td>
</tr>
</tbody>
</table>

Figure 4. Summary of the project’s costs per paper machine.

Determining the Project’s Return on Investment
Managers are accustomed to seeing proposals prepared in a particular way for the purpose of comparison to other competing projects, and to be sure the project is building value into the organization. The financial evaluation should take into account the time value of money and produce one or all of the following project value indicators:

- Discounted Payback Period (DPP)
- Internal Rate of Return (IRR)
- Net Present Value (NPV)

The time value of money relates to the assumption that a dollar is worth more today than at any point in the future. As such, future cash flows must be discounted relative to time so dollars can all be viewed in present value.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projected Benefits</strong></td>
<td>$0</td>
<td>$245,130</td>
<td>$245,130</td>
<td>$245,130</td>
<td>$245,130</td>
<td>$245,130</td>
<td>$245,130</td>
</tr>
<tr>
<td><strong>Upfront</strong></td>
<td><strong>$76,000</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ongoing</strong></td>
<td>$8,380</td>
<td>$9,300</td>
<td>$9,300</td>
<td>$9,300</td>
<td>$8,380</td>
<td>$9,300</td>
<td>$9,300</td>
</tr>
<tr>
<td><strong>Net Cash Flow</strong></td>
<td>-$76,000</td>
<td>$235,830</td>
<td>$235,830</td>
<td>$235,830</td>
<td>$235,830</td>
<td>$235,830</td>
<td>$235,830</td>
</tr>
<tr>
<td><strong>Discount Rate (K = 10%)</strong></td>
<td>1.0</td>
<td>.91</td>
<td>.83</td>
<td>.73</td>
<td>.68</td>
<td>.62</td>
<td>.56</td>
</tr>
<tr>
<td><strong>Discounted Net Cash Flow</strong></td>
<td>-$76,000</td>
<td>$195,739</td>
<td>$176,873</td>
<td>$160,364</td>
<td>$146,215</td>
<td>$132,065</td>
<td>$120,273</td>
</tr>
</tbody>
</table>

Figure 5. This table summarizes the cash flows and discounted cash flows associated with project costs and benefits.
Drawing data from the previous tables, the benefits of implementing the proposed program on two paper machines are summarized in Figure 5. Likewise, the upfront and ongoing costs are summarized in the same figure. The net cash flow is calculated by subtracting the costs from the benefits for each year. In year zero, the project yields a negative cash flow. This is often the case where start-up costs are required. However, in year one through seven, the project begins to create positive cash flow based upon reducing the failure rate with proactive maintenance and limiting the impact of failure events with predictive maintenance. A time period of seven years was selected because it becomes difficult to forecast accurately the status of the business the larger the planning horizon becomes. However, should these machines continue to operate, the proactive and predictive maintenance will continue to produce benefits indefinitely unless, of course, the value producing proactive and predictive maintenance activities are discontinued. The net cash flow figures for each year are discounted to reflect the time value of money. The discount rate is assigned by the accounting or finance department and usually indicates the inflation-adjusted required rate of return or cost to borrow capital.

Once all the cash flows are estimated and discounted, prepare a summary table identifying the project valuation calculations management uses to evaluate the value of the project and compare it to other opportunities (see Figure 6). For this project, the Net Present Value of the project for two paper machines equals $1,070,134. That means that the project, if selected for implementation will produce more than a million dollars of profit after discounting to adjust for the time value of money. This equates to an Internal Rate of Return of 310%. That means to equal the quality of the proposed investment, the company would have to find a fund or bank paying 310% interest annually on the money invested. Likewise, the project hits black ink after a 4.25 month payback period where, again, the dollars have been adjusted to reflect time.

**Defining Your Assumptions**

It is important that the proposal include a clear definition of the assumptions employed to arrive at the cost and benefit estimates. State assumptions clearly and succinctly. For example:

- Research by SKF, Oklahoma State University and others regarding the impact of particle and moisture contamination on rolling-element bearing life is accurate and applicable to the bearings in XYZ’s paper machines.
- Benchmark comparisons suggesting that oil analysis will reduce the severity of the failure event is accurate.
- The quotations and price estimates to deliver and set-up the elements of the fluid condition control program are accurate.
- Staff development and the best practices manual can be completed at the target price.
- Estimates related to the on-going costs for oil analysis, contamination control and staff training are accurate.

One can also add assumptions related to the organization’s costs of failure, the discount rate applied, or other issues management is sensitive about.

![Figure 6. This summary informs management what your value is worth... in their terminology... costs and benefits.](image-url)
Conclusion
Reliability professionals must begin to adopt a business philosophy to amend the technical philosophies to which we have adhered in the past. For some time we have asked management to take notice of our plans to deliver reliability, and now we are getting our wish. More senior level managers have become involved with and taken interest in reliability in the past two years than the preceding twenty years combined. We must meet them half way. It is incumbent upon the reliability professional to speak the language of management and translate technical programs into business value propositions.

As oil analysis specialists, learning the skills outlined herein will enable you to avoid mistaken dismissal of proposals that might have substantially improved the profitability of your firm. Conversely, they help you determine if your idea is a winner before taking it to management. Either way, the company wins and you win as an oil analysis professional. If you lack these skills, you should begin to develop them yourself, add appropriately trained staff or secure professional services from a consultant who can help you through the process of developing, justifying and implementing your lubrication management and oil analysis program.

References:

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