




Redefining plant availability with proactive condition monitoring

How leading pulp and paper companies
are optimizing operations



In the pulp and paper industry, future viability depends on transformation started today. Vital to that transformation is the adoption of proactive, on-going optimization of operations. The journey begins with critical asset reliability and expands to include plant-wide systems and “smart operations”.

Forty of the largest global pulp and paper manufacturers provided input for this white paper. Key insights revolve around how they are achieving better plant and equipment availability by adopting condition monitoring and management systems to improve asset reliability and plant operations.

While there is no “one size fits all” approach to condition monitoring, the applicability across pulp and paper manufacturing plants is universal and the impact, significant. Condition monitoring systems, augmented by AI (artificial intelligence) and ML (machine learning), are forging the way for plant-wide adoption, catalyzed by higher-order benefits and on-going operational optimization.

In the pulp and paper industry, maintenance is one of the major cost components of OpEx (operating expense). Maintenance, however, is crucial, as it impacts commercial risk, plant output, product quality, production cost, safety, and environmental performance. In addition, ever-increasing regulations to reduce carbon emissions have made it harder for pulp and paper manufacturers to remain profitable. To assuage this issue, pulp and paper mills must find environmentally friendly solutions that boost production and maintain quality at reduced maintenance costs. The answer lies in plant-wide condition monitoring solutions that can enhance safety while significantly increasing durability, reliability, availability, and productivity by avoiding breakdowns. As a result, these solutions help pulp and paper plants increase profitability.

Maintenance – A silent profit killer

Ten percent of revenue is attributed to maintenance costs in the pulp and paper industry. A significantly higher percentage than turbine manufacturing, car manufacturing, and the chemical industry. The machinery used to produce paper in large quantities and at high speeds is susceptible to damage and expensive bearing failures due to continuous operations. This affects the quality of the paper produced and increases maintenance and operational costs.

Downtime is a serious threat in any manufacturing business since a failure in one area could have a compound effect on other areas. Unplanned downtime, which could last longer than a couple of days due to asset unreliability, can lead to significant production losses. Of the total downtime in a plant, an estimated 63% is unplanned with only 37% being planned despite maintenance outages (planned downtime) of 4 to 24 hours being scheduled approximately every 4 to 12 weeks.

The most common reasons cited for unplanned downtime are machine unreliability along with pulping and pumping problems.

High production costs and lack of proper training also limit the ability to achieve a more proactive maintenance strategy, which in turn, can lead to greater problems.

Machine unreliability and maintenance issues are frequent and complex, and their solutions require special tools and expertise that are not always available onsite. Excessive machine vibration in paper mills and critical equipment failure are key maintenance issues that affect the overall efficiency of the plant.

For example, paper mill pumps undergo immense strain due to the transfer of viscous material throughout the pulping and pumping process. Sludge and slurry contain high solid content, large amounts of entrapped air, and chemicals for screening, cleaning, and bleaching, causing issues such as pitting and cracking, and lead to increased maintenance costs.

Equipment in pulp and paper plants is also susceptible to dust and high operating temperatures, and therefore, regular quality control checks are critical. If not inspected regularly, the equipment will not work optimally, reducing utilization and

MANUFACTURING DOWNTIME

63% UNPLANNED DOWNTIME** **37%** PLANNED DOWNTIME

**Leading cause of unplanned downtime is poor machine reliability

The cost of downtime

Downtime is incurred, for example, in the rebuilding and mechanical repair for bubbling on the surface of a press roll and excess vibration in the suction roll, sealing strips, deckles, and cover. Cost estimates for these repairs (and downtime) are **\$100,000–\$120,000 #** per day, including the 5 hours of downtime.

Similarly, issues with dryer sections, such as felt wear, line shafts, gearboxes, dryer can bearings, and frame wear can cost between **\$10,000–\$60,000 #** to repair and **\$100,000 #** to replace, along with one to two days of downtime.

– US Dollars

increasing production costs. The failure of pulp and paper equipment can cost plant operators between \$10,000 and \$20,000 US dollars per hour on average. The maintenance of operating equipment requires troubleshooting expertise and skilled operators, which can be a significant challenge. A dearth of onsite expertise can escalate into significant—and costly—production delays.



How to avoid the pitfalls associated with unplanned maintenance

Major pulp and paper manufacturers are looking to implement advanced condition monitoring systems to detect potential problems at the earliest stages of manifestation. This is absolutely essential in order to mitigate the negative risks of unplanned events. Condition monitoring systems also help monitor assets in real-time to collect and provide critical information to determine the potential cause, severity, and impact, and recommend corrective action. These systems can predict potential failures around 60–90 days in advance, allowing for timely maintenance decisions.

Pulp and paper plants primarily rely on traditional rule-based SCADA monitoring. The downside of SCADA systems, however, is that they cannot identify potential failures in instances where manually set thresholds are not breached. Over 80% of plants cannot calculate the complete cost of unplanned downtime—mainly because it is too complex to track all the cost components associated with unplanned downtime—though losses from unscheduled downtime can reach up to \$220,000 US Dollars per day on average in a pulp and paper plant.

To overcome this challenge, major pulp and paper operators are optimizing production lines to save energy and enhance the quality of the final product, while opting for extensive automation packages at the same time. These consist of machine process controls and quality controls, smarter maintenance solutions through sensors, monitors, and software that leverage data, analytics, and augmented reality, and the latest wireless technology for improved asset reliability.

Predictive and proactive maintenance is critical for the effective and efficient performance of the pulp and paper industry and can eliminate or reduce the effects of heat and dust on machinery and equipment. Faults in a single machine could ultimately delay the entire production process and lead to extremely high costs.

60–80%
OF ALL EQUIPMENT MALFUNCTIONS IN PULP AND PAPER MILLS ARE CAUSED BY INCORRECT OR LACK OF MAINTENANCE.

Moving from reactive to proactive asset maintenance

Asset condition monitoring technologies come in three forms: predictive, corrective, and reactive. Typically, in reactive and corrective technologies, the possibility that severe damage has already occurred by the time the problem is detected is high, leading to the replacement of several components. Reactive asset condition monitoring technologies are generally last-resort remedies, while corrective technologies do not detect a developing fault until some collateral damage occurs in the operating equipment.

Advancements in condition monitoring technology, such as systems with Advanced Analytics, Artificial Intelligence (AI) and Machine Learning (ML) capabilities, enable operators to detect a developing fault before it causes lasting collateral damage. This allows plant operators to carry out maintenance and reliability assessments strategically and proactively rather than in a tactical/reactive manner.

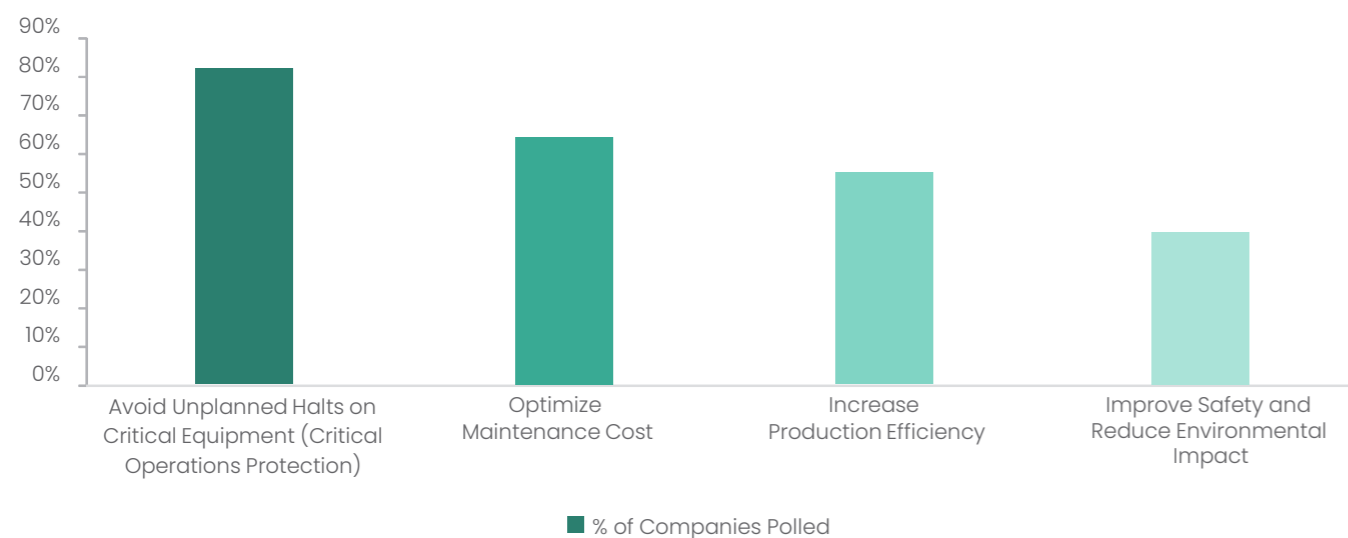
Benefits of condition monitoring

The main reason pulp and paper companies adopt condition monitoring technology is to track and address problems as soon as they develop to prevent disastrous outcomes. Condition monitoring compares measured physical parameters against known engineering limits to detect, analyze, and correct problems before failure. Many leading top pulp and paper companies have realized 30–40% savings over reactive maintenance and 8–10% savings over preventive maintenance. In general, companies can reduce maintenance costs by 10–15% annually using condition monitoring systems. Pulp and paper companies are mitigating this silent profit killer using condition monitoring systems to eliminate 40% of parent-roll tears during the converting process and 30% reduction in waste associated with the chipping process.

Key benefits of proactive condition monitoring

- Eliminate startup trips due to improper configuration and installation
- Ensure equipment health and optimize maintenance planning
- Minimize maintenance costs and downtime (a silent profit killer)
- Prevent data loss for events
- Improve safety and reduce environment impact

Triggers to installing condition monitoring systems



Applications of condition monitoring in the pulp and paper industry

Pulp and paper operations are prone to harsh environments; hence, major condition monitoring suppliers offer specific hardware and software offerings for efficient condition monitoring solutions. In the pulp and paper industry, condition monitoring is most often used with the following assets:

ASSET TYPE	ASSET	MAINTENANCE ISSUE	FAILURE CRITICALITY
Processing Equipment	Conveyor Belt, Chipper, Chip Classifier, and Agitator	Bearing Failure, Lube Oil Failure, Overheating	High
Rolling Equipment	Felt Roller, Spreader Roll, Suction Roll, Yankee Cylinder, and Drying Cylinder	Bearing Failure, Lube Oil Failure	High
Electrical Equipment	Electrical Motor, Compressor, Pump, Fan, Gear, Switch Gear, and Transformers	Bearing Failure, Lube Oil Failure, Overheating	Medium-High
Ancillary Equipment	Vacuum Pump	Bearing Failure, Lube Oil Failure, Overheating	Medium

Infrared thermography is used to inspect electrical systems, motors, and mechanical equipment for heat loss and leakage throughout the plant, liquid levels in boilers and other vessels, kiln walls for refractory breakdown, and steam traps and process lines for blockage.

Infrared thermography is also used to check lime silo product levels, material buildup in lime kilns, sludge level in storage tanks, and to detect problems in wet end vacuum pumps.

Vibration monitoring refers to the use of vibration analysis to detect and diagnose issues in equipment. It can be conducted as a continuous process or scheduled to detect changes over time. Condition monitoring systems help predict potential mechanical failures before they occur by identifying abnormal vibrations in paper-making machines. The data collected can improve the performance of paper-making machines and increase uptime by preventing the need for repairs.

Poor lubrication or contaminants in lubricant cause increased emission levels. Acoustic emission analysis is used to detect overload, cracks, lubrication problems, and machine faults.

Motor current signature analysis uses current and voltage to detect upcoming failures in pulp and paper mills at an early stage.

Key condition monitoring techniques used in the pulp and paper industry include:

TECHNIQUE	APPLICATION
INFRARED THERMOGRAPHY	Chipper, Chip Belt Conveyor, Lime Kiln, Recovery Boiler, Dissolver Tank, Black Liquor Processing Tank, Steam Turbines, Bleaching Towers, Paper Machine Rolls, Guide Rolls, Calendar
VIBRATION ANALYSIS	Chipper, Chip Belt Conveyor, Steam Turbine, Bleaching Tower, Paper Machine Roll, Guide Roll, Calendar
ACOUSTIC EMISSION ANALYSIS	Chipper, Chip Belt Conveyor, Steam Turbine, Bleaching Tower, Paper Machine Roll, Guide Roll, Calendar
OIL ANALYSIS	Chipper, Chip Belt Conveyor, Steam Turbine, Bleaching Tower, Paper Machine Roll, Guide Roll, Calendar
ELECTRIC MOTORS	Motor Current Signature Analysis

Major operational risks in pulp and paper manufacturing

Chipper: High vibration and continuous loads can cause breaking of chipper blades, which can damage the system. Proper vibration analysis to constrain vibrations under set limits can reduce this problem.

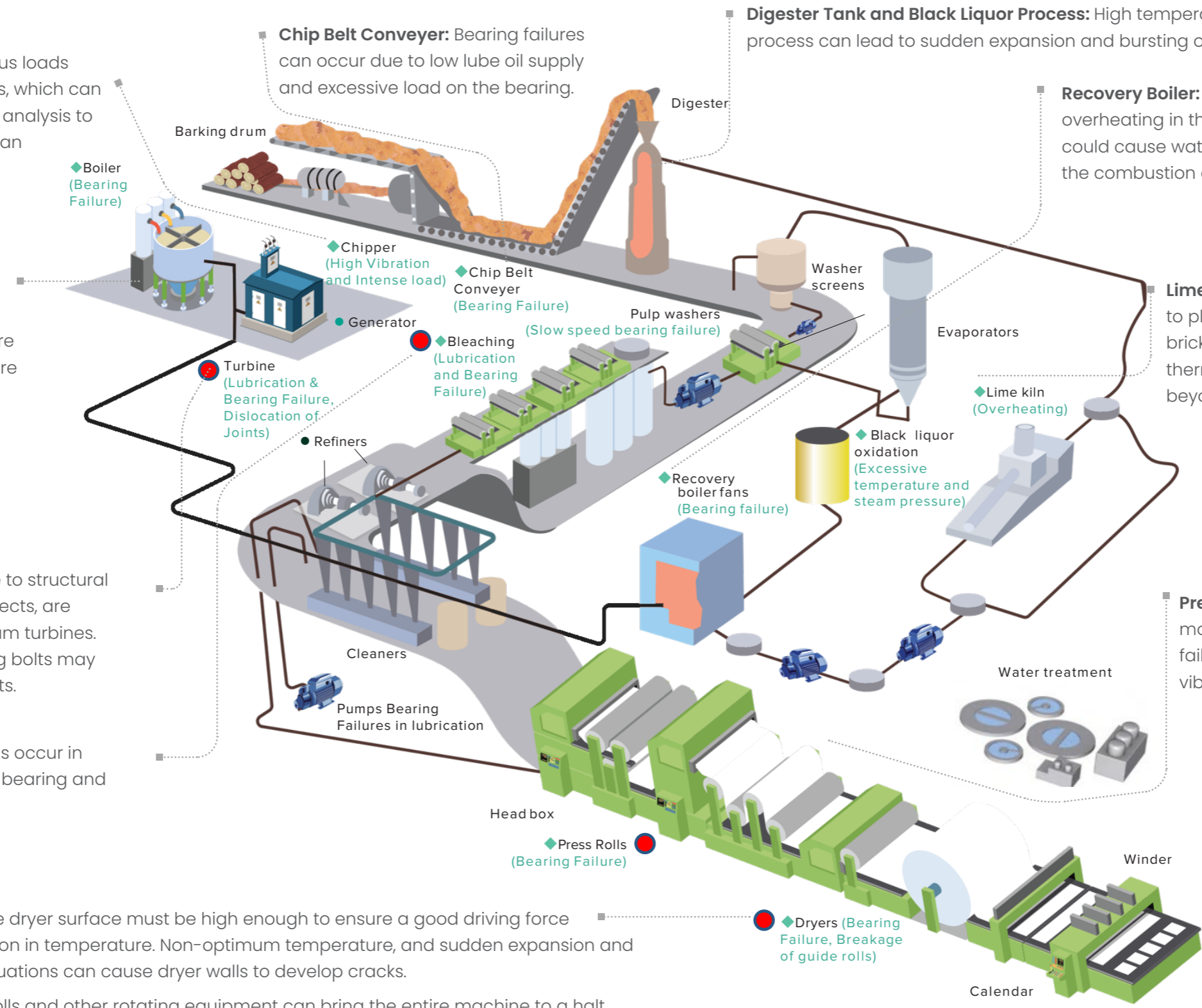
Boiler and Turbines Run on Hog Fuel: Chip and sawdust waste are used as biomass fuel to run boilers and steam turbines. These turbines are prone to lubrication and bearing failure problems that can be mitigated with proper vibration and lube oil analysis.

Steam Turbines: Bearing failures, due to structural misalignments and lubrication oil defects, are the major issues associated with steam turbines. While in operations, the turbine casing bolts may get loosen causing dislocation of joints.

Bleaching towers: Common problems occur in rotating parts and gear boxes due to bearing and lube oil failures.

Dryer Section: The temperature of the dryer surface must be high enough to ensure a good driving force for heat transfer without any fluctuation in temperature. Non-optimum temperature, and sudden expansion and contraction due to temperature fluctuations can cause dryer walls to develop cracks.

Drying Cylinder: Breakage of guide rolls and other rotating equipment can bring the entire machine to a halt, while bearing failure, a major issue in drying cylinders, can be analyzed and reduced by vibration analysis.



Digester Tank and Black Liquor Process: High temperature and steam pressure formed in the Kraft process can lead to sudden expansion and bursting of pipes.

Recovery Boiler: Proper thermography analysis can prevent overheating in the boiler section, which, if left unattended, could cause water tubes to explode, leading to waterlogging in the combustion chamber.

Lime Kiln: Overheating of the casing can lead to plastic deformation and detachment of brick linings; this can be avoided by using thermography analysis to identify overheating beyond a rated capacity.

Press Rolls: Paper press rolls have many moving and rotating parts prone to bearing failure that can be reduced with the help of vibration and laser.

Most critical nodes that need condition monitoring

Critical Nodes: Paper press rolls, dryers, and bleaching towers are most critical equipment that require condition monitoring followed by pumps, motors, and turbines.

Choosing the right condition monitoring solution

Condition monitoring is a sophisticated process that involves real-time monitoring and supervision of complete machine conditions throughout operations. Condition monitoring solutions are deployed at pulp and paper facilities to monitor machine health, detect potential failures, and improve reliability. Some of the key equipment protected by condition monitoring solutions include pumps, electric motors, fans and steam boilers. Nodes that are most susceptible to failure include rolling element bearings in the facility, bleaching units, press rolls, dryers and turbines.

On-premise vs. Cloud deployment

Typically, condition monitoring systems are implemented on-premise or hosted on a cloud server. On-premise deployment is the more conventional implementation of condition monitoring systems, giving organizations complete control over data. However, the installation, setup, and maintenance cost for on-premise condition monitoring deployment is considerably high. On the other hand, cloud deployment carried out via third-party vendor support helps enterprises understand the real-time condition of the machinery in their mills remotely. A key advantage of using cloud deployment is that implementation and maintenance costs are significantly lower since no IT and data storage hardware needs to be on-premise. Cloud deployment also provides easier, remote access to critical data. Some of the key risks of using cloud deployment, however, include data security, data loss potential, and higher long-term costs when compared to on-premise deployment.

Portable condition monitoring v/s online condition monitoring

In condition monitoring systems, online monitoring of critical assets that have an immediate impact on machine safety and the environment is carried out. Solutions utilize a sequence of sensors permanently mounted on critical machines that transmit data to plant operators either through a wireless network or a cabled network.

In the pulp and paper industry, online condition monitoring systems are particularly useful for machinery operated 24/7 and placed at hazardous and remote locations. Online systems can provide information about process performance and generate alerts of problems that might otherwise go undetected.

Portable condition monitoring is preferred in periodic maintenance and when there is an indication of unusual performance in the production process. These solutions consist of handheld devices that collect data temporarily for further analysis. Benefits include cost-savings and longer equipment life due to flexibility in route-based machine monitoring.

The perfect trio of hardware, software and services

Ideally, condition monitoring systems are a combination of hardware, software, and services, that provide a broad, connected view of machines operations. This allows operators to mitigate risk, boost safety, and reduce maintenance costs while improving equipment reliability, uptime, and efficiency. Key hardware components include vibration and infrared sensors, spectrometers, ultrasound detectors, spectrum analyzers, and corrosion probes. Data collected from these hardware components are processed by software solutions such as data integration, diagnostic reporting, order tracking analysis, parameter calculation, and signal processing. A variety of software solutions based on different technologies and feature functions are available in the market. Service support such as outsourced expertise for set-up and condition analysis services is critical for a successful condition monitoring program.

Condition monitoring enables a real-time view of machinery condition from a remote location, enabling problem alerts that might have otherwise gone unnoticed.



Condition monitoring can save hundreds of thousands of US Dollars annually

The selection of a condition monitoring system is influenced by many factors. There are two types of condition monitoring suppliers: pure condition monitoring system providers and integrated solution providers. More than 85% of the top 40 pulp and paper companies use integrated solutions.

Reasons for preferring contract-based suppliers of condition monitoring systems include flexibility of suppliers (short setup time, cost reduction), technical capability of suppliers (maintenance activities, flexibility of production systems compliance with quality and quantity), and on-time delivery.

Plant-wide predictive maintenance using condition monitoring systems offers increased equipment reliability and advanced information to improve planning, thereby reducing unexpected downtime and operating costs. This helps reduce maintenance costs and improve production efficiencies.

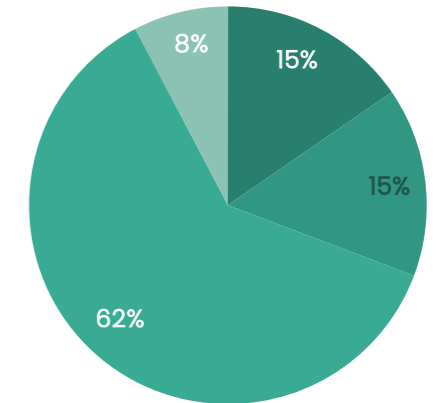
Leading pulp and paper companies prioritize equipment for condition monitoring based on criticality.

Trends by major geographic regions

NORTH AMERICA ACCOUNTS FOR 42% OF THE GLOBAL PULP AND PAPER INDUSTRY REVENUE

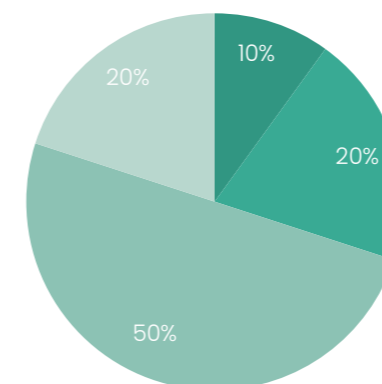
- Annual maintenance spend for more than 62% of manufacturers is \$50 to \$100 million US dollars.
- About 23% of North American pulp and paper manufacturers are using AI- and ML-based condition monitoring systems for operations.
- An estimated 62% of manufacturers in this region have opted for localized procurement, with about 38% expected to move to centralized procurement in the near future.
- About 23% of North American pulp and paper companies have adopted plant-wide condition monitoring.

MAINTENANCE BUDGET
(NORTH AMERICA), 2019



- Above \$200 MM US Dollars
- \$100-\$150 MM US Dollars
- \$50-\$100 MM US Dollars
- Below \$50 MM US Dollars

MAINTENANCE BUDGET
(EUROPE), 2019



- \$150-\$200 MM US Dollars
- \$100-\$150 MM US Dollars
- \$50-\$100 MM US Dollars
- Below \$50 MM US Dollars

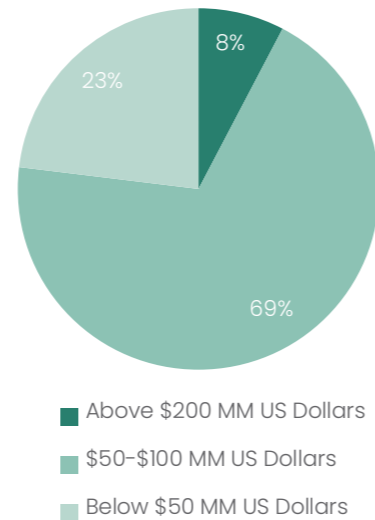
EUROPE THE EUROPEAN MARKET HAS ABOUT 26% OF THE PULP AND PAPER GLOBAL REVENUE

- The average annual maintenance spend is \$50 to \$100 million US dollars though about 30% spend more than \$100 million US dollars.
- While 20% of European pulp and paper manufacturers are using AI- and ML-based condition monitoring, about 50% are interested in adopting it.
- An estimated 30% of manufacturers in this region are using centralized procurement, with 70% expected to move to centralized procurement in the near future.
- Adoption of plant-wide condition monitoring comprises about 20% of pulp and paper implementations in Europe.

ASIA PACIFIC ACCOUNTS FOR 25% OF THE GLOBAL PULP AND PAPER INDUSTRY REVENUE

- Annual maintenance spend for this region's manufacturers is \$50 to \$100 million US dollars with 8% of manufacturers spending more than \$200 million US dollars.
- About 70% of Asia Pacific pulp and paper manufacturers are interested in using AI- and ML-based condition monitoring systems for operations.
- An estimated 85% of manufacturers in this region are using centralized procurement.
- Plant-wide condition monitoring is nascent, with about 15% of pulp and paper companies interested in its adoption in Asia Pacific.

MAINTENANCE BUDGET
(ASIA PACIFIC), 2019



Top players create IoT systems and models for various processes, such as detection and prediction of overloads on motor driven pumps and planning of production volumes for pulp and paper. For example, companies are investing in statistical analysis and machine learning applications which can assist in the graphical representation of process parameters over a period of minutes/hours/weeks. This can help identify patterns and schedule maintenance accordingly.

A major advantage of using IoT in condition monitoring systems is that it can enable proactive remote support and a fast and efficient way to ensure that optimal paper quality is achieved. Around 30% of the major global pulp and paper manufacturers are interested in implementing IoT-based systems to optimize their operations, while some 33% have actively implemented AI/ML functionalities into their condition monitoring systems, having realized the benefits for their operations.

Several major players in the global pulp and paper industry, such as International Paper, Kimberly-Clark, WestRock, and Georgia-Pacific, have already started implementing condition monitoring systems to measure the performance of their assets.

The road ahead

The rising adoption of cloud-based condition monitoring enables use of the latest technologies, such as the Industrial Internet of Things (IIoT) and advanced analytics, to make pulp and paper processing safer and more efficient. Having equipment interconnected through the cloud and other communication technologies allows for cloud-based predictive maintenance. A recent trend is to transform operations into 'smart plants', where maintenance is data-driven, with sophisticated sensor infrastructure deployed to keep equipment condition the prime focus.

The survey reveals that around 30% of the top 40 players in the pulp and paper industry are already using condition monitoring systems but are looking to upgrade systems with AI/ML capabilities. One of the primary drivers for the adoption of Artificial Intelligence and Machine Learning based condition monitoring systems is the significant decrease in the cost of data storage and transfer, as well as a drop in the pricing of computing power. Additionally, major pulp and paper companies have begun to recognize the potential impact that AI and Big Data can have on revenue and cost.

Companies tend to use machine learning models built with raw data variables, which can help inexperienced operators detect breakdowns earlier. By understanding data patterns, companies can optimize their production processes and increase their efficiency. Assets across facilities worldwide are monitored in real-time using AI, which reduces data processing time by more than 80%.



Improving risk mitigation

Global pulp and paper manufacturers are looking for condition monitoring systems that are flexible and easily integrated with existing ERP (enterprise resource planning) systems. In addition to monitoring asset health and performance, reducing energy consumption and lowering carbon emissions from operations are emerging as key trends. Further, the adoption of advanced technologies such as smart sensors, Industrial Internet of Things (IIoT) and Big Data, provide operators with real-time data and 3D animation to support training, operations, and maintenance functions.

In pulp and paper operations, condition monitoring helps ensure that repairs are based on using data from condition monitoring systems in accordance with best-in-class industry practices. Condition monitoring solutions and suppliers must meet the highest standards and increase asset management and productivity. Some condition monitoring solutions offer knowledge-based process measurement capabilities and collaborative operational centers to manage consistency and perform regular audits, resulting in higher uptime and quality for pulp and paper mills. Companies operate collaboratively between onsite personnel and remote experts who can access the same information and scrutinize analytics together; to help onsite managers make faster and better decisions.

Bentley Nevada is fully committed to support the pulp and paper industry maximizing asset output. To help companies achieve more reliable operations, Bentley Nevada has partnered with MarketsandMarkets to conduct an industry-wide survey to bring out the major issues in the pulp and paper industry. The survey results show that almost 60–80% of equipment malfunctions in the industry are due to improper or lack of maintenance.

Bentley Nevada condition monitoring system

For over 60 years, Bentley Nevada condition monitoring systems have been helping customers assess their goals, identify reliability gaps in current operations, and implement the appropriate corrective actions and strategies to keep operations running smoothly. Bentley Nevada machine condition monitoring solutions combine advanced hardware, intelligent software, and trusted service and support—providing a broader, connected view of operations. These systems enable pulp and paper operations to mitigate operational risk, enhance the safety of operations, and reduce maintenance costs.

Bentley Nevada condition monitoring solutions generate significant savings annually

Bentley Nevada condition monitoring system includes equipment such as wireless sensors and portable data collectors and analyzers which are brought together onto one unified software platform, System 1™, to provide asset monitoring and diagnostics. System 1 also provides scalability solutions and can be designed for diverse applications and equipment failure modes at pulp and paper facilities. Based on the maintenance requirements of operators, the Bentley Nevada condition monitoring system can be implemented as a portable, wireless, or tailored plant-wide solution.

Bentley Nevada also provides Bentley Host™, a condition monitoring software-as-a-service model that allows businesses to implement condition monitoring and machine health monitoring without large capital outlay.

One of the major advantages of Bentley Host is that it combines the delivery of hardware, software, and services into a single, secure offering that allows businesses to increase their reliability and availability with ease.

Pulp and paper operators can leverage the capabilities of Bentley Nevada to make real-time, condition-based decisions for predictive maintenance programs with a single monthly subscription fee. By implementing the Bentley Nevada condition monitoring system, actionable insights based on asset health can be developed to optimize outage and maintenance planning. This can result in a 5–10x cost reduction compared with unplanned and reactive outages. Bentley Nevada also offers cybersecurity solutions to ensure that pulp and paper plant systems are up-to-date and protected from continually evolving threats.

Key advantages of Bentley Nevada condition monitoring solutions:

- User-driven condition monitoring and diagnostic workflows
- High resolution trend, alarm, and startup/shutdown data
- Modern and intuitive interface and continuous user involvement
- Remote portable data transfer
- Best-in-class rolling element and hydrodynamic bearing diagnostics
- Scalable, integrated solutions that protect assets, plants and global operations



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to speak with a subject matter expert
about your pulp and paper operations.



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The research used in this whitepaper has been commissioned by Bently Nevada†, a Baker Hughes business, and underwritten by MarketsAndMarkets Research Pvt Ltd, the world's largest revenue growth advisory firm. MarketsandMarkets™ provides quantified B2B research on 30,000 high growth niche opportunities/threats which will impact the revenues of 70–80% companies worldwide. Almost 75,000 top officers across eight industries worldwide approach MarketsandMarkets™ for their painpoints around revenues decisions. We have 850 fulltime analysts and SMEs tracking global high growth markets following the Growth Engagement Model (GEM). MarketsandMarkets's flagship competitive intelligence and market research platform, KnowledgeStore, connects over 200,000 markets and entire value chains for a deeper understanding of unmet insights along with market sizing and forecasts of niche markets.



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