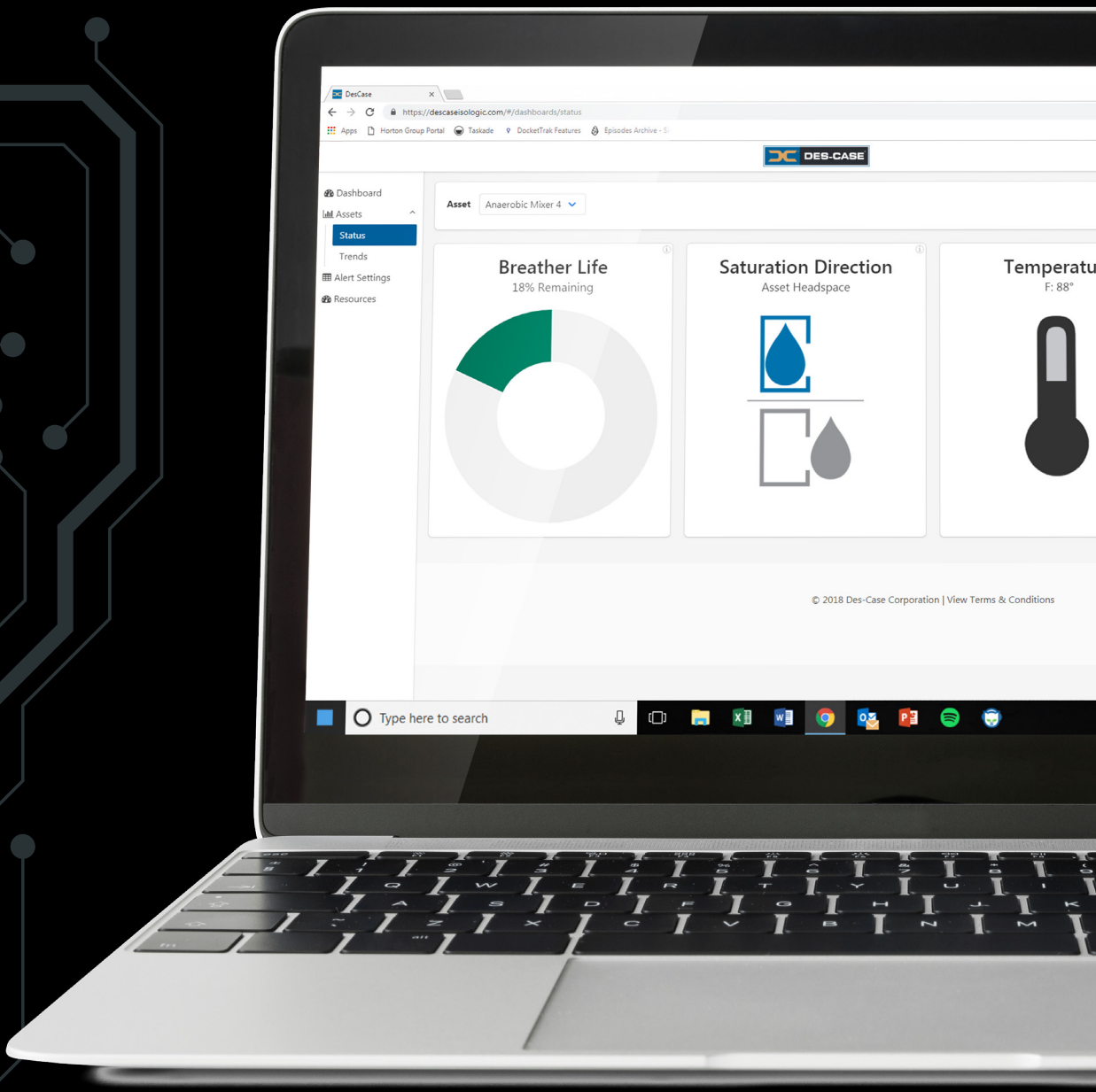
LEVERAGING IOT FOR CONDITION-BASED MAINTENANCE



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LET'S START WITH THE BASICS

WHAT IS CONDITION-BASED MAINTENANCE?

Condition-based maintenance (CBM) is a maintenance strategy that monitors the condition of your equipment to determine the necessary maintenance to perform. Unlike planned maintenance (PM), where maintenance is performed based upon predefined scheduled intervals, the goal of condition-based maintenance is to identify the need for corrective maintenance when it is needed – and not before. The goal of condition-based maintenance is twofold; to increase the time between maintenance tasks, because maintenance is done on an as-needed basis, and to eliminate failures that can be introduced when unnecessary maintenance activities are performed.

Condition monitoring is a vital component of any condition-based maintenance strategy because it provides the data that makes a condition-based maintenance task actionable. Loosely defined, condition monitoring can be described as the process of measuring a parameter or group of parameters that are indicative of the condition of a piece of equipment. Condition monitoring data can be gathered continuously or at certain intervals, providing immediate notice of a significant change from normal conditions. Condition monitoring also provides early failure prediction or prevention, allowing for timely action to avoid a catastrophic equipment failure ensuring longevity and smooth operation of the equipment. Minimizing machine downtime can reduce maintenance costs, increase labor productivity and avoid loss of revenue.

LET'S START WITH THE BASICS

TYPES OF CONDITION-BASED MAINTENANCE

There are several different condition monitoring techniques commonly used for industrial equipment including:

- **Vibration analysis** – rotating components such as bearings and gears all exhibit a certain degree of vibration. As they degrade, fall out of alignment or become imbalanced, the amount of vibration increases. Through trending, vibration analysis can be used to detect when this becomes excessive. By monitoring characteristic fault frequencies, vibration analysis can not detect a problem but it can be isolated to a specific component and failure mode based on specific information such as bearing size, speed of rotation, number of gear teeth, etc.
- **Oil analysis** – Oil analysis involves the measurement of three key components within the oil: the health of the lubricant, the presence of common contaminants such as particles and moisture and the presence of wear debris. As a proactive tool, oil analysis can identify problems with the health or cleanliness of the lubricant before machine failure starts to occur
- **Infrared** – IR cameras can be used to detect high temperature within a machine. This includes "hot spots" within rotating and reciprocating equipment as well as energized electrical components such as transformers, voltage regulators and electrical panels.
- **Ultrasonic** – A number of different problems can be determined by measuring ultrasonic emissions. These include gas (e.g. compressed air) and steam leaks, electrical arcing and coronas and under or over lubricated bearings.
- **Motor current analysis** – both electrical and mechanical anomalies can be detected by fluctuation in the current drawn by electrical motors, allowing corrective maintenance activities to be performed before a failure starts to occur.

CONDITION MONITORING: A HISTORICAL PERSPECTIVE

No matter the technique used, traditional condition monitoring has one major drawback. Data is collected on some predetermined time interval, in the hope that the sampling interval is frequent enough and the detection technique sensitive enough that an early warning of impending machine failure can be found. And while time-based condition monitoring has proven valuable, for very critical assets – particularly in high speed applications – real-time condition monitoring involving permanently mounted sensors has been used for many years. In this case, data is collected from sensors positioned on your asset, providing a continuous audit of the health of your machine. A real-time report can be built that not only provides the current status of your asset but trend analysis can also predict potential issues and when they're likely to occur. While it's hard to argue that real-time monitoring doesn't have advantages over time-based measurements, historically the cost of deploying sensors and the associated infrastructure has precluded real-time data monitoring in all but the most critical assets.

USING SENSORS TO CONNECT YOU TO YOUR ASSETS

THE INTRODUCTION OF IOT IN CONDITION MONITORING

When was the last time you checked your heart rate after exercising, counted the number of steps you take per day or maintained a log of your sleep times? Either it's been a while or maybe you never did it at all because of the amount of time and discipline it would take to collect that data. Today, the thought of manually tracking these conditions would be considered ridiculous with the introduction of affordable activity trackers.

In the last decade, we've seen a rapid increase of IoT-enabled solutions into the industrial world. Traditionally, machine condition monitoring has relied as much on an employee as on technology. However, better and cheaper sensors, broader connectivity, more sophisticated analytics, less expensive storage and multi-cloud technology is eliminating the need to perform manual time-based tests to monitor your machine's health. The IoT is automating and adding intelligence to machine condition monitoring and allows more time for operational optimization.

The Industrial Internet of Things (IIoT) is opening new doors for companies when it comes to condition monitoring for predictive maintenance. Like activity trackers have done for health-conscious individuals, sensors placed on industrial equipment are providing a more efficient, accurate and real-time solution for condition monitoring. This type of IoT-enabled monitoring provides ongoing insight into overall machine health.

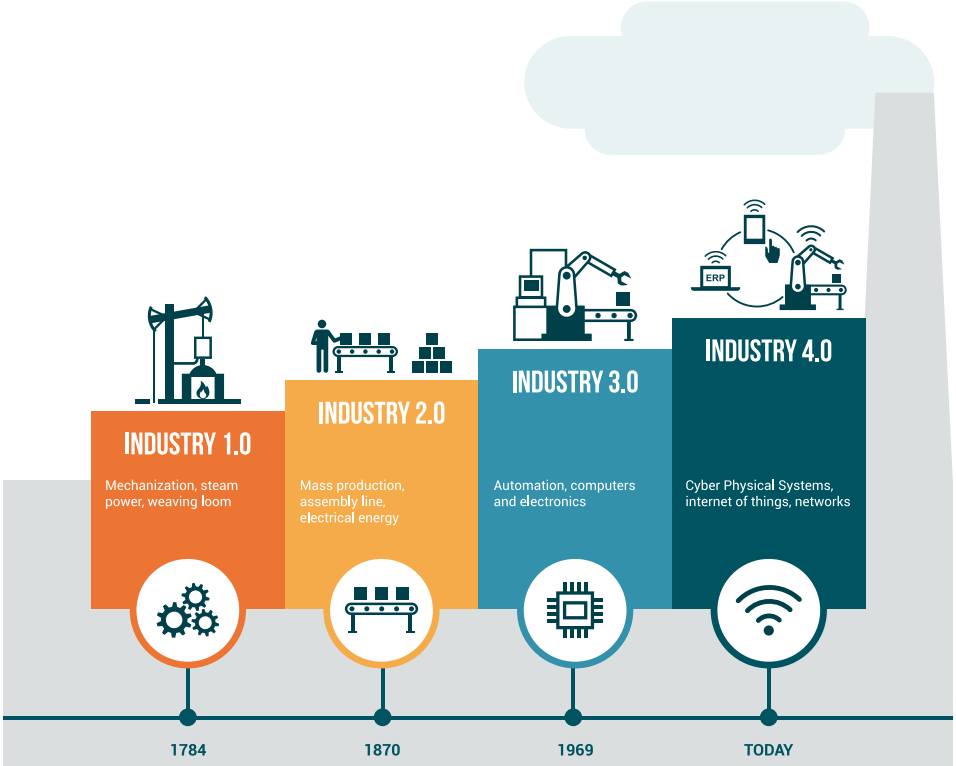
By connecting equipment, organizations can capture massive volumes of data from sensors and other connected devices, so they can not only cut unplanned downtime and its associated costs, but also create new operational efficiencies, exploit new opportunities in supply chain optimization, and accelerate their overall digital transformation strategies.

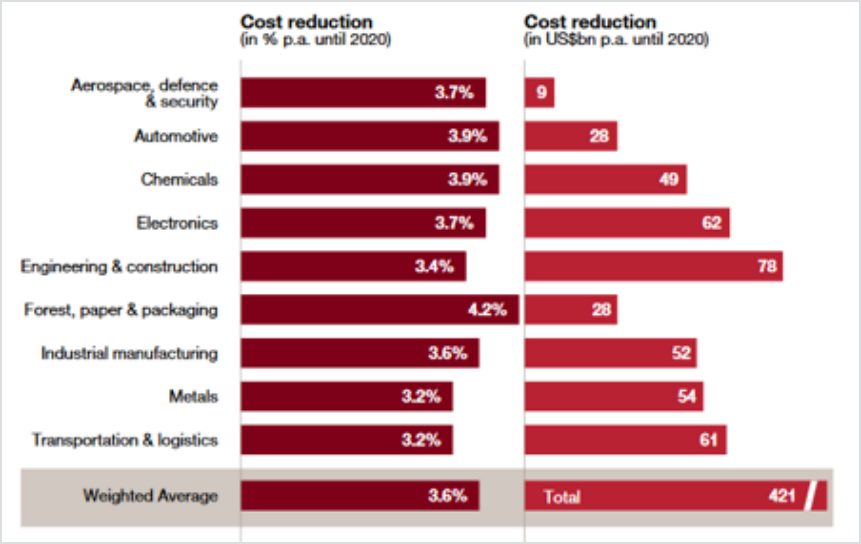
USING SENSORS TO CONNECT YOU TO YOUR ASSETS

ECONOMIC IMPACT OF INDUSTRY 4.0

McKinsey & Company estimates that implementation of IoT across worksites could yield an economic value of $160 billion to $930 billion per year in 2025. This value would come from cost savings, productivity improvements, increased uptime, and new revenue opportunities (extending the productive hours each day at a mine, for example). The most significant impact would come from improvements in operating efficiency, which could have an economic impact of as much as $470 billion per year across worksite industries in 2025.

The second-largest potential impact, and the one this paper focuses on, could be from condition-based and predictive maintenance practices, which cut routine maintenance costs, reduce breakdowns, increase productive uptime and extend the useful life of machinery. According to McKinsey these maintenance improvements could have an economic impact of $360 billion per year in 2025.





Source: www.pwc.com

According to a 2016 Global Industry 4.0 Survey by PWC, on average, companies expect to reduce operational costs by 3.6% p.a., while increasing efficiency by 4.1% annually. High levels of cost reduction are expected in every industry sector studied. Some of these cost savings can be achieved by implementing condition monitoring technologies, the foundation of Industry 4.0.

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6 BENEFITS OF IoT CONDITION-BASED MAINTENANCE

COMPARED TO TRADITIONAL TIME-BASED CONDITION MONITORING, REAL-TIME MONITORING INVOLVING IOT ENABLED SOLUTIONS OFFER SEVERAL DISTINCT ADVANTAGES:

1. Identify issues before they escalate

Even the smallest issue can snowball into a serious problem if it goes unnoticed for too long. Continuous manufacturing processes have any number of single points of failure that can halt production.

Not only does real-time condition monitoring allow you to determine areas for improvement, but it can also help manufacturers identify potential problems and take the necessary actions before issues occur, often well in advance of time-based monitoring.

- Sensors track changes in vibration, temperature, oil quality and cleanliness, and then output to detect any issues with corrosion, wear, misalignment, imbalance, or lubrication.
- Service maintenance can automatically be scheduled ahead of time to prevent part failure or system damage.
- Critical outages and unplanned downtime can be avoided by identifying potential equipment failure allowing corrective work to be scheduled during scheduled work outages.

6 BENEFITS

2. Reduce unplanned downtime

Run-to-failure might be the simplest maintenance strategy but it is not a recommended strategy. Waiting for something to break, can waste valuable production time, money and potential revenue. A continuous monitoring solution provides a clear picture of their asset's overall health, greatly minimizing the occurrence of unexpected failures. Coupled with advanced data analytics, real-time condition monitoring can provide a much earlier warning of impending problems allowing for longer lead times for corrective work.

3. Decrease maintenance costs

IoT-enabled condition monitoring solutions give you the data to get early notices of failures or avoid a pending failure that if not detected or left unresolved, could become catastrophic and extremely costly to your maintenance budget.

4. Avoid hazardous or hard-to-access environments

Most time-based condition monitoring techniques require a technician to access equipment under normal operating conditions. As such, safety becomes a primary concern with routine condition monitoring. By deploying IoT sensors, real-time data can be captured and analyzed without exposing employees to workplace hazards.

TWO REASONS YOU NEED TO MONITOR THE CONDITION OF YOUR OIL

Studies show that approximately half of lost machine life is due to mechanical wear and approximately 80% of mechanical wear is caused by particle contamination in the oil.

It has been estimated that most production organizations lose between 10 and 15% of their plants total maintenance budget each year due to downstream effects of poor lubrication.

5. Better information for better decision-making

Using sensors to collect data could reveal operational inefficiencies that would not be apparent until a catastrophic failure occurs. Receiving as much advance notice on failures or pending failures provides more time for you to make the appropriate decisions on a better asset location, environment adjustments, oil changes, etc.

6. Improve labor efficiency

IoT-enabled condition monitoring solutions ensure that work only needs to be scheduled that truly needs to be done. This helps to eliminate the 50% of PM work that has be estimated to be unnecessary, freeing up valuable resources for other value-added tasks.

MOVE TO THE LEFT

IoT CONDITION MONITORING AND THE D-I-P-F CURVE

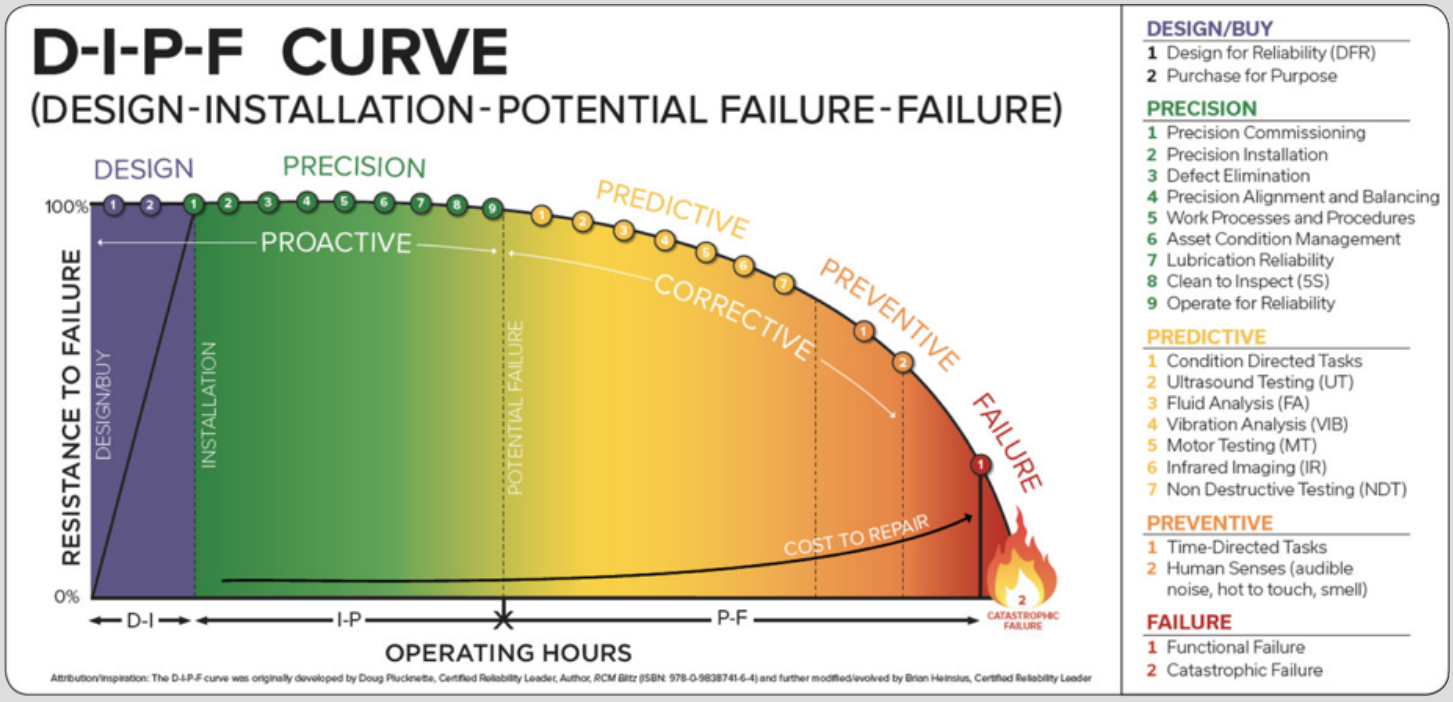
Condition monitoring cannot be discussed without linking back to the D-I-P-F Curve , a graphical representation of how potential failure progresses from Design (D), Installation (I), detection of a Potential (P) failure, and Functional (F) failure occuring. For condition-based maintenance to be effective as a strategy, the sooner a problem or potential problem is detected, the better.

With real-time or immediate identifications and alerts of a failure, IoT-enabled solutions for predictive maintenance allow you to move even farther left along the P-F curve than ever before. For example, for a bearing to start to have abnormal vibration, the bearing must have a defect to generate vibration or heat. Chances are there were subtle but small changes in operation, likely reflected in process data, that led to the eventual, noticeable high vibration. With the right operation data, this abnormal condition can be detected well in advance of catastrophic failure, providing ample time to address the problem without experiencing any downtime.

However, these solutions are limited to providing more time to address and fix a machine failure, not prevent one from happening.

+ MOVE TO THE LEFT

Precision maintenance can provide the opportunity to recognize potential problems or failure catalysts, allowing proactive decisions to prevent machine failures from happening. Operating within the I-P curve is the only way to truly prevent equipment failure and extend equipment life. Critical data related to how a machine is beign operated, how well it's aligned and balanced and the health and cleanliness of the lubricant can all be captured using real-time condition monitoring, allowing IoT-based solutions to be used as proactive maintenance tools.



Source: www.reliabilityweb.com

Just like modern healthcare cannot overcome faulty genes, condition monitoring cannot overcome poor machine design or installation. However, by capturing data in real time and using advanced analytics, manufacturers can use IoT to look at the in-service performance of their equipment to make critical decisions around the way their equipment is designed, installed and operated.

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INVESTING IN THE FUTURE OF RELIABILITY

THE BUSINESS CASE FOR IoT CONDITION MONITORING

Executives are hearing plenty these days about the promise of the Internet of Things (IoT) benefitting industrial environments. Unfortunately, it is not always easy to establish a clear business case for investing in these new technologies. Nonetheless, the momentum of IoT remains undeniable, with better and cheaper sensors, broader connectivity, more sophisticated analytics, less expensive storage and multi-cloud technology.

Companies today are under tremendous pressure to deliver a higher quality of products and services at lower costs. Any expenditure companies do make is expected to deliver a measurable return on investment (ROI).

INVESTING IN THE FUTURE OF RELIABILITY

In one of the most comprehensive compilations of maintenance costs ever published, the Aberdeen Group, a Boston-based research think tank compiled a survey of manufacturing companies in an attempt to quantify the cost of poor maintenance on overall performance. In doing so, they categorized companies into lower quartile, average and upper quartile performers and compared three key metrics: availability, quality and maintenance costs as a function of overall sales. The results, which are summarized in Table 1, showed truly remarkable results.

	Availability	Delta	Yield	Delta	Maintenance Costs/ Sales	Incremental Change In Maintenance Costs Assuming Fixed Sales
Lower Quartile	81.8%	-	79.2%	-	23.5%	0.0%
Average	87.2%	5.4%	81.9%	2.7%	20.8%	-11.5%
Upper Quartile	88.8%	7.0%	84.2%	5.0%	17.2%	-26.8%

Table 1: Aberdeen Group study showing the impact of maintenance on availability, quality and yield

Compared to lower quartile performers, companies that exhibited upper quartile maintenance practices showed an average improvement in availability of 7% (81.8% vs 88.8%) and an increase in yield of 5% (79.2% vs 84.2%). Put simply, companies that better maintain their assets are able to run their assets more reliably resulting in greater throughput and more first pass quality products. No surprise there.

However, what is really interesting is to look at the lower, average and upper quartile companies' maintenance costs as a function of sales. Conventional wisdom would hold that to better maintain our asset base you need to spend more, not less on maintenance. But in the Aberdeen study, the opposite appears to be true. The average performer showed an 11.5% reduction in maintenance costs (20.8% vs 23.5% as a % of sales) compared to the lower quartile performer, while an upper quartile performer spent a whopping 26.8% less (17.2% vs 23.5%) on maintenance. It is clear then that good maintenance costs less!

So where does IoT for condition-based maintenance have the largest impact on your business case? By being able move further to the left on the D-I-P-F curve, your maintenance investments can more significantly decrease your maintenance costs with earlier and better insights into machine failures. This allows you to catch a failure the moment it occurs or before it even occurs avoiding the significant costs of downtime.

An Industry 4.0 report by McKinsey & Company estimates the value of digitalization:

- Up to 50% reduction in maintenance costs
- Productivity increases of 3-5%
- Reduce equipment capital investment by 3-5% by extending the useful life of machinery

The report points out, "In manufacturing, these savings have a potential economic impact of nearly $630 billion per year in 2025."

OUR IoT CONDITION MONITORING SOLUTION

HOW OUR IoT CONDITION MONITORING SOLUTION CAN HELP PREVENT MACHINE FAILURES

IsoLogic™ Technology

What if you had a sudden increase in moisture levels inside your equipment's headspace? Even though a failure may not have happened yet, water is the second most destructive cause of failure causing rust, corrosion and loss of oil film strength. It can be particularly problematic in hydraulic systems causing sludge and varnish build up that can cause valve stiction as well as cavitation within hydraulic pumps.

A good example of sensor technology supporting precision maintenance occurred with one of the largest sustainable forest products companies in the world. They have a large asset called a Sorter composed of 120 large hydraulic cylinders and various hydraulic valves & pumps. Hydro-cleaning had been conducted in proximity to the hydraulic power unit (HPU) and many of the cylinders attached to the asset. Unfortunately, water had been able to ingress into the HPU system.

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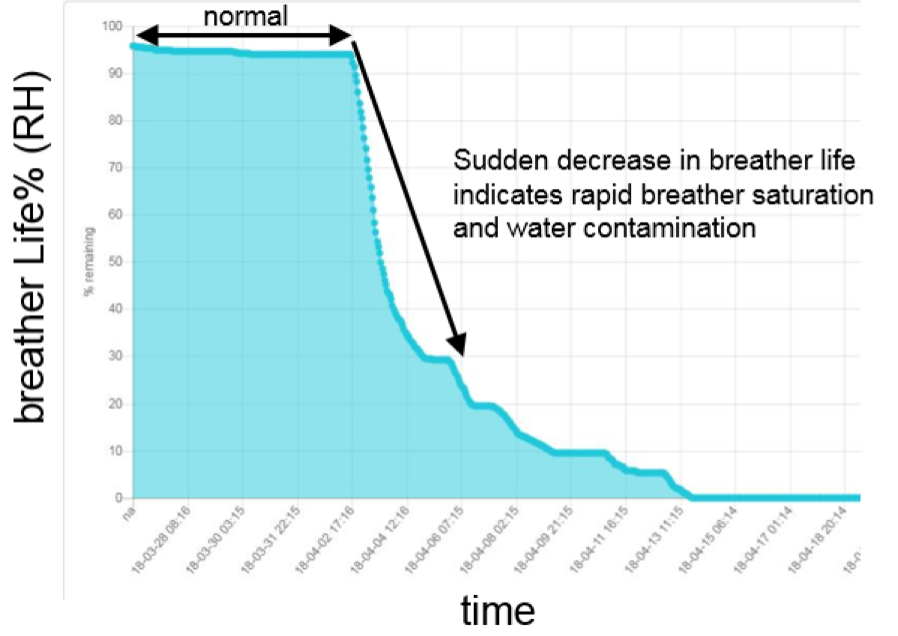
+ OUR IoT CONDITION MONITORING SOLUTION

Prior to the hydro cleaning taking place, the water levels in the oil were acceptable at under 0.003% (30 ppm). Shortly after the cleaning, an increase in moisture saturation was detected immediately by a Des-Case IoT-enabled breather. Des-Case IsoLogic™ is a patent-pending sensor technology placed inside our trusted VentGuard™ breathers, creating the most accurate and first connected breather on the market.



Without the sensors' ability to provide immediate and actionable data this failure mode could have gone unchecked for weeks, maybe months, causing potentially extensive damage to the hydraulic pumps, valving and the oil.

They immediately filtered the oil to help remove any free and entrained water in the system and also turned the HPU heater on and maintained an average temperature of approximately 130 degrees to help dry out the moisture. Water levels returned to under 0.003% with no undue failure occurring.

For the newly build survey vessels, the Searcher & Galaxy,

Contamination Sensors

Fugro, owner/operator of a fleet of specialized multipurpose survey vessels equipped with state-of-the-art survey spreads, purchased our Smart off-line filter units to be mounted to their central hydraulics system, which drives the deck equipment like A-Frames and winches.

On top of the hydraulic tank of the HPU a smart off-line filter was installed, the filter unit acts as a kidney loop continuously pumping a small amount of oil through extreme fine filters which remove both solid particles and water. In addition, the filter is equipped with a Contamination Monitoring Sensor which reports oil cleanliness and water content.

The monitoring unit is connected to the Ships Alarm Monitoring System so any possible increase in contamination, temperature or water ingress is detected and alerts the crew and immediate corrective action can be taken.

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+ OUR IoT CONDITION MONITORING SOLUTION

Oil Quality Sensors

An Oil Quality Sensor provides real-time monitoring of oil degradation and water ingress. With this sensor, expensive oil changes are based on oil condition, not on an historical schedule.

The sensor is a live, highly flexible and cost effective condition-based monitoring solution, designed to be permanently mounted within any lubrication system on any type of machine. Over 60 times more sensitive to oil contamination than any other dielectric constant measuring sensor, it provides real-time monitoring of water ingress and oxidation levels.

The importance of implementing an effective monitoring and maintenance program for lubricants in critical plant machinery has never been greater. With the escalating price of crude oil and the vast improvements that are being seen in the quality of lubricants available today, it is more important than ever for organizations to ensure that they are maximizing the service life of the oil used. Monitoring oil condition is clearly fundamental to understanding the optimal time to change. Change too early and the cost is significant, change too late and the costs can be even greater!

SEE MORE BENEFITS

OF DES-CASE CONDITION MONITORING SOLUTIONS
BY VISITING **DESCASE.COM/CONDITIONMONITORING**

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