

Vibration Analysis in AI-Powered Maintenance



By Traction in partnership
with Noria Corporation



Table of Contents

3	The Future of Maintenance is Now
4	The Evolution of Maintenance
5	Predictive Forecasting vs. Real-Time Strategies
5	AI-Powered Maintenance: The Basics
6	Benefits of AI-Powered Maintenance
6	What is Vibration Analysis?
8	How to Analyze Vibration Patterns
8	Benefits of Vibration Analysis
9	The Power of Combining Vibration Analysis with Real-Time Strategies
9	How to get there
10	Closing the Loop on Maintenance with an Industrial Copilot

The Future of Maintenance is Now



The industrial maintenance world is transforming faster than ever, driven by advancements in artificial intelligence and smart IoT (Internet of Things) technologies. Traditional strategies like preventive, reactive, and even predictive maintenance, while still widely used, are being rapidly outpaced by AI-powered maintenance solutions that deliver unparalleled insights and precision.

AI-powered maintenance combines the best of condition-based maintenance (CbM), reliability-centered maintenance (RCM), and predictive diagnostics (AI-PdM) to provide real-time intelligence and actionable recommendations. These solutions can predict potential failures and provide detailed action steps to address them. In turn, maintenance teams transform from reactive decision-making protocols to a proactive and optimizing orientation.

At the heart of these advancements lies vibration analysis, a powerful tool that gains new capabilities when paired with AI-driven strategies.

While vibration analysis alone can detect anomalies and forecast potential failures, combining it with AI enables the identification of root causes. From there, repairs are prioritized, and asset performance is continually optimized. This integration empowers technicians and managers to anticipate problems and eliminate guesswork, reducing downtime and operational inefficiencies.

The future of maintenance is no longer an abstract concept. Companies already adopting AI-powered maintenance are achieving significant cost savings, improving equipment uptime, and extending asset lifespans—all while boosting ROI. The tools are here, the technology is proven, and the benefits are too substantial to ignore. The question is no longer "when" but "how quickly" your organization can embrace this game-changing shift.

The Evolution of Maintenance

The maintenance industry has undergone transformative changes over the years. Evolving from reactive to predictive strategies to AI-driven solutions, each step has achieved greater efficiency, cost control, and equipment reliability.

Historically, maintenance relied heavily on reactive or time-based methods. Equipment was repaired only after failure or serviced on fixed schedules. This approach often led to costly downtime, unexpected disruptions, and unnecessary repairs. On the other hand, scheduled maintenance resulted in over-servicing assets and increased expenses.

With the rise of predictive maintenance, the industry took a significant leap forward. Predictive maintenance introduced the concept of using data and technology to forecast potential equipment failures. Incorporating condition monitoring became instrumental in tracking machine health and identifying patterns to predict likely faults and failures.

However, maintenance teams were still tasked with interpreting the data, devising action plans, and ensuring follow-through. Take vibration analysis, the most common type of condition monitoring, as an example. If a misalignment was detected well before a machine breakdown, it still required a skilled professional to analyze the data, develop a maintenance plan, and issue a work order.

Eventually, predictive maintenance evolved further by integrating artificial intelligence and machine learning. AI-powered solutions brought the capability to analyze vast amounts of data in real time, delivering insights into equipment health and conditions. Today's AI-driven systems prioritize tasks, issue recommendations, and enable quicker decision-making. Teams have the precise information needed to avoid downtime.

From reactive responses to real-time strategies, the evolution of maintenance reflects the growing role of intelligent systems in transforming how we manage and care for critical assets. The journey has been one of continuous innovation, with AI-powered maintenance now leading the way toward a more efficient, cost effective, reliable future.



Predictive Forecasting vs. Real-Time Strategies

Predictive forecasting and real-time strategies are two approaches to optimizing industrial equipment performance and preventing failures. While both leverage data and advanced technologies, they differ in their methodology and the level of insight they provide.

Predictive forecasting relies on historical data, IoT sensors, and algorithms to identify patterns and trends that signal potential failures. Analyzing these patterns enables maintenance teams to estimate when an issue may occur, allowing for proactive scheduling of repairs or replacements. However, this method still requires manual analysis and decision-making to implement maintenance actions.

Real-time strategies, powered by AI and machine learning, move beyond prediction to deliver actionable insights in the moment. These systems provide recommendations tailored to current operational data by continuously monitoring equipment conditions. A real-time approach allows teams to address issues instantly, reducing delays and ensuring precise maintenance decisions.

While predictive forecasting is valuable for planning, real-time strategies represent an evolution. By combining continuous monitoring with intelligent automation, real-time systems empower organizations to maximize uptime and overall efficiency.



AI-Powered Maintenance: The Basics

AI-powered maintenance and facility management might sound futuristic, but they're already a reality. AI-powered maintenance can learn, adapt, and interpret unpredictable information using advanced smart systems. Much like a prescription, it provides teams with actionable recommendations—such as adjusting operational parameters, performing maintenance tasks, or replacing components—to optimize performance and extend equipment lifespan.

AI-powered maintenance builds on the data analysis techniques of predictive maintenance by incorporating artificial intelligence (AI) and machine learning. To operate effectively, a robust and powerful IT infrastructure is required. By integrating additional elements such as quality control and engineering data, AI-powered maintenance delivers even more precise and accurate recommendations.

Like predictive maintenance, implementing AI-powered maintenance involves investment and fine-tuning deep learning algorithms to ensure effectiveness and optimal performance.

Benefits of AI-Powered Maintenance

Implementing an AI-powered maintenance strategy offers numerous advantages, including reduced unplanned downtime, increased productivity, and improved profitability. AI-powered strategies often use condition monitoring to detect potential failures early on and to recommend timely repairs. This improves operational efficiency and maximizes equipment availability.

Additionally, AI-powered maintenance optimizes maintenance activities, leading to better resource allocation. The ability to access and analyze data remotely promotes virtual collaboration among teams, facilitating knowledge sharing and faster decision-making. Its scalability allows AI-powered maintenance to be implemented across multiple assets and locations, regardless of size or complexity, ensuring consistent operational improvements.

Ultimately, AI-powered maintenance improves overall equipment effectiveness, reliability, and longevity, helping companies save time and money over the long term.

What is Vibration Analysis?

All machines emit vibration patterns during operation, but occasionally, these patterns become abnormal. And this is why maintenance teams focus on analyzing the vibration of critical assets. Vibration analysis—measuring and monitoring asset vibration levels—is a foundational step in preventing mechanical failures. It enables engineers and maintenance professionals to detect abnormal vibrations that may signal issues like misalignment, unbalance, wear, or bearing defects.

Vibrations representing both velocity and acceleration are collected over a short period and subdivided into three axes: axial, horizontal, and vertical. This allows for a detailed analysis of vibration influence in each direction individually.

Amplitude values—both peak and peak-to-peak—are examined to assess the impact on components. By analyzing these signals, waveforms are created, enabling comparisons that help detect and diagnose failures.



Trigger	Frequency	Amplitude	Comments
Unbalance	1 X rpm	Proportional to the imbalance, greater in the radial direction	Usually appears in the first harmonic
Misalignment / Bent Shaft	1/2/3/4 X rpm	Large in the axial direction	Misalignment between bearings
Clearance in the Bearings	½ X rpm	Large in the vertical direction	As the frequency is less than ½ rpm the phase can be variable
Lack of Mechanical Firmness	2 X rpm	Unstable	Usually affects the alignment
Loose Straps	1 X rpm	Unstable	-
Defective Gears	High	"Blips"	Frequency between 15,000 and 40,000 rpm
Deteriorated Bearings	High	"Blips"	Frequency between 15,000 and 40,000 rpm
Lubrication	High	-	The amplitude changes significantly due to the lubrication
Twisted Shaft	1 X rpm	Large in the axial direction	The amplitude can be present in a pulsatile form

How to Analyze Vibration Patterns

Vibration spectrums can be obtained and measured in three different ways:

1. Global Level Vibration Meter **Without Filter**

Measures the global vibration value over a broad frequency range.

2. Global Level Vibration Meter **With Filter**

Similar to the previous method, it provides focused results by filtering the vibration levels of key components that require monitoring.

3. Frequency Analyzers

These are used when the filter width is very narrow. Frequency analyzers can perform a Fourier Transform on random, periodic, or transient signals.

Once you've decided on a method to measure machine vibrations, the next step is learning how to analyze a vibration spectrum. Here are key values and characteristics to consider when examining vibration spectrums and levels:

Vibration Amplitude

Represents the severity of vibration and is measured in G, the acceleration due to gravity.

Peak Value

The maximum value reached on a spectrum during a single cycle.

Peak-to-Peak Value

The difference between a waveform's maximum positive and maximum negative amplitudes.

RMS Value (Root Mean Square)

Often the most important metric in vibration analysis. It reflects the energy within the vibration profile, indicating the potential destructiveness of the vibration.

Benefits of Vibration Analysis

Vibration analysis directly contributes to cost reduction by enabling teams to predict when maintenance is necessary. This proactive approach helps maintenance teams avoid machine breakdowns, reduce expenses, and return valuable time to the company.

Minimizing unplanned downtime allows maintenance routines to be optimized and extends the lifespan of assets. Addressing atypical vibrations before problems arise results in improved efficiency and increased profits.

Vibration analysis plays a key role in proactive maintenance strategies, monitoring asset health data in real time to prevent unexpected issues. This process utilizes data sampling equipment, which can be operated manually or automatically, online or offline.

Online condition monitoring sensors are the most efficient and cost-effective option. These sensors integrate machine learning and artificial intelligence to collect real-time vibration data seamlessly.

The Power of Combining Vibration Analysis with Real-Time Strategies

Vibration analysis synergizes with AI-driven predictive strategies to enable:

Early Fault Detection

Continuous vibration monitoring helps teams identify subtle deviations from normal patterns, signaling potential issues early.

Asset Condition Monitoring

Condition-based maintenance (CbM) uses vibration signatures to provide insights into the overall health and performance of machinery.

Root Cause Analysis

Analyzing vibration data and patterns enables maintenance teams to pinpoint the root causes of abnormal vibrations, such as unbalances, misalignments, or worn-out components.

Maintenance Planning and Optimization

Gaining insights into equipment conditions through vibration analysis allows maintenance teams to optimize their schedules and activities.

Trend Monitoring

Tracking vibration patterns over time and maintaining records for each machine helps maintenance professionals evaluate the effectiveness of actions and assess equipment performance.

How to get there

Implementing real-time strategies requires a practical approach to maintaining and optimizing equipment and assets throughout their life cycles. Managing and deploying AI-powered maintenance demands that teams engage in strategic planning, including setting clear maintenance goals, prioritizing assets, and developing tailored strategies. Teams must also choose the appropriate approach—preventive, predictive, or AI-driven maintenance—based on each asset's criticality and individual needs.

Once the maintenance strategy is defined, the next step is implementing the systems and processes needed to support real-time maintenance activities. This involves monitoring and data sampling systems that leverage technologies like IoT sensors and devices to capture real-time equipment data.

Teams must determine how to execute, track, and manage maintenance activities. This involves scheduling and prioritizing tasks, allocating resources, and ensuring timely completion of prescribed actions. Organizations should also prioritize continuous improvement by leveraging the data and insights generated throughout the maintenance process.

Closing the Loop on Maintenance with an Industrial Copilot

Vibration analysis is more than just data sampling—it's the foundation of a truly proactive maintenance strategy. But insights alone aren't enough. To drive real impact, those insights need to seamlessly translate into action, ensuring that every intervention happens at the right time.

Tractian bridges that gap by integrating vibration monitoring with a fully connected asset lifecycle platform. Predictive diagnostics identify issues before they escalate, automatically triggering work orders, aligning tasks with the right technicians, and ensuring spare parts are available when needed. From initial detection to resolution, every step is streamlined, reducing downtime and maximizing reliability.

By eliminating inefficiencies and unnecessary disruptions, Tractian enables maintenance teams to focus on what truly matters—strategic decision-making and long-term asset health. Instead of constantly chasing failures, teams can take control of their maintenance strategy, backed by AI-driven insights.

Predictive maintenance isn't just about preventing breakdowns—it's about redefining how maintenance is managed. With Tractian as your Industrial Copilot, maintenance stops being a reactive cost center and becomes a driver of efficiency, uptime, and operational excellence.

[Get Started](#)

