HOW EFFECTIVE IS YOUR MAINTENANCE STRATEGY?
So you’ve bought into the reliability-based maintenance concept lock, stock, and barrel and have developed a program that includes all of the key elements: planning and scheduling, predictive maintenance, and root-cause failure analysis. But the mountain of cash that all of the leading reliability pundits promised has yet to materialize. Worse, you’re spending more money than when you first started down the road to reliability.

Many organizations, disillusioned by the lack of progress toward their financial targets, end up cutting their fledgling reliability programs and going back to the reactive maintenance model. This ultimately keeps them from reaching best-in-class status in their marketplace. If you find your program in this situation, it might be because you made one crucial mistake: You didn’t follow the money.

Many reliability programs are what I’ll call technology-driven versus money-driven. Reliability leaders focus a great deal of their time and energy searching for the latest breakthrough technology and spend less time crunching numbers. We’ve all been guilty of looking for the “better-built mousetrap.” The problem with this approach is that no matter how technologically advanced the mousetrap is, you still have to place the trap in the right place to catch the mouse. And the mouse in our story is money.

The deck is stacked against the reliability leader, as an ever-growing number of better-built mousetraps are entering the marketplace. An ever-growing army of salespeople is working hard to convince you that their company has the answer to your problem. I’ve got a news flash for you: I have yet to meet an executive who cared one iota about the latest
technology, but all of them seem to care a whole lot about money. So if you want to get the type of support that will make your program successful, show them the money.

Don’t get me wrong; there are certain program elements such as planning and scheduling and full utilization of your CMMS that are foundational to successful reliability programs. The payback for these program elements usually lags the initial investment period by anywhere from several months to years. And you need to invest in these foundational elements to be successful. But many other program elements can give you immediate returns on your investment, bringing much-needed cash (i.e., credibility) to your effort. And you can find these hidden gems by following the money and using what I call a zero-sum maintenance strategy.

The principle of employing a zero-sum maintenance strategy is quite simple. It relies on the reliability leader’s ability to recognize that time and money are limited resources. The most-successful leaders learn to focus on the opportunities that present the greatest potential return on their investment. Understanding the cost in both time and money, calculating the potential return on that investment, and then pursuing only the program elements that promise a reasonably high return will ensure that your efforts generate rather than consume cash.

How to get there? The following principles are a starting point.

1. Learn to do the math.
2. All maintenance tasks should address a specific failure mode. Use the least-expensive and most-effective task to do the job.
3. Start with centrifugal pumps.
4. Use life-cycle cost (LCC) analysis to make decisions.
5. Look at your PM work.
6. Don’t forget activities and initiatives that have little or no maintenance payback.

1. LEARN TO DO THE MATH
First and foremost, teach yourself to always think like an accountant instead of a maintenance professional. This is difficult for most of us; we are hard-wired to solve problems, not crunch numbers. But how many of your decisions actually generate a hard dollar payback? Take your vibration program. Most everyone would agree that a vibration analysis program is essential to any reliability excellence strategy. But ask yourself the following: How much money does your vibration program save? What does it cost to operate? How much equipment should you cover with this technology to maximize the return on investment (ROI)?

I have worked in the corn-milling industry my whole career. A well-known predictive maintenance company developed a benchmark study for the chemical industry that compared profitability with the percentage of equipment covered by a number of the most-widely used predictive maintenance technologies. Early in my career, the company shared with me its study and insinuated that the chemical industry was a good benchmark for the corn wet-milling industry. The service provider recommended that best-practice companies employ first-quartile equipment coverage levels. Figure 1 shows the percentage of equipment coverage levels by quartile for vibration analysis.

<table>
<thead>
<tr>
<th>Cost Performance</th>
<th>% Equipment Covered by Vibration Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Quartile</td>
<td>80.0</td>
</tr>
<tr>
<td>2nd Quartile</td>
<td>68.0</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>45.0</td>
</tr>
<tr>
<td>4th Quartile</td>
<td>17.0</td>
</tr>
</tbody>
</table>

FIGURE 1. Chemical industry benchmark study

I’m not here to suggest the company wasn’t well-intentioned, but its recommended coverage level did not produce the best ROI for our facility. I can’t share our actual coverage percentage, but I can tell you it is significantly below first-quartile levels.

We developed our routes using the following criteria:
- Only include rotating equipment whose failure modes can be readily detected with vibration analysis.
- Use criticality analysis and an understanding of the cost of lost production to establish a threshold for equipment covered.
- Review all equipment that fell below the cutoff. Review the 10-year history of the cost of maintaining the equipment. Estimate the cost reduction that might be realized by covering the equipment with the technology.
- Compare the cost reduction with the cost of adding the machine to the route. If the target ROI is achievable, add the machine to the route.

2. ALL MAINTENANCE TASKS SHOULD ADDRESS A SPECIFIC FAILURE MODE
All maintenance departments have a tribal history. Have you ever asked someone why a task was being performed a certain way and been told “because we’ve always done it that way”? When you start looking at all maintenance tasks and ask yourself which failure modes are being ad-
dressed by completing the task, you’ll be surprised by the inefficiencies that exist.

I encourage you to develop a culture in which all work requests address specific failure modes. This is where reliability-centered maintenance (RCM) can be extremely beneficial. But RCM studies can take a great deal of time to complete, and time is a resource that’s always in short supply.

I have discovered a unique approach that can streamline the process. We use what I call RCM object-type templates. Take a common equipment class, such as centrifugal pumps, and complete a generic failure modes and effects analysis (FMEA) without identifying equipment-specific operating context or failure consequences.

This approach will let you quickly understand the general failure modes associated with the equipment class. Once you understand the failure modes, look at the variety of tasks and technologies that you can use to identify and correct each failure mode. Ask yourself two questions.

- Will the inspection task or technology address the failure mode?
- If so, is it the most cost-effective method at my disposal?

### 3. START WITH CENTRIFUGAL PUMPS

If I had to pick one place to set mousetraps in your facility, I’d set them around your centrifugal pumps. Why start there? Centrifugal pumps are the most common type of equipment found in most facilities; reliability principles for this asset class are well-understood; and many pumps are not designed or installed to best-in-class reliability standards. In addition, the payback for pump improvements is usually two-fold, yielding both energy and maintenance savings.

Review your list of bad-actor pumps. Unless the primary failure modes are related to the material of construction or to mechanical seal fluid film quality or consistency, chances are that the pump is operating far from its best efficiency point (BEP). Many times when this is the case, the potential energy savings will be 2.5 to 3 times greater than the maintenance savings. Do not forget to tap into energy-efficiency rebates; they can be a great source of payback when you complete your pump improvement project.

We use a data-driven approach to determine whether the proposed solution will provide a meaningful return on our investment. Our assessment process is as follows:

- Understand the primary failure mode(s).
- Model the process operating requirements using a system curve rather than a single duty-point approach. You will be surprised how seldom pumps are modeled using a system curve. If you doubt this, ask your local pump supplier.
- Perform a machine assessment, looking for mechanical root causes of the failure. Examples include pipe strain and mechanical looseness resulting from base deterioration.
- If the primary failure mode is related to mechanical seal leaks and the analysis in steps 2 or 3 does not identify the root cause, chances are that the root cause is related to seal fluid film quality, pressure, or fluid film stability. We have found that modifying API Plan 54 arrangements to our best-practice standard or installing a “seal pot” API Plan 53A usually resolves the issue.

Make sure you include the cost of evaporating water for inboard seal leaks or the cost of waste treatment for any water not recycled to a collection tank for outboard seal leaks.

To quickly model system performance, one must know what size impeller is in the pump. When we started our journey toward world-class pump reliability, we didn’t know the answer to this question for the majority of pumps in our plant. Engineering records weren’t always readily available, and process changes weren’t always documented.

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Do nothing</strong></td>
<td><strong>3180 no VFD</strong></td>
<td><strong>3180 with VFD</strong></td>
<td><strong>Recycle line back to tank to keep flow above low continuous flow</strong></td>
</tr>
<tr>
<td><strong>Life cycle cost (NPV)</strong></td>
<td>$302,395</td>
<td>$311,790</td>
<td>$238,466</td>
</tr>
<tr>
<td><strong>Life cycle cost (useful life aggregate)</strong></td>
<td>$615,847</td>
<td>$560,808</td>
<td>$411,570</td>
</tr>
<tr>
<td><strong>Useful life (years)</strong></td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td><strong>Installed cost (total cost of project)</strong></td>
<td>$0</td>
<td>$81,465</td>
<td>$91,333</td>
</tr>
<tr>
<td><strong>Alliant Energy rebate</strong></td>
<td>$0</td>
<td>$9,000</td>
<td>$11,000</td>
</tr>
<tr>
<td><strong>Maintenance costs (NPV)</strong></td>
<td>$59,868</td>
<td>$34,782</td>
<td>$20,148</td>
</tr>
<tr>
<td><strong>Maintenance cost (useful life aggregate)</strong></td>
<td>$119,880</td>
<td>$70,050</td>
<td>$49,045</td>
</tr>
</tbody>
</table>

FIGURE 2. Example LCC analysis spreadsheet
If this is a problem at your facility, I’d suggest that your job plans for pump change-outs where the impeller size is not known include a request for the craftsperson to document and record the impeller size. Include that information in your CMMS. Because we do not stock all impeller trim sizes, choosing instead to stock only full and the most common trim sizes, we include the information as a text line rather than a material code.

4. USE LIFE CYCLE COST (LCC) ANALYSIS TO MAKE DECISIONS

I’ve heard many people talk about LCC analysis, but I don’t believe it’s commonly used for problem-solving/decision-making. It’s not as difficult as many would make it out to be, but it does require discipline. The reason I’ve heard most often for not using LCC analysis is that it’s too difficult to calculate maintenance and operating costs. But if you have modeled your process and you know your annual production capacity requirements and the motor and driven-equipment nameplate efficiency, energy costs will be easy to calculate.

And if you have maintenance strategies and repair histories for like equipment in a similar operating context, maintenance costs can be estimated. To become proficient with this or any other tool, however, you have to use it. As you complete more and more LCC analyses, your estimating techniques will improve.

Figure 2 shows a sample LCC analysis for one of our bad-actor pumps. We completed the analysis and chose Option 3 because it had the lowest total cost of ownership over the course of the pump’s life cycle. You will notice that Option 1 tells us to “do nothing.” As previously stated, we are hard-wired to solve problems, so living with the problem does not feel like a solution to the reliability professional. But if the LCC analysis indicates that doing nothing produces the lowest total cost of ownership and you have the time to manage the problem, I’d recommend that this be your course of action.

The project was completed and the new pump commissioned 27 months ago. I’m happy to report that the maintenance costs since startup for this example have been only $225. Compare this with an average annual maintenance cost of $14,500 for the three-year period before the modification, and you can readily see the cash flow that can be generated by attacking your bad-actor pumps.

5. LOOK AT YOUR PM WORK

PM optimization is another fertile field to look to for cost savings. If you have a preventive maintenance program and you haven’t performed PM optimization (PMO), chances are you have too many PMs. PMs should be used only to address failure modes that are time-based or are hidden from detection without performing the inspection. RCM studies indicate that only 10%–12% of failure modes exhibit these types of failure patterns. As a first cut, you should review existing PMs, and recalling Principle #2, ask the following questions.

- Which failure mode is the PM supposed to prevent?
- Is there a more-efficient task you can use to avoid or address the failure?

Remember, the act of starting and stopping equipment induces failure modes, so use PMs only where condition-based tasks will not do. When we employed our first cut, we were able to eliminate $157,000 worth of PMs without increasing the number of failures.
But this first cut is only the starting point of PMO. PM frequency can be optimized by analyzing the cost avoidance (both production impact and the failure maintenance that occurs between PM intervals) and comparing it with the cost of performing the PM.

Figure 3 illustrates this principle. Plotting the cost of the PM and the cost of the sum of production and failure maintenance cost avoidance will yield the frequency that will produce the lowest total cost of ownership.

6. DO NOT FORGET ACTIVITIES WITH MINOR MAINTENANCE PAYBACK

Finally, do not forget activities that produce good ROI but have little or no favorable impact on the maintenance budget. There are tried-and-true maintenance program elements that, while increasing maintenance costs, produce great returns on time and money invested.

Consider, for instance, an ultrasonic leak detection program for steam traps. The ultrasonic steam trap program hits maintenance budgets twice: First, the maintenance department has to pay for the resource to perform the survey; then it has to pay for the steam traps to be replaced. But although our steam trap program increases maintenance costs, it has a total ROI of between 5:1 and 7:1.

If you want to get better financial results from your reliability program, stop chasing technology and follow the money. Get into the habit of being able to cost-justify each of your program elements. Do not get caught in the pitfall of constantly pursuing a better-built mousetrap. Sound reliability principles have not changed much over the years. Take the time to do the math and understand what the activities you pursue cost in time and money as well as the kind of ROI you stand to gain, and see how many mice (dollars) you end up catching with this bait.  

Phil Beelendorf is maintenance technology senior manager for Roquette America Inc. For more on the philosophy behind zero-sum maintenance strategies and how to use LCC analysis to produce a lower total cost of ownership for your reliability program, contact Beelendorf at phil.beelendorf@roquette.com.

“The most-successful leaders learn to focus on the opportunities that present the greatest potential return on their investment.”
IS YOUR PLANT AT RISK OF FAILURE?

Use this self-assessment tool to rate your facility and spot signs of potential trouble

by Glyn Thorman, Huron Consulting

Difficult economic conditions have plants and their employees shuddering at the thought of downsizings and closures. Production costs, maintenance expenses, foreign competition, and other factors all present concerns.

Is your plant at risk of failure? Have you considered what warning signs may exist that would help you identify potential trouble in the future? If you were aware of these problems, could you address them, or would they simply be a fixed element of your plant’s culture?

Over many years, I’ve worked with plants and mills representing industries ranging from steel to paper. All have had unique operating factors, be they cold weather conditions or food safety imperatives. However, all have had basic similarities. Risk seminars, whether conducted for managers at a refinery, a pharmaceutical site, a paper mill, a bottler, or a military base, would have far more similarities than differences when it comes to basic functioning elements.

Participants would face the same questions: Is safety a concern? Do labor costs trouble you? Have you experienced a decline in vendor product and service quality? Is your workforce aging faster than you can hire replacements? Is equipment reliability low or slipping? These questions exist at virtually every plant or facility, and they have the potential to significantly alter the survivability of a business.

Much like health risks flagged because of genetics, lifestyle habits, or work environments, plant risks also can be identified. I have compiled 25 risk statements describing conditions at some plants I have visited. Each statement doesn’t reflect a guaranteed path to failure, but several existing together can indicate trouble.

Rate Your Facility. Read each statement and rate its level of concern at your site. A statement that is very prominent and true of your plant would be rated a 5, while a statement that does not at all reflect a current condition at your site would be rated 0. Partial agreement would be rated somewhere in between. After you rate all the statements, tally the scores and consider your risk potential based on the scoring guide. (Because many other factors affect the strength of a plant, such as leadership structure or product demand, the results may or may not be conclusive of a plant at risk.)

(0, 1, 2, 3, 4, 5) 1. Your plant is more than 20 years old. Older plants have much inefficiency if they haven’t been continuously updated. This doesn’t mean an older plant is always at risk but rather that it can be. The pendulum can swing either way on plant age, but older plants typically have some inherent risks.

(0, 1, 2, 3, 4, 5) 2. Your plant has in excess of 200 employees. Having more people isn’t bad, but it can force a plant to move more slowly than facilities that can make decisions quickly with a strong consensus. Apathy can enter in as headcount increases, too, if employees think they’re seen as numbers more than names.

(0, 1, 2, 3, 4, 5) 3. Safety is either poor for your plant or poor in general for your industry. It has been said that a good safety program with good results reflects a good plant. If you improve safety, you improve performance. For industries that have poor safety in general, survival risk is low for everyone. Plants are lost to foreign competitors when government regulations demand safety improvements that U.S. plants cannot financially justify.

(0, 1, 2, 3, 4, 5) 4. There are “sister” plant(s) with similar capacities and similar products. Always a difficult subject to discuss, plants need to realize that a sister plant that matches production but at a cheaper cost makes your plant at risk as much as a foreign competitor does.

(0, 1, 2, 3, 4, 5) 5. Your industry is seeing overproduction levels based on market demand. In a buy-and-sell market in which the buyers have control, the sellers had better be under control. Cost, quality and delivery schedules have to be met by your plant, or someone else will meet them. Third- and fourth-quartile plants will fall away if industry overproduction remains an issue.
6. Foreign competitors are beating you in two of the following three categories: selling price, quality, or shipping costs. Many U.S. facilities are protected solely by the oceans. If shipping costs and import duties were not a factor, many plants would be at risk. This applies for the makers of almost any commodity product that has little if any brand preference associated with it.

7. Your organization is in the continuous process industry. This industry relies on 24/7 production. Any production time lost because of reliability issues is lost forever. If you’re in a continuous operation every day, you can’t use weekends to catch up. If you are not prepared to be reliable every day, be prepared to face a competitor that is.

8. Your industry is in steel or other heavy-metal manufacturing. This has little to do with the steel industry’s current competitive issues. Rather, it has to do with the adversarial environment among contractors, union employees, and management witnessed at many of these plants for years. A competitor can walk in the front door – unnoticed as internal battles rage on – and take market share.

9. Union grievances are either very rare or very common. An HR manager at a paper mill once proclaimed to me that he hadn’t had a grievance filed in years. Of course he hadn’t, because his department had conceded to every union demand. Upon review, it became clear to me that the mill would face difficulties resulting from a lack of fortitude by this manager. At the other end of the spectrum is the situation in which grievances are filed daily.

10. Training is minimal (less than 1% of wages) for both hourly and salaried employees. Training is both a learning experience and a reflection of the value a plant places on its employees. If your plant has little or no training, it’s possible that that new methods aren’t being introduced and a competitive edge is being lost.

11. The plant has a high absentee or tardy rate. Plants that see high tardy or absentee rates generally suffer from low employee morale and/or ineffective HR management.

12. One or more employee unions are present. Union employees may receive a fairer wage, better work conditions, and greater benefits, but a plant can be at a risk if there are competitors that operate nonunion plants (foreign or domestic). Union-organized competitor plants, too, can be a threat if they’re able to operate more efficiently.

13. Maintenance overtime is in excess of 20%. Emergency work exceeds 15%. High overtime can indicate an inability to run reliably, thanks to the time and personnel needed to perform emergency repairs.

14. The plant’s maintenance department has more than 30 craftsmen. At some point the communication channel in a plant becomes more fragmented as departments become larger. Repair time can slow even as the number of personnel increases.

15. The maintenance department has no CMMS or an underused one. Successful maintenance managers view a CMMS as a carpenter would a hammer. Plants that lack a good system or fail to use a good system are constantly reacting to disasters rather than focusing on preventing them.

16. Maintenance planners do not exist. Maintenance planners ensure that maintenance work gets done with the right tools and the right resources. Jobs cannot be efficiently accomplished when there is no planning and no planner to perform the work.

17. The preventive and predictive maintenance program is weak or has poor "completion on time" rates. Preventing equipment failure is always more effective than performing repairs. A key element of failure detection and prevention is the timely performance of PM and PdM on targeted high-risk equipment. If your site has not conducted a formal critical-equipment risk analysis, you may be spending your time and money on the wrong focus.

18. 50% of the craftspeople are older than 40. As the workforce ages, new health issues and productivity factors come up. And as older employees retire, many plants allow little transition time for capturing and transferring these workers’ years of knowledge.
19. The maintenance backlog exceeds 8 weeks or is unknown. Small jobs left unfinished become big jobs or evolve into catastrophic failures; it’s the adage of “pay me now or pay me more later.”

20. There is a high reliance on outside contractors to complete routine repairs. Many plants have a significant maintenance department but use outside contractors for much of their work. Use contractors for jobs employees can’t do, not jobs they don’t want to do.

21. There is at least one contractor with a permanent presence on site. Unless there is a corresponding reduction in plant craftsmen, permanent on-site contractors should be viewed with concern. Are they filling in for peak work needs or becoming a base expense?

22. Production staff has minimal ownership of the equipment and believe it’s a maintenance responsibility. At many plants, operators are button-pushers only. When the equipment breaks, they call maintenance and tell them to fix their equipment. The operator has little or no responsibility for machine condition monitoring.

23. The parts in the maintenance inventory have a low or unknown level of accuracy. Repairs can’t be made when the inventory of repair parts is incorrect. Well-run facilities have inventory accuracy of >98%.

24. Few if any parts on site are vendor-consigned. Because vendors are often willing to stock parts on-site at their expense for a greater share of the business, this relationship is of value to most plants. Facilities that do not pursue this simple trend are wasting money.

25. The plant does not calculate OEE (overall equipment efficiency) or does not calculate it correctly (quality % x availability % x full rate of speed % = OEE). No greater measurement exists for plants than knowing how their production equipment is performing.

Total your score:

Scoring key

> 75  You may wish to take corrective actions, such as increasing training or improving a PM program.

25-75  Consider some improvements, especially if your risk appears to be growing.

< 25  You’re in a better position than many, but strive for improved scores in troublesome areas.

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