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Reliability/Asset Management eHandbook



**Proactive Approaches For Improving
Reliability and Maintenance**



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Avoid Bad Turns with Rotating Equipment

Identify damaged and worn components before they cause problems

By Amin Almasi, WorleyParsons Services Pty. Ltd.

VIBRATION-BASED CONDITION monitoring can provide crucial insights about a process plant's rotating machines. Indeed, analysis of vibration data can pinpoint a number of common malfunctions and problems.

Rotors usually are the principal source of vibrations. These vibrations eventually are transmitted to the machine's pedestals, casing and foundation. So, measuring vibrations at their actual source is vital for correct evaluation of equipment health. That's why the generally accepted practice is to utilize two non-contacting displacement transducers installed in an orthogonal XY configuration (usually +45° and -45° from vertical) on or near each radial bearing. Vibration measurements on a machine's casing from velocity pickups or accelerometers just provide indirect information about the vibration source. In addition, it's extremely useful to install axially oriented non-contacting proximity transducers for the rotor assemblies.

Let's now look at how vibration data can identify specific issues, including unbalance, misalignment, loose stationary and rotating parts, and worn bearings (Figure 1).

UNBALANCE

This is the most common malfunction in chemical processing rotating machines. It stems from unequal mass distribution at each section of the rotating assembly. In an unbalanced condition, the rotor's mass centerline doesn't coincide with the axis of rotation. The unbalance represents the first fundamental mechanism to transfer rotational energy into vibration. The unbalance vibration speed equals the rotor assembly rotating speed. The unbalance vibration is a typical sinusoidal waveform. The rotor response depends on both the rotor combined dynamic stiffness (i.e., the effects of stiffness and damping) and the unbalance excitation. Therefore, any changes in the rotor-dynamic response may result from either a change in unbalance or a change in the restraining rotor-dynamic stiffness components (e.g., a shaft crack can reduce rotor stiffness).

MISALIGNMENT

The second most common malfunction is a rotor getting out of alignment. This causes a constant radial



force that pushes the rotor assembly to a side. The same result can occur from a strong radial component of the fluid flow in the rotating machine.

Because of the radial force, the rotor gets displaced from its original position, increasing rotational eccentricity; this is particularly problematic at bearings and seals. The rotor assembly also may become bowed and rotate in a bow configuration. These conditions lead to nonlinear effects, adding higher-order harmonics of vibration components (particularly second-order (2x) harmonics) to the rotor's synchronous component (1x) response. The appearance of 2x harmonics with comparable vibration amplitude to the first harmonic is a good indication of an alignment issue.

Axial measurements additionally may indicate an impending excessive radial load or misalignment problem on a rotating machine.

Continuously acting radial load causes reversal stresses in the rotor. For a high-speed continuously operating machine, the number of the stress reversal cycles may swiftly reach the fatigue limit — and thus prompt rotor cracking and premature failure.

ROTOR RUBBING

Contact between the rotor and the stationary part of a rotating machine is a serious malfunction that could lead to a catastrophic failure. Rubbing usually occurs as a secondary effect of a primary malfunction, such as unbalance, misalignment, fluid-induced dynamic



Figure 1. Missing or out-of-position roller bearings lead to telltale vibrations.



effects or self-excited vibrations. Rub-related failures occur quite often in chemical processing equipment.

A light partial rub at a high rotating speed usually results in fractional sub-synchronous vibrations, along with the synchronous vibration ($1\times$). In a machine with a relatively low rotating speed, the rotor bounces inside the contact point, producing multiple high harmonics in addition to $1\times$.

High radial (normal) and corresponding frictional (tangential) forces at the contacting surfaces during a rotor rub could lead to extremely severe damage of the seal and rotor surfaces in a very short time. In addition, the rotor operates under severe alternating stress with relatively high frequency.

Rotor-to-stationary-element rubbing actually is a very harmonic-rich vibration phenomenon, resulting in rapidly changing system parameters with a tendency for chaotic motions. The diagnosis of rotor rubbing from vibration data is based on the appearance of: 1) sub-synchronous fractional components (particularly $\frac{1}{2}\times$); 2) relatively high harmonics ($2\times$ and $3\times$); and 3) changes in shaft centerline position.

FLUID-INDUCED INSTABILITIES

Rotating shafts generally operate in a fluid environment. An interaction between the rotor and the surrounding fluid becomes significant if the clearances between rotating and stationary parts are small and rotation is eccentric. Because of friction between fluid and machine components, the shaft rotation generates a circumferential fluid flow. This, in turn, produces a dynamic effect on the rotating machine parts. Such situations occur in lightly loaded fluid-lubricated bearings, seals, balance pistons, stator/blade tip clearances, rotor/stator peripheries, and rotors filled with fluids such as those in centrifugal pumps and compressors. Dynamic effects of rotor/fluid interaction are

known as “fluid whirl” or “fluid whip” rotor self-excited vibrations.

The whirl frequency is generated purely by the fluid interaction and is related to the fluid film radial damping. The fluid involved in the circumferential motion transfers energy from rotation to lateral vibration. For well-balanced rotors, the whirl vibrations are quite persistent. At the beginning of a fluid whirl, the rotor vibrates as a rigid body.

When the rotating speed approaches the transfer speed (i.e., rotating speed \times first critical speed/whirl speed), the rotor self-excited whirl vibrations get smoothly transformed into fluid whip, with a frequency asymptotically approaching the rotor high-eccentricity first critical frequency (i.e., the first critical frequency slightly modified by high-eccentricity nonlinearities). The fluid whip is usually persistent. At certain rotating speeds, however, it may disappear and then reappear again. Instabilities may cease and recur.

The main cause of the whirl/whip vibrations is the fully developed circumferential fluid flow. Reducing the circumferential-flow-related tangential force strength will make the rotor more stable. This may be accomplished either by moving the shaft to the higher eccentricities by applying a “friendly” external radial load force to the rotor, or by modifying the fluid flow pattern. Appropriately loaded noncircular bearings, bearings with lobes and grooves, and, particularly, bearings with tilting pads fulfill both objectives. Nowadays, tilting-pad bearings are very common in high-speed rotating machines. Seals with swirl brakes and anti-swirl injections achieve the goal of circumferential flow reduction, resulting in stable rotor operation. The shaft rotation at a higher eccentricity not only can reduce circumferential velocity ratio, but also may raise the fluid film’s radial damping and stiffness, which are beneficial for shaft stability. Increasing the fluid pressure also can provide greater



fluid radial stiffness. Some reports indicate externally pressurized bearings offer good stability features, but others point to operational problems and dynamic issues for some pressurized bearings. So, approach the use of such bearings with great care.

Diagnosing fluid whirl/whip vibrations may be relatively easy, particularly when transient startup or shutdown vibration data are available. However, identifying the actual cause of the instability is more difficult, especially when only the whip vibrations are present.

Because of the bearing/fluid interactions, the fluid whirl vibrations have frequencies slightly lower than $\frac{1}{2}\times$ (for most bearings, whirl speeds usually range from 0.38 to 0.47 of the rotor speed). The fluid seal or stator/blade tip whirl vibrations may exhibit quite different vibration behavior and frequencies. This is especially true when the seals are equipped with swirl brakes or anti-swirl injections as well as when there's a significant level of fluid recirculation, as often happens in process pumps and compressors. The whirl vibrations even may exhibit frequencies higher than the rotating frequency ($1\times$).

LOOSE PART

Looseness between the rotor supporting pedestal and the foundation (for example, due to a loose bolt) is a common malfunction. The unbalanced force carried by the rotor occasionally may exceed the gravity force (or other forces) applied to the machine. This can cause a periodic lifting of the pedestal, resulting in a reduction in system stiffness, its cyclic variability and impacting. As a result, the rotor may exhibit changes in synchronous responses, and fractional sub-synchronous vibrations (most commonly $\frac{1}{2}\times$) may appear. The diagnosis of pedestal looseness (particularly foundation bolt looseness) usually is based on the appearance of $\frac{1}{2}\times$ vibrations and visual inspection of the bearing, pedestal and foundation fastenings.

Looseness in rotating elements such as disks or thrust collars mounted on rotating shafts (or bearings untightened in bearing pedestals) represents another type of malfunction. A disconnected disk or a thrust collar still may rotate but at a different speed than that of the machine's shaft. A loose bearing may start rotating (dragged into motion by the rotating shaft) or may stop suddenly. The clearances, friction conditions between the shaft and the loose part, and the tangential external force applied to the part (such as the external fluid dynamic drag) play important roles in the rotor-dynamic response. A loose rotating part usually carries an unbalance that changes the balance state of the rotating machine. This results in a modification of the synchronous vibrations ($1\times$) and also appearance of the loose-part unbalance-related vibration components.

The loose part rotating frequency usually is a function of the shaft/loose part clearance, the surface friction, and the tangential drag coefficient. Depending on the particular machine, the latter can make the loose part spin faster or slower than the rotor rotating frequency. In both situations, friction and fluid drag act in opposite directions. At steady-state conditions, the two may balance each other, giving a constant loose-part rotating frequency. If loose part speed doesn't differ very much from the rotor rotating speed, the resulting vibrations exhibit the characteristic pattern of a beat. Most often, however, the looseness of a rotating part leads to transient conditions.

BEARING PROBLEMS

Hydrodynamic and rolling-element bearings used in rotating machines feature a small bearing clearance that's appropriate for normal operation of the rotor. Poorly lubricated or worn bearing surfaces inevitably increase the clearance — and thus decrease system stiffness. Excessive bearing clearance can cause variable bearing-system stiffness, thereby providing



nonlinear conditions for unbalance-related excitation that may lead to rotor instability.

The physical phenomena occurring in the worn (or oversize) bearing system resemble a mirror image of those during rotor-to-stator rubbing. In rubbing, during a cycle of vibration the system becomes periodically stiffer, which can lead to an increase in the average stiffness. In the worn (or oversize) bearing system, the average stiffness decreases. The rubbing occurrences are described as “normal-tight” situations, while the worn (oversize) bearing is “normal-loose.” In both situations, two other physical phenomena, namely friction and impacting, are involved. However, their role and strength differ in each specific case. Distinguishing a worn (or oversize) bearing malfunction from rubbing requires careful study of the recorded vibration of the rotor.

During rubbing, there’s a high rotor lateral excursion from the rubbing spot and, therefore, more impacting; unsteady transient motion occurs. Within a worn (or oversize) bearing, the journal remains close to the bearing surface, even when the contact is broken. The consecutive contacts don’t produce relatively high power impacts. There are far fewer transient components and weaker high harmonics in the vibration spectrum of a worn bearing compared to the rub cases.

SUCCESS STORIES

Let’s now look at three process-plant case studies that show the value of vibration data in diagnosing malfunctions.

One site relies on a large, ≈ 14 -MW, $\approx 3,600$ -rpm compressor. Vibration values (peak-to-peak) of 36μ , 5μ and 12μ were observed at $1\times$, $1.5\times$, and $2\times$, respectively. There also was considerable $\frac{1}{2}\times$ sub-synchronous vibration (31μ , peak-to-peak). Detailed study of the vibration data showed the strong $\frac{1}{2}\times$ sub-synchronous vibration came from light rubbing of the rotating assembly of this compressor train. Inspection of the machine confirmed this rubbing.

Another plant was concerned about a compressor train with an electric-motor-driven rotor supported by oil-lubricated bearings that ran at $\approx 6,000$ rpm. Observed main vibration elements (peak-to-peak) were $\approx 41 \mu$ at $\approx 0.4\times$ of the rotating speed and $\approx 34 \mu$ at $1\times$. The high $\approx 0.4\times$ value indicated a bearing whirl problem. So, the plant installed modern tilting-pad bearings in the compressor train to solve the problem.

The third facility operates a medium-size, 11-MW, $\approx 4,000$ -rpm compressor train. Recorded main vibration amplitude components (peak-to-peak) were 41μ at $\frac{1}{3}\times$, 47μ at $\frac{1}{2}\times$, 52μ at $1\times$, 15μ at $1.5\times$, 16μ at $2\times$, and 13μ at $3\times$. The $\frac{1}{2}\times$ and $\frac{1}{3}\times$ sub-synchronous vibrations, plus the rich spectrum of higher harmonics (particularly $2\times$), pointed to a loose pedestal connection. A careful site inspection showed loose foundation bolts. The plant repaired the foundation and regouted the train. ●

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How to reduce risk and costs with advanced reliability management: *Key steps for leveraging limited resources and critical assets*



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Backflush Away Fouling

Flow reversal can remove fiber buildup in heat exchangers

By Andrew Sloley, Contributing Editor

FOULING SERVICES present difficult challenges for heat exchangers. Fouling can result from reactions, sticky materials, solidification and many other causes. In biofuels plants, fibers often lead to fouling problems. Backflush operation can reduce the effect of fouling in these plants.

There are two approaches to backflush. In a short-period backflush, which can last from a few minutes to a few hours, flow direction is reversed to dislodge fibers; then, the regular flow pattern is re-established. In a long-period backflush, which can extend for days to months, the exchanger is operated with flow in the reverse direction until it fouls again; then, flow is switched back to the normal direction to dislodge the second round of fiber fouling.

A plate-and-frame exchanger in a new biofuels plant required a short-period backflush to reduce the maintenance load in cleaning the plates. Figure 1 shows the backflush configuration on one

side of the unit; the other side has a comparable setup.

The backflush procedure consists of four steps:

1. Open the supply bypass around the exchanger. At this point, the fouling fluid completely bypasses the exchanger.
2. Open the exit bypass around the exchanger. This allows the fouling fluid to go through both bypasses.
3. Close the normal flow line exit side valve. The fouling fluid still bypasses the exchanger.
4. Close the normal flow line supply-side valve. Now the flow is reversed and backflush begins.

At no time is the exchanger blocked in. This is important. A blocked-in side might fail from thermal expansion or vaporization (depending upon temperature profiles). Never allowing a side to be blocked in prevents many problems.

A successful bypass here also requires attention to other details.

Because the bypass lines may lack flow for extended periods, valves are located at high points to help reduce the possibility of solids' accumulation. Additional modifications to handle the solids include installing full-bore flush valves as close as possible upstream and downstream to all block valves. The flush valves are mounted on the top of the lines to prevent solids' accumulation. (Water can flush any plugs out of the lines.)

Thermal relief valves also are necessary to prevent exchanger rupture due to accidental closing of isolation valves and fire exposure contingency.

Under some conditions, fouling may be so severe that the backflush doesn't work effectively. So, the layout must allow for quick swapping out of an exchanger. The bypass lines enable either running without an exchanger installed for a short period or a quick switch to a spare unit.

One initial concern was unit control stability when removing the exchanger from service. The process requires operation at a specific temperature. The heat-integration system can handle one out-of-service exchanger at a steady-state condition. However, dynamic response when removing the exchanger is a different matter. Some questions arose about how stable the entire system would be under the backflush conditions.

In this case, backflush only occurs when heat transfer is so low that removing the exchanger incurs negligible loss of duty. A more serious concern is process response once the exchanger is suddenly much cleaner — but experience in this system shows no problems.

The backflush installation works well for this service. Economics were reasonable despite the number of valves and the amount of piping involved. The backflush keeps the exchangers cleaner at relatively little maintenance cost. Taking the exchanger apart for mechanical cleaning would be much more expensive.

Consider backflush particularly for removal of fibrous or easily dislodged material. It provides little benefit for sticky fouling or polymer deposits. ●

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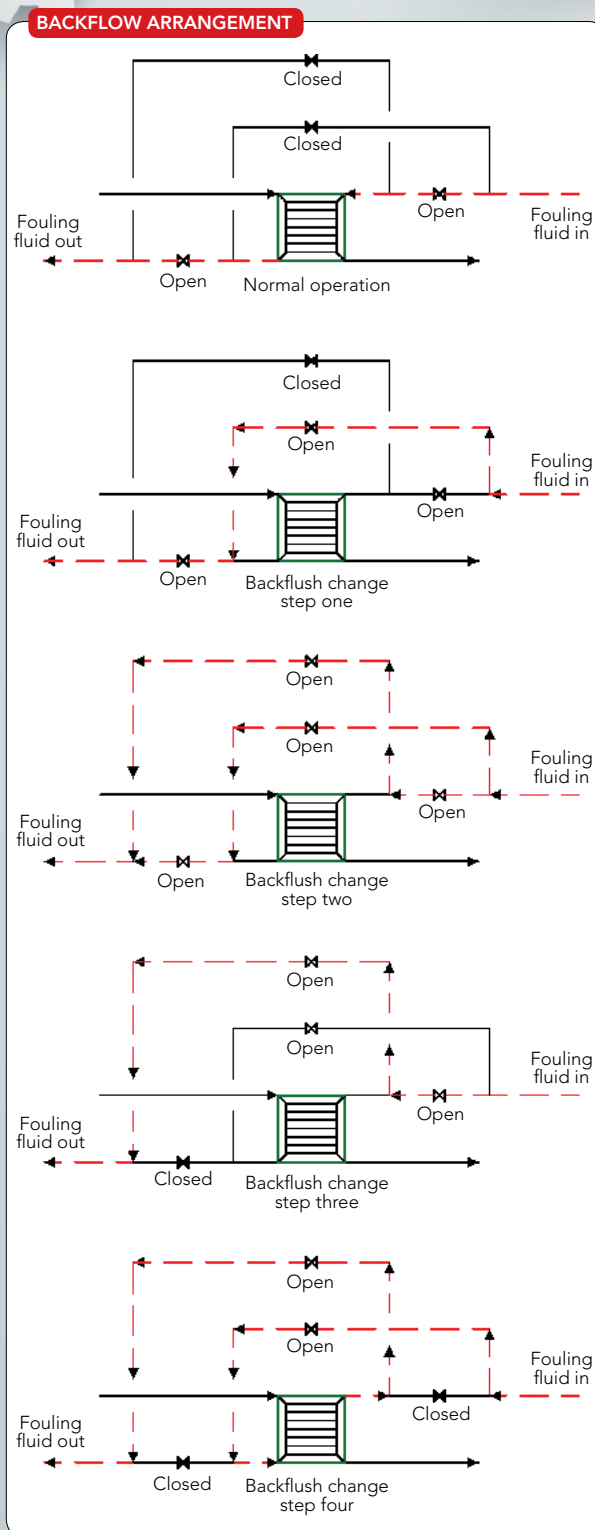


Figure 1. Four-step procedure and design details ensure a safe and effective backflush.

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Reduce Risk and Costs with Advanced Reliability Management

Use these key steps for leveraging limited resources and critical assets

RELIABILITY PROGRAMS are now standard business practice in companies that rely heavily on machines, equipment and other physical assets. But, in today's lean economy, companies have fewer resources than ever to manage and maintain these assets. They face challenges in identifying new and cost-effective ways to ensure their assets are performing and that they are managing to minimize operational risks.

Recognizing the challenge of balancing limited resources with prioritized risks, top companies in manufacturing, energy, transportation, healthcare and other asset-intensive sectors are now beginning to adopt advanced reliability solutions based on enterprise asset management (EAM) software. These companies are identifying intelligent ways to address:

- Excessive asset maintenance costs.
- Excessive asset performance risks.
- Suboptimum energy usage.
- Inadequate management of reliability, quality and safety.

Leading performers of reliability-centered maintenance (RCM) are adopting new approaches so that they can intelligently match limited resources with

critical priorities. They are rightsizing maintenance rather than bluntly downsizing it.

With advanced reliability solutions, organizations can cost-effectively ensure the high performance of their assets, a key factor in their ability to meet customer expectations and continue driving growth.

In this white paper, you'll learn about:

- Trends that are driving new thinking in reliability-centered maintenance.
- Challenges that companies are now facing in the absence of new solutions.
- Key dimensions and benefits of advanced reliability solutions.
- How companies are generating results with advanced reliability solutions.
- Criteria that companies are using to assess advanced reliability solutions.

While contemplating the costs and risks associated with properly managing and maintaining your enterprise assets, you'll want to know the tools and best practices to apply to meet your reliability objectives. This paper provides guidance based on current market events.



MARKET DRIVERS AND TRENDS

RCM is about ensuring that assets perform according to their intended functions without failure for specific periods, and under stated conditions. The approach, originally adopted by major airlines, came into wide usage in the 1960s and 1970s, with the work of several authors on the subject.¹

RCM revolutionized the managerial discipline of physical asset management by driving down defect rates and driving up quality levels. It provided a framework for asset maintenance and management, capital maintenance planning, risk management, and compliance with policies and regulations.

But asset management has become increasingly challenging in recent years. Today, companies find themselves struggling to manage and maintain their assets in ways that were viable in a stronger economy and a less competitive marketplace.

Quite simply, companies have fewer resources to manage and maintain their assets than they would have had in years past. Furthermore, equipment often becomes more complex and expensive to maintain. Corporate leaders are restraining (or reducing) budgets and demanding new efficiencies. This isn't merely a cyclical phenomenon, but more likely a pattern that will become the new normal. Managers responsible for assets must accomplish more with less.

Given this pattern, asset lifecycles are longer than ever. Companies are unwilling to replace machines in the same timeframes that they might have replaced them in the past. Instead, they are demanding that these assets be maintained and leveraged for longer periods. Researchers find that top-performing companies achieve significantly better results by implementing risk mitigation strategies that set them apart from laggards.

According to Aberdeen Group, best-in-class companies are:

- Three times as likely as laggards to establish standardized controls to reduce the impact of risks.
- Four times as likely as laggards to invest in risk management technology to automate the identification, quantification and prioritization of risk.
- Six times as likely as laggards to implement a condition-based maintenance approach to

monitor asset conditions in real time and establish controls to mitigate the risk of asset failure.

“The challenge facing asset-intensive industry today is to understand how to leverage existing technology investments and advanced asset management capabilities to effectively manage risk across the enterprise,” states Aberdeen.²

THE CURRENT STATE: MISALIGNMENT IN THE ENTERPRISE

Against the backdrop of constrained budgets and aging infrastructure, asset managers face a number of key challenges. To continue to perform effectively in today's demanding economy, they need to determine how to surmount them. Challenges they confront include:

Excessive asset maintenance costs. The most significant problem that asset managers face is a tendency to overspend on maintenance activities because of inadequate awareness of true maintenance requirements. Without visibility into asset priorities, asset condition, and the risk profile of assets, it's easy to misallocate limited maintenance resources. It's easy, for instance, to upgrade machines that are operating perfectly well and are unlikely to fail — even machines that represent no significant risk to overall operations.

Excessive asset performance risks. Risks tend to accumulate when companies have under-invested in certain asset maintenance activities or have failed to acknowledge their importance. This can happen when companies slash maintenance spending without appropriate insight into their asset-related risks and priorities. They might find themselves unable to meet a customer's order, for instance, because a failed machine was inadequately tracked and maintained.

Suboptimum energy usage. One key factor in asset management and maintenance is energy usage. Both high- and low-energy usage can be indicators of low-performing assets — a signal that equipment maintenance or replacement is required. Moreover, excessive energy usage can lead to excessive energy costs, an issue that requires continuous monitoring.

Insufficient management of reliability, quality, and safety. Considering the constraints on today's



organizational budgets, asset management investments must be closely aligned with the priorities of the enterprise. It's difficult — if not impossible — for companies to meet defined policies and performance levels if they can't adequately match available resources with prioritized needs. They will see levels of reliability, quality, and safety fall below their own expectations, and possibly the demands of customers and regulators. They become vulnerable because they cannot consistently meet expectations on key metrics that matter to their operations and reputations.

At this point, many organizations remain misaligned in terms of asset management needs and budgets. They lack the insight and visibility necessary to identify and meet their priorities in a cost-effective way. They lack enterprise asset management systems that are actionable and easy to use. Indeed, they lack a clear path to superior reliability and asset performance.

OPTIMIZING WITH ADVANCED RELIABILITY SOLUTIONS

To overcome current challenges associated with asset maintenance, a growing number of companies are adopting advanced reliability solutions. These solutions allow them to intelligently invest in EAM capabilities that give them deep visibility into their assets, allow them to plan and prioritize for maintenance more effectively, and help them avoid the tendency to overspend or underspend on maintenance activities.

Built on a foundation of best-in-class EAM, advanced reliability solutions allow you to execute an array of maintenance strategies based on prioritized objectives, cost concerns and existing risks. You can define the risk profile of your assets to determine the best way to manage them. Mission-critical assets, for instance, might receive high levels of attention and preventative maintenance. By contrast, non-critical assets might see less management rigor and frequency. Many variables such as the age, usage and condition of the asset can be factored into these decisions.

Advanced reliability solutions now include multiple EAM capabilities:

Risk profile management. It's critical to understand the risk profile of assets. Using advanced systems, users can understand the role that assets plays in supporting the business, moving beyond reactive maintenance or calendar-based maintenance to predictive and priority-driven maintenance. Assets can get the attention appropriate to their actual condition and their existing or potential level of impact.

Asset-based analytics. Analytical tools provide visibility, insight and perspective to drive smart decisions on maintenance investments. Statistical analysis models can help you assign probabilities and identify risks. Users can track asset failure history, failure probabilities, and other factors that can support maintenance budgeting, planning and execution.

Management by exception. Reliability programs can generate a great deal of data, much of which is difficult to manage and interpret. Advanced solutions provide a layer of intelligence that can help you analyze and identify patterns with greater ease. This allows decision makers drive action based on anomalies and recognize when there's a high probability of equipment failure. Most importantly, plant personnel won't need a high degree of expertise to interpret the data once these capabilities are configured and implemented.

Consumer-grade usability. There's no benefit to having advanced capabilities if they're inaccessible to users. Truly advanced solutions address this challenge by providing a consumer-grade experience, simplifying and streamlining usage of the EAM system to enhance reliability programs. Whether users are in the office or in the field with wireless tools, EAM software should work the way employees do, matching the specific context of the business.

Embedded training. Considering that managers and workers are prone to change, it's important that the knowledge and skills associated with asset management and maintenance be easy to acquire and apply. Embedded training eliminates the need to continually retrain people to achieve high performance.



By recognizing priorities, increasing asset visibility, analyzing patterns and responding with greater agility, companies are now discovering they can accomplish far more with their existing asset maintenance budgets. They can reduce costs even as they reduce their risks. They can perform at higher levels of reliability, quality and safety without requiring more resources. Ultimately, they can meet the challenges they're experiencing in an increasingly cost-conscious, yet risk-prone environment.

Advanced reliability solutions can provide several key benefits. Users can:

Reduce costs. Avoid overspending on either unnecessary or low-priority maintenance tasks to reduce maintenance costs. Users can also reduce costs associated with excessive energy usage, a key indicator of necessary asset maintenance.

Reduce risks. The system can identify and track high-priority assets, to help manage risks in a superior fashion, whether these vulnerabilities are regulatory, operational or reputational.

Meet performance objectives. Whether the objectives are tied to uptime, downtime, quality, safety or some mix, it's essential to find a cost-effective way to meet them. Through advanced reliability solutions, the analytical and operational tools ensure users are fully leveraging and maintaining assets.

Align maintenance with the business. Spending must match the priorities of the enterprise. It's not just about maintaining equipment, but about right-sizing maintenance so limited budgets are invested in the most appropriate ways.

Clearly, the bar is rising with regard to expectations for asset management and maintenance. An advanced reliability solution can help meet or exceed those expectations.

CASE IN POINT: HEINZ FROZEN FOOD CO

When Heinz Frozen Food Co. set its sights on improving its manufacturing and maintenance process efficiency with leading-edge technology, the company knew that implementation of a new system would require a monumental change in culture for its employees.

Located in Pocatello, Idaho, Heinz Frozen Food Co. is a division of H.J. Heinz Co. LLP. Sharing the corporate Heinz passion for serving up good food, the frozen food division strives to provide delicious and nutritious products that consumers can easily make at home.

After careful analysis of several competitive applications, Heinz chose an EAM application by Infor for several reasons. Milton Slagowski, maintenance manager at Heinz Frozen Food Co., explains, "It was not only a web-based enterprise system that met all of our maintenance function needs, but, more importantly, it was the most cost-effective solution." As manufacturing and maintenance employees began using Infor EAM after implementation, the company gained better visibility into its processes and realized that more progressive Lean manufacturing and maintenance practices would enable more significant efficiency improvements.

Heinz began incorporating Lean manufacturing and maintenance practices that brought improved results in a short time. "We started to identify maintenance waste elements—those that didn't add value—and to use Infor EAM as it was meant to be used: in concert with Lean manufacturing and lean maintenance," says Slagowski. "And we started to understand change enablers such as awareness of what needs to change, understanding of our goals and objectives, and engagement by everyone from top management to those performing the tasks."

Once all of the change enablers aligned to achieve the targeted results, the company began realizing efficiency improvements. "What we learned was that Lean practices are instrumental in implementing an EAM application to achieve excellent results quickly and cost-effectively," Slagowski says, "and that asset reliability is a key tool for successful Lean manufacturing operations. They have a mutual relationship. And Infor helped us understand the process to achieve our goals and get consistent results."

SEEING RESULTS

Through Infor EAM built-in configurability, Heinz was able to continuously adapt the system and



incorporate lean maintenance processes in a timely and cost-effective manner. As Heinz began removing common maintenance waste from the process, it began an integrated approach to designing and improving manufacturing and maintenance work toward the ideal internal customer-focused state. “As a tactical approach, we looked for everyone’s input with an emphasis on quality and safety the first time, and incorporated lean practices as a comprehensive business strategy,” says Slagowski. “We saw lean maintenance as the way to preserve assets in good operating condition and improve reliability in both the short term and the long term.”

The primary lean tools that the company adopted were Infor EAM, maintenance planning preventive maintenance, total productive maintenance, reliability-centered maintenance and reliability engineering to eliminate failures. Other lean tools it used were 5S, to keep things in order; 5 Whys, to ensure ease of use; Kanban, to provide a visual representation of progress in the work cycle; Hansei, to enable reflection upon errors and correction of them; Genshi Genbushu, to allow seeing the work to spark ideas on how to improve; and Kaizen, to review four-hour progressive manufacturing tasks to eliminate waste. Slagowski notes, “We used Infor EAM features such as KPI [key performance indicator] inboxes and reports to see our hours worked per month, rework hours, overdue PMs, and planned-hour ratios. Then we tweaked our processes to achieve our efficiency goals.

“Reactive maintenance amounts to tremendous waste, whereas planned maintenance enables 30% more actual work to be completed. Using Infor EAM and lean practices, we can verify that working out a maintenance plan ahead of time saves three to five times the total time invested.”

Additional and unnecessary maintenance time also translates to astronomical cost increases. Adds Slagowski, “Reactive maintenance costs \$400 per hour, and corrective action costs \$200 per hour. But with planned maintenance in which we incorporate lean practices with Infor EAM, the cost is only \$75 per hour. Infor EAM Enterprise is designed to enable changes that will upgrade with new releases, saving IT costs.”

New maintenance practices that resulted in culture changes at Heinz proved positive in many ways. “Our maintenance planners now interact with our maintenance-performing professionals,” says Slagowski. “Together we’ve documented and sustained best practices and gained employee involvement and communication with the aim to help each other reach common goals. We all feel like we have a vested interest. These are all important ingredients to sustaining success in any operation.”

Heinz has claimed considerable gains in process efficiency. “Following our use of Infor EAM and lean practices, we’ve realized 10% to 11% efficiency improvements, and our maintenance costs have dropped by 5% to 10%,” notes Slagowski. “Efficiency has grown in various areas, such as work done by technicians who don’t need to hunt for parts because they’re kitted, and in maintenance stores and production. We’ve also reached world-class levels of maintenance inventory management: 1% of estimated replacement value.”

On its journey to optimally streamline its manufacturing and maintenance processes toward its production-focused ideal state, Heinz embraces continuous improvement. “Time invested in planning with EAM, lean maintenance practices, and a focus on continuous improvement more than pays for itself. We had to adapt our operations and systems to reach our short- and long-term goals, and Infor EAM’s agility and built-in best practices guided us in the process. We now get optimum life out of our profit-making and profit-supporting assets.”

DECISION CRITERIA FOR INVESTING IN SOLUTIONS

Companies that have adopted advanced reliability solutions generally have used several decision criteria to determine whether a particular solution is appropriate and can address their key objectives. Among those criteria:

Enhanced visibility. Look for solutions that provide deep and actionable insight into enterprise assets. The solution should help prioritize and manage assets based on level of risk and impact.

Ease of use. The solution should conquer complexity, so that people can manage and maintain



assets in a superior way without having extensive analytical or technical expertise. It should be easy to use EAM tools in the office and the field.

Application consolidation. The solution shouldn't simply be bolted on to an existing ERP system. That will only add cost and complexity, undermining objectives. Look for a solution that is or can be easily embedded in an enterprise asset management system, particularly if you've already invested in EAM. You should have a single, unified solution — one version of the truth in one database.

Collaborative intelligence. Expect a solution to facilitate collaboration across functional, departmental and enterprise boundaries. Users should be able to track assets beyond the immediate business footprint and back into the supply chain, ensuring, for instance, that parts are available when needed.

Management by exception. Users need to automate the analysis of high data volumes, and make it actionable through routine reporting and exception-based alerts. These capabilities reduce the need for analytical experts to understand and act on data.

Energy as an indicator. Look for a solution that treats energy as an integral component of analysis. Given that energy usage is often a leading indicator of potential breakdown, failure or other maintenance requirements, it's critical that energy consumption monitoring and analysis be a key dimension of any reliability solution.

Drawing on decision criteria such as these, companies with asset-intensive businesses have identified advanced reliability solutions that help them optimize their investments in asset management and maintenance. They achieve greater reliability while managing their costs and risks in

superior ways. They reach their key performance objectives, even in a continuing era of lean and demanding budgets.

DOING MORE WITH LESS

Companies today are managing their assets with fewer resources. To cost-effectively minimize operational risks and ensure optimum asset performance, top-performing organizations are adopting advanced reliability solutions based on EAM software. They are rightsizing their maintenance systems, identifying intelligent ways to minimize asset maintenance costs, performance risks, and energy usage, while ensuring maximum reliability, quality and safety.

Successful organizations are choosing easy-to-use, single, unified solutions that provide actionable insight into assets to help prioritize assets based on risk level and business impact. These solutions facilitate collaboration across the enterprise and into the supply chain, and provide exception-based alerts when assets are performing outside optimum conditions. Moreover, the solutions integrate energy use in analyzing asset data, since higher energy use and resulting higher cost are leading indicators of potential asset failures.

Using advanced reliability solutions, organizations can ensure that their assets maintain high performance at the lowest cost, meet customer needs and drive growth. ●

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Add Value to a Predictive Maintenance Partnership

Detailed analysis of maintenance records can further improve equipment reliability

By John Pucillo, Director of Product Development, Predictive Service

IF A manufacturing or processing business is to be successful, the reliability of the equipment it depends upon mustn't be taken for granted. A failure of just one machine integral to a production process can result in significant losses in repair costs, downtime and throughput, thus it's crucial for operators to take steps to foresee breakdowns or inefficiencies whenever possible. For this reason, many companies have turned to predictive maintenance (PdM) partners to detect potential issues and determine solutions before emergency situations ever occur, allowing for more effective planning.

Specialists such as Predictive Service use special measuring devices to analyze the health and functionality of every component of a specific piece of critical machinery, giving early warning of pending failure and providing long-term assessment of equipment conditions to help customers plan for maintenance and avoid downtime during normal production hours. Equipment is analyzed using methods such as vibration analysis, infrared inspection, oil analysis and sensory inspections to determine what risk factors exist for that specific unit. For example, analysis could reveal flaws are developing in a rolling element bearing that will eventually fail; a PdM service will then notify the equipment owner to allow for repairs or replacement to be scheduled when convenient, not during an emergency.

Beyond offering savings by greatly reducing the likelihood of in-service equipment failure, PdM is helpful in avoiding unnecessary costs related to premature maintenance on functional machinery. Determining when maintenance is truly needed based on the condition of equipment instead of adhering to a generic, calendar-based maintenance program, helps

prevent machine downtime and minimizes service costs. Additionally, servicing a piece of equipment only when necessary reduces the likelihood of issues occurring as a result of human error during service-related interactions with machinery.

Predictive maintenance can help companies avoid costly problems with their equipment, but it often results in a temporary solution to a problem. The PdM process can be cyclical if potential issues are only identified and fixed for the moment. Sometimes the root cause of the equipment problem isn't addressed as part of the PdM process, resulting in future redundant issues. While a substantial amount of money is still being saved through the PdM engagements compared to when equipment failure actually occurs, there's still opportunity for more extensive savings if root causes of problems are investigated and long-term solutions are implemented based on well-supported findings.

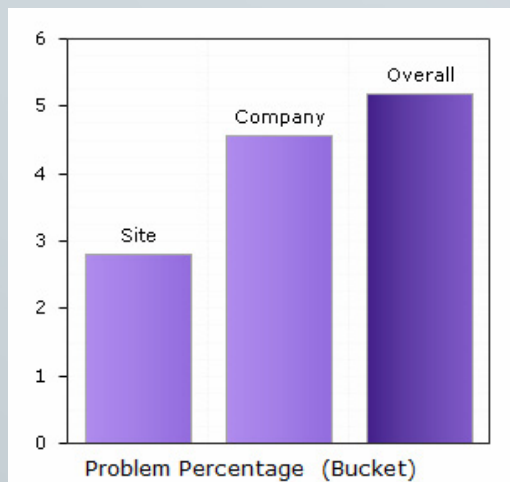


Figure 1. Percent problems found provide a benchmark for equipment classes.



THE NEXT STEP: INCREASING RELIABILITY

It's here that the idea of reliability analysis and subsequent consulting comes into play. Every time a PdM company analyzes equipment, they have an opportunity to record what risk factors were detected, how often, and how expediently problems must be addressed based on potential severity. By tracking historical data for every piece of equipment analyzed, it becomes possible to determine trends in the equipment's behavior and strategize to address recurring problems as a result.

For instance, if a belt drive used to turn a part within a machine is a cause of increased vibration levels, a predictive service company using vibration analysis techniques might be able to isolate the problem and determine the recommended corrective action. If this finding is recorded reliably within a database (see Figure 2), it becomes possible to look back at the history of the machine and determine whether there are repeat issues with belts, or whether it's simply one of a variety of issues experienced over time with that unit. If it's determined there's a history of belt issues across all machines, an opportunity presents itself to go beyond simply suggesting replacement of the belt — the PdM company can choose also to ask the obvious question: "Why?"

At this point, a company can move beyond simply providing PdM services and become a true reliability

partner. No longer concerned with dealing in the "here and now" and only identifying potential issues, a reliability partner looks to the future by consulting recorded data and positing why failures or potential failures are happening. The service provider can then collaborate with the customer to determine what steps can be taken to avoid the need for maintenance and parts replacement in the future.

Consider the case of the belt drive. If a PdM provider has discovered that several times in the past belts have worn out quickly and failed, they can take their research a step further, asking, "Is this belt lasting as long as it should be according to the manufacturer? If not, is another factor causing failure?" It's frequently the case that faulty parts aren't responsible for creating risks; A human element is often to blame. In the case of the belt drive, belts generally require proper tension and alignment to be effective — something easily thrown off by improper installation, training or tools — not poor equipment design. If this is found to be the case, steps could be taken to alter procedures or retrain employees on proper techniques or ways to add precision, ultimately diminishing the need to replace the belts and, in turn, diminishing the amount of money lost in relation to the purchase of new parts and machinery downtime. In the end, the unit's reliability is improved long term.

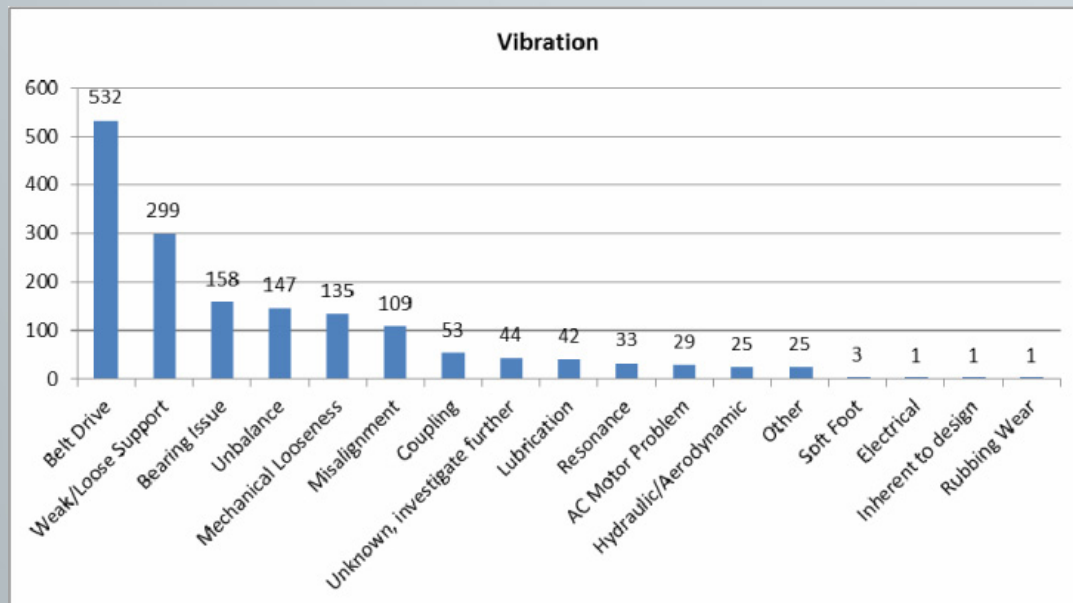


Figure 2. Data from a vibration analysis program recorded over three years reveals trends in equipment failure.



PREDICTIVE MAINTENANCE & RELIABILITY ANALYSIS: A RECIPE FOR SAVINGS

There's substantial savings inherent to PdM. Keeping strong records helps deliver cost justification to PdM customers, and can help to calculate ROI. According to the data gathered from thousands of PdM events, the cost of recommended repairs is a mere fraction of the millions of dollars that would have been lost by customers as a result of lost production value during downtime or equipment replacement due to failure. In fact, these repair costs can even be challenged by the energy wasted due to inefficient or failing equipment. Additionally, well-conducted PdM could eliminate the cost of hundreds of unnecessary maintenance events over time.

Reliability analysis can take those savings to an entirely different level. Program management and close collaboration with a PdM service can help manufacturers and processors greatly increase throughput, reduce the need for maintenance and realize operational efficiency with assessment methodology and process or product management advice.

CHOOSE THE RIGHT RELIABILITY PARTNER

When it comes to keeping your operations running smoothly, PdM is a great investment. It's prudent when choosing a PdM partner, however, to consider the overall value the vendor provides. A low-cost provider might seem like the most economical choice for PdM services at first, but further research will likely unveil that they can't or won't provide value-added reliability analysis. Remember, that if you don't get to the root cause of a problem, it can easily resurface in time. It's generally the case that business operators aren't aware of issues with their equipment until it's too late, making it important to partner with a company that has the expertise and resources to give you a comprehensive perspective of your machinery and overall operations.

PdM program management and reliability analysis can change your very expectations for your business. With the right partner, you can make sure adjustments are made correctly the first time, and that you're operating equipment that you can rely on well into the future. ●

Predictive Service: Improving Reliability at No Additional Cost

WHILE IT may seem against a predictive maintenance (PdM) company's self-interest to take steps to minimize the amount of PdM a customer will require in the future, at Predictive Service, we believe that reliability analysis should be standard to every engagement. Our customers have come to rely on us for our unfaltering dedication to preventing failures within their facilities, and now we're adding value to these relationships by minimizing potential issues even further. We can examine not only equipment and material problems, but all issues affecting maintenance and reliability. It could be the case that certain tools need deployed to address a problem, such as a laser alignment device, or it may be that facility processes need revisited. Whatever the situation, our experienced program analysts are well-qualified to develop customized, step-by-step improvement plans to achieve an effective asset-management strategy. We're dedicated to working with our customers to eliminate defects and, ultimately, improve precision in operations. We make it easy to see how making tweaks to the way your business operates today will yield undeniable value for years to come.

Whereas other PdM vendors keep analytical data private or only record the results of their service visits in one-off, static documents, we maintain a dynamic database of years of PdM events and failure modes to ensure we can efficiently share what we find with our customers to deliver maximum value. Our award-winning, web-based Viewpoint® data storage system makes historical information readily available and easy to share with our customers, whether for a single facility or every facility a customer operates. Viewpoint's intuitive reporting of robust, cumulative data makes it simple for us to distill trends and work toward identifying root causes of failure. Best of all, it enables us to provide this reliability analysis at no additional cost to our PdM customers.

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