Whitepaper

Predictive Maintenance

How an innovative maintenance strategy helps future-proof your business.

All parts of success

Executive Summary – Predictive Maintenance Ensures Sales and Success

As a **small** or **medium-sized** business (SME) operating in the manufacturing sector you know that unplanned downtime and technical failure of production equipment and plant may seriously affect your bottom line. Production line stoppages and being unable to meet your contractual obligations might result in resource **claims, financial penalties** and **loss of business.**

Hence, well-**maintained machinery** and **plant** are a **vital component** when it comes to future-proof your business. This is why companies across the manufacturing sector needs to come up with a **maintenance strategy,** to pre-emptively minimise stoppages and prevent unplanned downtime and the extra costs incurred by the latter.

In the past, this strategy was usually centred around carrying out **maintenance work at regular intervals,** and if necessary, fixing any issues in the process. These days, large corporations and SMEs alike use state-of-the-art **sensors, diagnostics equipment** and **AI** as the basis of preventive maintenance. This allows early detection of latent technical problems that might result in stoppages and downtimes later, preventing unplanned stoppages and sudden downtime caused by emergency repair work. The keyword here is “predictive maintenance”.

In this white paper, we explain how you as a manufacturing business can use the opportunities provided by digitalisation to formulate a **preventive** and **predictive maintenance strategy.**

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Predictive Maintenance & Repair in Manufacturing

Each unplanned production line stoppage costs money. The worst-case scenario is spare parts not being available right away, resulting in days or maybe weeks of downtime. However, the ability to detect latent technical issues ahead of any eventual equipment failure allows you to order **replacement parts in time,** and to schedule planned maintenance work in a way that doesn't, or hardly doesn't, interrupt the manufacturing process.

The main challenge in the past was that machinery and plant were basically black boxes. Meant you didn't know what was happening under the hood. Mechanical fatigue, damage to parts and other forms of wear and tear were detected during scheduled maintenance work only – or after sudden equipment failure that resulted in the entire manufacturing coming to a standstill.

These days, everyone knows precisely how to prevent such unwelcome surprises, using sensors and solutions that pick up on the even the smallest changes happening inside of equipment. This enables swapping out damaged part before they cause machine downtime, or before the failure of a part causes damage to other components. Many of these sensors can be retrofitted to equipment of the pre-digital age.

While **developing a predictive maintenance strategy,** fitting sensors and implement solutions necessitates **upfront investment** this, however, reduces costs in the long term which, in the end, amounts to huge savings. You don't just prevent unplanned stoppages; you also increase the service life of your equipment.

In terms of future competitiveness, any forward-looking manufacturing business simply must replace traditional maintenance work with innovative approaches. Means, it's now time to come up with predictive maintenance strategy.

Losses Caused by Production Line Stoppage: Facts & Figures

80%

Do you know what one hour of **unplanned production downtime** is going to cost you as a business? If you do, you are in the minority. Despite stoppages in manufacturing being among the main cost drivers, and being able **put your entire business at risk,** many companies don't know the precise amount of money they lose during each hour of downtime. According to a survey carried out by the International Society of Automation (ISA), 80 percent of businesses cannot put a number to the loss caused by stoppage [1].

Precisely how much money a business **loses during downtime** depends on its size, the sector it operates in, and on a large variety of other (cost-related) factors. Oftentimes, the consequences are massively underestimated. Whenever fixing a technical issue after equipment or plant failure takes a very long time, the costs skyrocket. "We are easily talking **a couple of hundred euros per hour and per piece of equipment**," explains Jan Dornbach, an MRO service engineer [2]. "Some companies run up losses totalling over 5 figures each year."

50%

A study by Senseye surveying 56 large businesses across the production / manufacturing sector revealed a surge in the costs caused by downtime since 2020. In 2022, **unplanned stoppage** turned out to be 50 percent more expensive than in 2019/20. On average, a company loses 25 production hours each month. Among the worst affected is the automotive industry, with one hour of downtime costing more than 2 million USD.

11%

According to a Senseye survey, companies **lose about 11 percent of their overall annual revenue** due to production line stoppages [3].

5%

A study carried out by eMaint shows that the average manufacturing company loses at least **5 percent** of its production capacity as a result of downtime. In a lot of cases, it's more like 20 percent. The automotive and metal-processing industries are the ones experiencing the most downtime each year [4].

Production Line Stoppageas a Cost Driver

As mentioned above, each minute of production downtime does cost you money. Downtime means no output and, hence, no profit, with fixed costs (such as staff wages, facility upkeep etc) to be paid regardless. If troubleshooting and sourcing spares take a lot of time, the costs will go up further. Moreover, there is the money you need to pay for fixing issues and repairs, amounts that frequently turn out to be much higher than expected.

Staff wages and service costs	**Loss of sales opportunities**	**Long waiting times or delivery issues**
Damaged reputation	**Staff working overtime**	**Resource reclaims**

Crucially, most unplanned downtime is caused by issues related to a company's structure.

These include

- no or lacking transparency when it comes to equipment conditions
- servicing plans being inadequate
- lack of knowhow /tools resulting in insufficient maintenance
- members of the workforce making mistakes
- lack of / low-quality spare parts

All businesses, and SMEs in particular, need to take into account all of above when calculating the true costs of production line stoppage. However, while calculating costs is all well and good, it's all about preventing these costs in the first place.

The key here is optimising maintenance and repair operations in a smart way.

Step 1: From Reactive Maintenance to Preventive Maintenance

Many businesses operating in the manufacturing sector, and the SMEs among them in particular, still centre their regular maintenance work around a **Reactive Maintenance** strategy. This approach is simple: carry out any unscheduled repair work only in the event of equipment or plant no longer being functional. This maintenance strategy stems from a time when technology was less sophisticated which meant less failures and repair work being comparably easy. Also, back then, sensor design wasn't at the level it is now. No data processing either as this only became available with the onset of digitalisation.

These days, considering the increasingly **complexity of manufacturing equipment** and the ongoing digital interconnection of machinery, reactive maintenance no longer constitutes the most effective and cost-effective strategy. The biggest drawback is a lack of plannability.

Reactive maintenance strategies do not enable the prediction of equipment failure. The worst-case scenario here is downtime that coincides with periods of full order books or labour shortages. Moreover, staff deployment and stocking spares is not plannable and hence prevents the coordination of both which, in the long term, proves to be **very expensive.** On the other hand, **Predictive Maintenance** improves plannability and reduces costs in an effective way.

Step 2: Preventive Maintenance – Plannability Instead of Flying Blind

A preventive maintenance strategy enables businesses to be proactive. The goal is to predict equipment failure and carry out repair and maintenance work in a way that prevents production line stoppage. This involves scheduling and carrying out maintenance work in a very efficient manner that also makes equipment downtime or failure less likely.

Compared to reactive maintenance, this method goes hand in hand with a massive cost reduction. According to Industrial MRO guidelines, businesses are able to slash costs by an estimated 12 to 18 percent by implementing a Preventive Maintenance strategy [5].

Preventive Maintenance: Benefits and Approach

Besides the important aspect of saving money, Preventive Maintenance comes with a range of other benefits that include

- increased equipment service live
- prevention of extra costs and damage to reputation as a result of downtime
- lower repair costs
- ensuring staff occupational health and safety
- consolidation of different maintenance tasks
- increased transparency and lower expenditure when stocking spares

There are different approaches to planning preventive maintenance work. The time-based method centres around businesses using in-house data about past equipment downtime and production line stoppage (Mean Time Between Failures). On the other hand, the use-based method looks at the operational life or lifecycles of equipment i.e. the accumulated operating hours and the resulting wear and tear.

Regardless of the method, in the end, it means coming up with a maintenance plan that details the recurrent intervals at which the work needs to be carried out. This also includes regular inspection. The management of the whole process that comprises planning and completing the tasks as well as assessing and optimising the outcome afterwards uses Computerized Maintenance Management System (CMMS) software.

Detailed information on how to use maintenance plans and what to pay attention to, refer to our „Equipment & Plant Maintenance Plans“ guide.

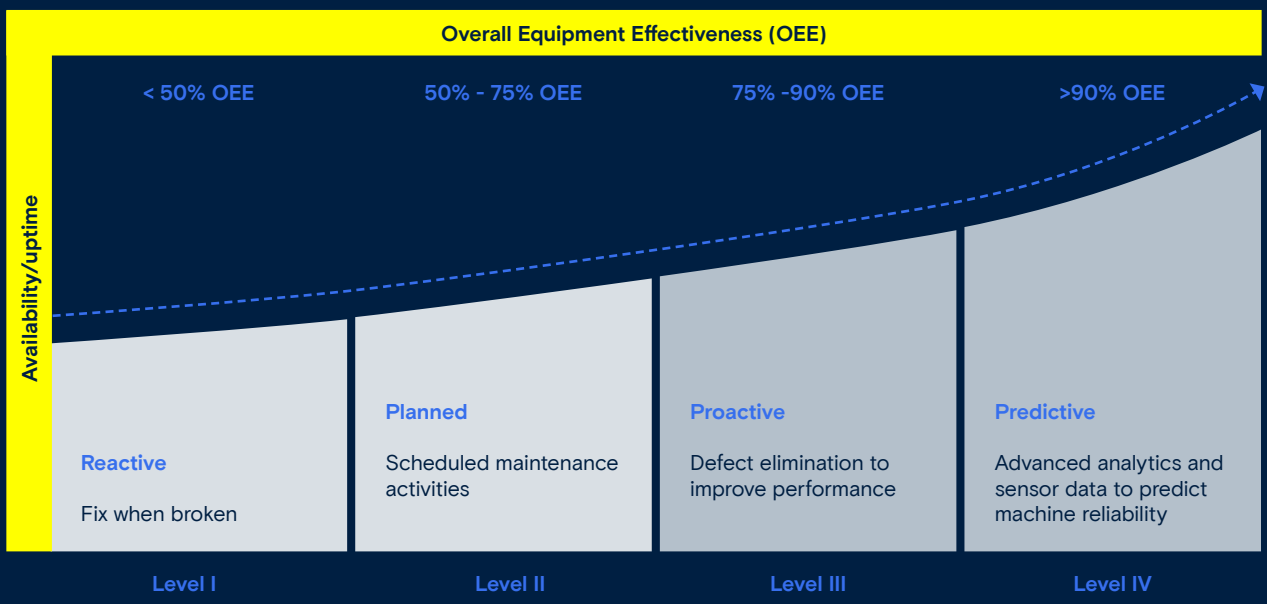
Step 3: Predictive Maintenance: Using Real-time Data to Optimise Maintenance

Preventive vs. Predictive Maintenance

Preventive maintenance centres around inspections at regular intervals, regardless of the actual conditions of machinery and plant. Service engineers do their job complying with best practice polices and using historical maintenance data as a reference. In this context, knowing your equipment inside out helps setting suitable maintenance intervals. However, even optimised preventive maintenance schedules are still speculative and, hence, approximations of reality.

Which is also the main challenge: carrying out maintenance work too early results in increased costs and unnecessary downtime while overly long intervals increase the risk of production line stoppages.

Predictive maintenance strategies, however, are not based on estimates of total operational hours and the resulting wear and tear. They involve collecting real-time data of equipment and use this information to calculate precisely when to carry out maintenance work. Means repairs are made when required. Moreover, downtimes are about 25 to 30 percent shorter when compared to other maintenance strategies [5].
Predictive Maintenance enables businesses to avoid both swapping out parts too early (which drives up maintenance costs) and doing the work too late to prevent unwanted downtime.



Source: https://www2.deloitte.com/uk/en/insights/focus/industry-4-0/using-predictive-technologies-for-asset-maintenance.html

Benefits of Predictive Maintenance

Fewer work-related Accidents

Optimised resource planning

Longer equipment service life

Smoother manufacturing

Lower maintenance costs

Less downtime

How Predictive Maintenance Works

This maintenance strategy requires machinery and plant to be equipped with digital sensors, data loggers and other analytics tools that acquire relevant information in real time. Afterwards, the data are stored and, first and foremost, analysed.

In this context, **“Condition Monitoring”** plays an important role when it comes to keeping an eye on equipment electronics, especially on those electrical units of measurement that change, or change slowly. For more information, refer to our „Condition Monitoring: Non-stop Monitoring of Machinery and Plant” guide.

As the amount of data collected in the process is huge, additional **technologies** including **Artificial Intelligence (AI)** and **Machine Learning (ML)** are used. The calculate the likelihoods of downtime using the available data forwarded by sensors. In the case of an **anomaly,** such as a slight change in vibration patterns inside of a machine, the service engineers are **alerted,** and that long before the equipment fails.

Another **advantage of these methods** is that the issue, or wear and tear, can be located right away. Means there is enough time to do repair work or replace components **before equipment breaks down.** Moreover, they make regular maintenance work that proves to be expensive in the long term obsolete.

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Preventive und Predictive Maintenance - A Practical Approach

Almost all manufacturing businesses need to keep an eye on the vital parts of machinery and plant. To do this, most companies use vibration analysis, IR imaging and circuitry monitoring.

Vibration Analysis

It's the moving parts of **motors, pumps** and **gear-boxes** that are the main focus when it comes to preventing equipment failure. Means monitoring their condition using **vibration analysis** is of utmost importance.

Vibration analysis involves measuring and assessing oscillations generated by machinery, or one of its components. The detected patterns are compared to the default pattern. Any **anomalies** usually suggest that there are latent issues such as component untrueness, alignment errors, wear and tear and excessive friction, all of which might result in sub-standard performance and malfunction in the long term. This means you can **take care of these problems** right away.

Carrying out a vibration analysis requires a **vibration tester.** Vibration testers are reliable and highly sensitive probes. They feature a **magnetic base** which allows **attaching them to equipment,** and that even in constraint space and hard-to-reach places. These instruments take very accurate readings of oscillation patterns and display the **results** on the **in-built screen** right away.

Examples of precision vibration testers available at conrad.de/schwingungsmesser

Voltcraft
VBM-85 Vibration Tester

Infrared Thermography Analysis

Another key area of preventive and predictive maintenances involves monitoring the temperature of equipment parts. Temperatures of machinery are monitored using either infrared thermography or infrared spectroscopy. When it comes to moving parts, infrared thermography is the method of choice, detecting increased friction in joints and bearings long before the respective parts become defective.

IR thermography analysis gives insights of whether to schedule an inspection / carry out maintenance work. IR thermography works with a wide range of equipment, **as long as** the tested parts generate enough heat. **Another benefit** is that it's non-contact which boosts workplace safety for service engineers.

IR thermography uses **thermal imagers** with in-built screens that display temperature hotspots ranging from **-20 to +500** or, in some cases, to **+600 degrees Celsius.** In the case of the latter, it definitely makes sense to archive the images taken by the camera and the recorded temperature level.

This enables a **comparison** of the status quo and past scenarios which adds to the validity of the analysis.

Examples of high-quality thermal imagers available at
conrad.de/waermebildkameras

Testo
868s Thermal Imager

Circuitry Monitoring

Monitoring circuitry non-stop is key when it comes to ensure the ongoing functionality of machinery and plant. Otherwise, damage as a result of power surges and short circuiting will become an issue. Residual Current Circuit Breakers (RCCBs) are a common way to protect electronics against these risks, separating the affected circuitry from the mains supply.

Communication-enabled RRCBs continuously monitor electrical plant and machinery, **alerting service staff** whenever current and/or power readings exceed a preset limit. This results in inspection and/or maintenance work being carried out, Moreover, these devices also regulate the power supply of a piece of equipment which significantly boosts **plant availability**. All in all, this means full transparency down to the final circuit.

Communication-enabled RCCBs with built-in *differential current monitoring technology form the backbone of circuitry monitoring. These products wirelessly connect to a data transceiver (Powercenter 1000). This **data transceiver** collects the data and forwards them to a PC, a mobile device or to an **IoT interface.**

Examples of data transceivers and RCCBs

Siemens
7KN1110-0MC00
Powercenter 1000

Siemens
5SL6016-6MC
5SL6 COM

Siemens
5SL6016-6MF
*5SL6 COM RCM**

Siemens
5SV6016-6MC16
5SV6 COM

Circuitry Monitoring Methods

Alerts when limits are exceeded	Prevent malfunction by taking early action
Measuring amperage, voltage, mains frequency and temperature	Deduct equipment failure at final circuit level
Built-in cycle counter, service hours counter and SC counter	Plannable replacement of RCCBs Predictive maintenance
Planned power-off vs failure-triggered power-off	Facitlitates targeted and time-efficient trouble-shooting
Measuring current, energy and power	Break-down of energy consumption from mains supply to final circuitry
Measuring differential currents across a wide frequency range	Early detection and prevention of stoppage and failure
Remote power-up function	User-defined automated power-up settings
RCB and insulation resistance testing	Wide range of features for automated plannable testing and documentation

Best Practice

Initially, setting up or switching to predictive maintenance does pose a significant challenge to many businesses. Frequently, manufacturers don't know where to start, or what to do, to make the most of optimised maintenance strategies. Here are some examples of best practice, to help you figure out what works for you.

Project Planning

As with any other **roll-out of new technology,** predictive maintenance solutions require a detailed **project and action plan.** This plan outlines the precise goals in a specific, measurable, attainable, relevant and time-bound manner (SMART method). Moreover, ongoing progress analysis (Controlling) helps the **workforce** get to grips with the new procedures, and to acquire new skills step by step.

Less is more

Instead of rolling out AI-based predictive maintenance solutions across your entire business, start out with small-scale pilots. The **easiest way** to do this is to pick **one or two pieces of equipment that are really suited to the setup.** This allows you to gain insights and get hands-on experience.

Keep Going and Scale

As soon as your pilots are running smoothly, **continue the roll-out.** The good news is that predictive maintenance solutions are scalable. Means a business that started out with one or two interconnected pieces of machinery can easily turn itself into a smart manufacturing plant within **six to twelve months.**

Conclusions

For SMEs operating in the manufacturing sector, improving their maintenance strategies is essential when it comes to competitiveness and adaptability. Outdated methodology such as **Reactive maintenance** is no longer suited to nowadays' **highly complex** and interconnected production lines, and rapidly drives up **costs.**

For businesses, implementing a new strategy means facing **new challenges.** However, simply choosing to ignore this won't work in the medium and long term. In short, **digitalisation** is here to stay. And only investing in a smart **maintenance strategy** right now will make sure that your business stays **futureproof and competitive.**

If you are among those who don't want to already fall behind, below we look at a variety of components and how to use them, to make it easier for you to get things off the ground.

- Everything you need for maintenance, production and safety: Predictions, Actions, Benefits – An Overview
- Measuring instruments, environmental testers, diagnostics equipment and lots more: Predictive Maintenance Applied
- Manufacturing quality: Nothing Goes Without Basic Equipment

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