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Proactive maintenance is the key enabler of smart production in the metal industry

How leading metal manufacturers are redefining plant availability via proactive asset reliability

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Metal is an essential part of the global economy, used extensively across building, infrastructure and transportation industries. The time-tested versatility of steel and other alloys continues to enable modernization and technological advancement around the world.

Staying competitive in metal manufacturing requires reliable and efficient operations. Simultaneously, increasing pressures from commodity, energy, and compliance costs together with fluctuating demand, underscore the need to achieve new levels of production efficiency.

Unplanned downtime - the bane of manufacturing - must be minimized significantly in order to achieve next-level operational optimization, maintain safety and preserve profitability. The key to mitigating unplanned downtime is the improvement of asset reliability. Leading metals manufacturers are achieving increased uptime, efficiency and profitability while reducing maintenance spend. Outcomes show a reduction of maintenance cost as a percentage of RAV (Replacement Asset Value) by 60%, from 5% of RAV to 2% of RAV.[1] The key enabler is proactive maintenance via condition monitoring systems, the gateway to smarter metal manufacturing and a stronger future.

The adoption of proactive maintenance has led the metal manufacturing industry on the path to transformation. This whitepaper presents survey insights from 20 of the largest global manufacturers of metals, who stress a clear and urgent need to improve plant and equipment availability, reduce maintenance costs, and enhance asset reliability. Over the next few years, the adoption of new maintenance strategies, along with the use of the industrial internet of things (IIoT), artificial intelligence (AI), machine learning (MI), and other emerging Industry 4.0 technologies will be vital for the profitability of the metal industry.

Maintenance is both a crucial capability and a major operating expense in the metal industry. The far-reaching impacts of maintenance span commercial risk, plant output, product quality, production costs, safety, and environmental performance. Rising raw material and energy costs put additional pressure on profitability. Further amplifying this pressure on metal manufacturers are the increasingly stringent regulations to reduce carbon emissions. As a result, operators must find solutions to enhance production and reduce maintenance costs.

Leading metal manufacturers are fully embracing proactive maintenance solutions. By leveraging pre-failure alerts, repairs can occur at the lowest possible maintenance cost and with minimal or no operational disruptions.

Maintenance: A path to profit

Maintenance accounts for almost 10-15% of the production cost in the metal industry. Despite this steep cost, maintenance approaches are not optimized and are more reactive in nature, which leads to incremental—and often unnecessary—costs as well as unplanned downtime. Additionally, improper maintenance negatively affects product quality, resulting in reduced efficiency and delayed return on investment.

Downtime, especially when unplanned, is a major threat in manufacturing environments since a failure in one area can have a snowball effect in other areas. **Despite an average of 10–12 hours of maintenance (planned downtime) being scheduled every 1-2 months, an estimated 60% of the total downtime in a plant is unplanned.** Unplanned downtime starts with functional failure and often triggers a cascade of negative reactions and escalating costs that lead to losses in production and profit.

In metal manufacturing, the most common reasons for unplanned downtime are machine unreliability and incidents in blast furnaces, crushers, and conveyor belts. Each piece of metal manufacturing equipment requires specific care and attention. Gas boosters and exhausters in a coal chemicals unit handle coke oven gas, a highly inflammable commodity, whereas sinter plant blowers and waste gas fans handle air containing highly abrasive sinter dust. Even the turbo-generators of a captive power plant require round-the-clock vigilance involving a variety of parameters. Additionally, the seemingly innocuous forced draft and induced draft fans of the reheating furnaces are crucial as their failure can reduce hot strip mill/plate mill production by 33-50%.[2] Operational parameters in these equipment, such as excessive machine vibration, high temperature, and mechanical stress, when not proactively monitored, can lead to critical equipment failure.

Machine unreliability and maintenance issues are frequent and complex in metal production, and resolving them requires special tools and expertise that are not always available on-site. Globally, skilled workers are retiring at record rates. Facing decreasing levels of **skilled operators,** in some cases, creates difficulty in attracting the right type and amount of talent needed to bridge the growing on-site knowledge gaps.

To mitigate such risks, major metal manufacturers are adopting proactive maintenance systems that can proactively detect and isolate potential problems at their inception. This is essential to avoid the negative, and often irreversible, effects on production through unplanned events. Proactive maintenance systems help monitor assets in real-time to determine the potential cause, severity, and impact of impending failure and recommend corrective action before failure occurs. These systems can typically predict potential failures about 3-4 months in advance, allowing for timely and cost-effective maintenance. The use of proactive maintenance systems can result in at least a 5% improvement in the availability of critical equipment.

Preventing unplanned maintenance costs

Maintenance approaches in metal plants rely primarily on traditional manual survey methodology and techniques. Many plants are unable to calculate the precise cost of unplanned downtime—mainly because it is highly complex and consists of multiple first-order and second-order cost components. However, estimated losses from unscheduled downtime in a metal plant can reach up to $500,000 USD per day, on average.

To mitigate the risks of unplanned downtime, save energy, and enhance the quality of the final product, metal operators are optimizing production lines. Leading companies are opting for extensive automation packages, with machine process and quality controls, and smarter maintenance solutions using digitalization, augmented reality, edge computing, and analytics.

IMPROPER MAINTENANCE LEADS TO **60-70%** OF ALL EQUIPMENT MALFUNCTIONS IN METAL PLANTS.

Evolving maintenance trends in the metal industry

Maintenance approaches to asset health are of three types: reactive, preventative, and predictive. Reactive asset maintenance activities are last-resort remedies as corrective measures that do not detect a developing fault until collateral damage occurs in the operating equipment. This is an outdated and inefficient way to conduct maintenance when technology enables more sophisticated and cost-effective methods.

Preventative maintenance refers to regular, routine maintenance to keep equipment up and running and preventing unplanned downtime and increased costs due to unanticipated equipment failure. For example, one machine may require lubrication for every 100 hours of operation, while another may require an inspection on an annual basis. Most large metal manufacturers are moving away from this labor-intensive approach because of its high upfront cost and complex nature.

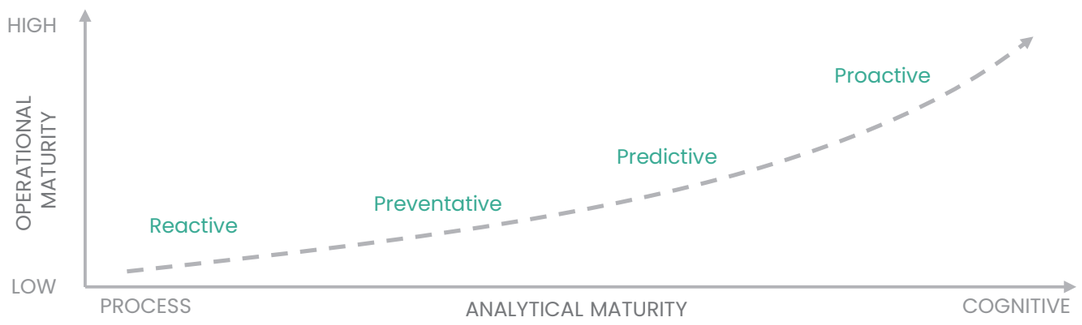
The metal industry has been using condition monitoring in a piece-meal or limited manner for over 20 years as a predictive strategy to monitor critical equipment and identify performance changes in the health of equipment or its components. Condition monitoring helps predict unplanned downtime and plan scheduled maintenance to increase the reliability of the equipment by measuring physical parameters against known engineering limits to detect, analyze, and correct problems before failure. However, proactive maintenance, a new wave of maintenance strategy still in a developing stage, is being hailed as the next level of reliability and maintenance best practices.

The future of asset reliability in metals belongs to proactive maintenance

Proactive maintenance uses advanced analytics to not only make predictions about maintenance, but also act on those recommendations. Proactive maintenance requires that various asset management and maintenance systems be well integrated. Implementing this approach across an enterprise would send a work order to field technicians based on this information and oversee the entire maintenance workflow.

Proactive maintenance couples the condition-based data of predictive maintenance with the failure mechanism to act prior to a downtime event and thereby avoid the predicted damage to the asset. This cognitive approach draws on the inherent process and operational knowledge and uses big data, analytics, machine learning, and artificial intelligence.

Maintenance approaches



Comparison table between reactive, preventative and proactive maintenance

MAINTENANCE APPROACHES	BENEFITS	CHALLENGES
Reactive	• Maximum utilization and production value from asset • No upfront cost to manage • Minimal maintenance staff needed	• Unpredictable and inconsistent downtime • High costs associated with fixing machine failures. • Repairs tend to be urgent which may require overtime labor
Preventative	• Lower maintenance costs • Less equipment malfunction and unplanned downtime • Increases asset lifespan	• Need for spare part and inventory management • Increased planned downtime • Maintenance on seemingly perfect assets.
Proactive	• Increased efficiency due to minimized downtime • Streamlined asset maintenance and reduced downtime; recommends maintenance only when required • Flexible reliability management in terms of recommendations about plant maintenance	• Culture: Depending on the level of trust in technology in an organization or the long-held beliefs of what maintenance is and how it should be carried out, there may be significant hurdles to implementing proactive maintenance.

Capabilities of Condition Monitoring systems

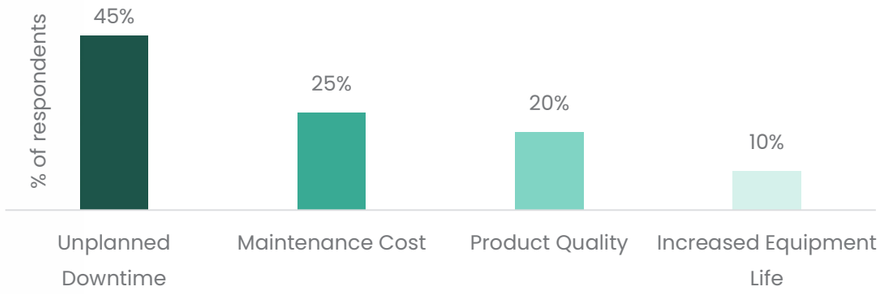
- **Automation:** As automation increases in manufacturing, the speed of response required in dealing with maintenance issues becomes faster. Automation also enhances worker safety.
- **Operating conditions:** Assets fail both by their own means and the manner in which they are operated. For instance, a pump manufacturer will recommend specific operating design conditions such as discharge pressure and temperature but with significant variabilities in process operating conditions such as pump speed and the composition of the fluids. Proactive analytics consider these parameters and also makes recommendations accordingly.
- **Asset performance:** A high level of sophistication is required to organize assets and process data. Traditional plant historian and analysis tools are not adequate to ensure asset performance. This has given way to IIoT and analytics platforms that are unique in their ability to ingest years of operational data and massive quantities of unconventional data scattered through different systems of record.

Proactive maintenance using condition monitoring in the metal industry

Condition monitoring is vital to proactive asset management in the metal industry. It is used to control the operating condition of steel mills, which is essential to optimize profitability. Metal industry operations are prone to harsh environments; hence, major condition monitoring suppliers offer specific hardware, software and services for effective condition monitoring solutions. In the metal industry, condition monitoring systems are used to maintain plant availability, maximize foreshadowing time, and avoid secondary damages.

Triggers to install CM systems

The underlying triggers to adopting condition monitoring solutions are primarily unplanned downtime and also maintenance costs, followed by product quality and increased equipment life, as shown in the diagram.



Condition monitoring is most often implemented for the following critical assets in metal production operations:

ASSET TYPE	ASSET	MAINTENANCE ISSUE	FAILURE CRITICALITY
Sinter Plant	Casings, rotors, bearings, shafts, impellers, shaft seals, balance drums, couplings	Overheating, bearing failure, severe vibration	High
Blast Furnace	Conveyor belts, motors, gearboxes, pulleys, idlers	Bearing failure, electrical failure, overheating	High
Austenizing Furnace	Impellers, bearings, stators, rotors, terminals	Overheating, electrical failure, environmental issues	Medium
Annealing Line	Impellers, stators, rotors, terminals, bearings	Structural issues, bearing failure, belt failure, overheating	Medium
Process Pumps	Motors, impellers	Electrical and mechanical failure	Medium

Major operational risks in metal manufacturing

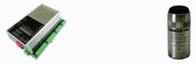
Bently Nevada Solutions

● Condition monitoring and protection

Orbit 60 3500 Series 2300

ADAPT 3701/40 1900/65A AnomAlert

■ Condition monitoring



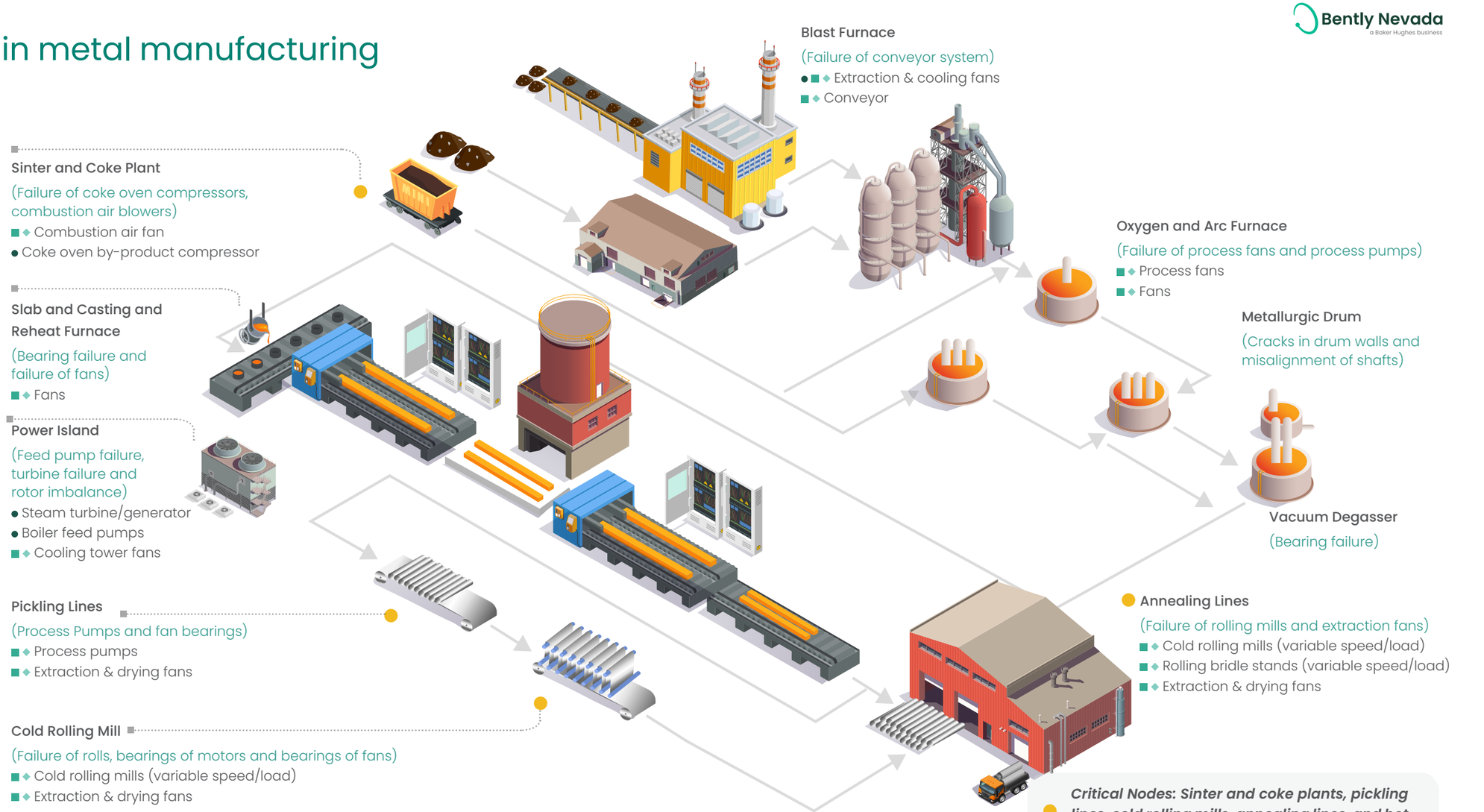
vbOnline Pro and Ranger Pro

◆ Portable data collection

SCOUT100, vbx series, and COMMTEST/SCOUT220/240

System 1—one platform, endless possibilities Improve equipment reliability, uptime and efficiency

System 1 represents Bently Nevada's flagship condition monitoring solution that seamlessly integrates with our industry leading products including online and portable devices. System 1 provides scalability by adapting to the condition monitoring requirements at your facility, as well as flexibility by connecting to any Bently Nevada's field devices.



Sinter and Coke Plant (Failure of coke oven compressors, combustion air blowers)

- High temperatures severe vibration can result in failures.
- This can be reduced through vibration analysis and temperature monitoring.

Slab and Casting and Reheat Furnace (Bearing failure and failure of fans)

- Lack of lubrication, excess pressure, and structural misalignment results in the failure of fans in the reheat furnace section.
- Oil analysis and position monitoring can help in maintaining such nodes.

Power Island (Feed pump failure, turbine failure and rotor imbalance)

- Overheating of motors and body of the feed pumps are the main causes of failures.
- Vibration analysis, temperature analysis, oil analysis and position monitoring are steps to mitigate such failures.

Pickling Lines (Process pump and drying pump failure):

- High temperature and improper lubrication are the major causes of such equipment failures in this node.
- Temperature monitoring can address such failures.

Cold Rolling Mill (Failure of rolls, burning of motors and bearings of fans)

- High stress and temperature are the key reasons for such failures.
- Proper thermography along with vibration and oil analysis can prevent such damage.

Blast Furnace (Failure of conveyor system)

- Overheating, lack of proper lubrication and misalignment of a belt can cause such failures.
- Such failures can be addressed using- Oil analysis, position monitoring, vibration monitoring and current monitoring.

Oxygen and Arc Furnace (Failure of process fans and process pumps)

- High pressure causes undue stress on bearings and seals leading to such failures.
- Vibration analysis is a useful technique in mitigating this issue.

Metallurgic Drum (Cracks in drum walls and misalignment of shafts)

- Uneven temperature and sudden expansions and contractions are the root causes behind the issues.
- Temperature monitoring and vibration analysis can assist in resolving such issues.

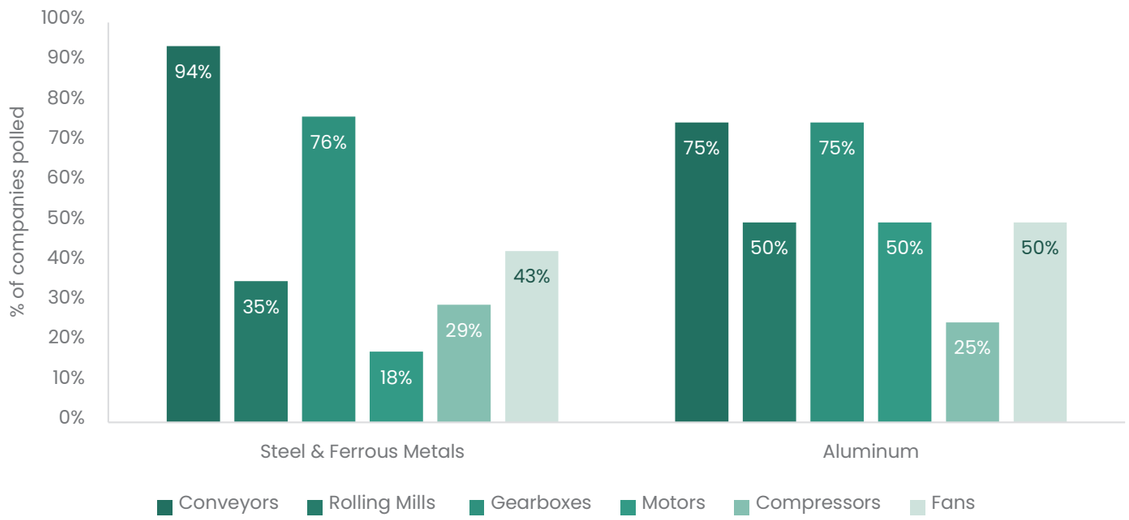
Vacuum Degasser (Bearing failure)

- Failure in this node occurs mostly due to excess load and lack of lubrication.
- This issue can be resolved using pressure monitoring and oil analysis.

Annealing Lines (Failure of rolling mills and extraction fans)

- Excessive load and overheating of rolls result in the failure of fans, motors and misalignment of rotor shafts.
- Oil analysis, position monitoring and vibration analysis can prevent such damages from occurring.

Metal manufacturing assets with high frequency of failure



Data from the top 20 metals manufacturing companies suggests that conveyors and gearboxes fail more frequently than other equipment. As such, steel and ferrous metal producers focus more on monitoring the health of conveyors and gearboxes, as do aluminum-producing companies. Different condition monitoring techniques, such as temperature analysis and vibration analysis, can improve the operational efficiency and working condition of these assets leading to lower incidences of failure.

Choosing the right condition monitoring solution

In metal plants, condition monitoring is used to monitor machine health in real-time and detect potential failures before they occur. All condition monitoring solutions, however, are not created equal. Here are some of the features and benefits to consider.

On-premise vs. Cloud deployment

Typically, condition monitoring systems are deployed on-premise or hosted on a cloud server. On-premise deployment is the conventional method, giving organizations complete control over data. By implementing a cloud-based solution, facilities can minimize the on-site required infrastructure, licensing, installation setup and maintenance costs for the software component. Cloud deployment provides faster access to critical data and prompt alarms while leveraging third-party expertise and remote monitoring without the investment of on-site hardware.

Portable condition monitoring vs. online condition monitoring

In condition monitoring systems, online monitoring and periodic portable condition monitoring are often blended throughout a plant. Critical assets that have an immediate impact on machine safety, environment, and production are monitored via a sequence of permanently mounted sensors that transmit data to plant operators through a wireless or cabled network. Online condition monitoring systems are particularly useful for machinery operated 24/7 and situated at hazardous and remote locations. Remote monitoring can enable system-wide process automation in steel mills by incorporating vibration measurements along with load current measurements for rapid sampling to better understand the dynamics of fan loads.

Portable condition monitoring is used for periodic maintenance and when unusual performance in a production process is indicated. Handheld devices are used to temporarily collect data for further analysis.

Hardware and Software

Optimal condition monitoring systems use a combination of hardware connected via a software hub to integrate disparate data sources and provide insights via industry-tailored algorithms. Major 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.

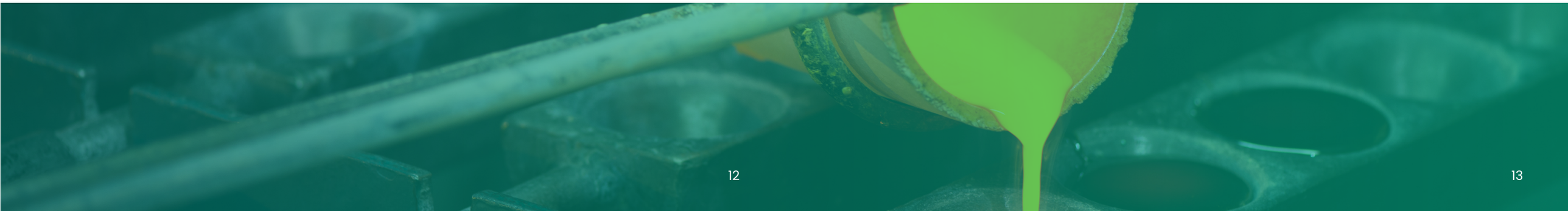
Plant-wide condition monitoring

Plant-wide condition monitoring, as the name implies, is the monitoring of all eligible vibrating and rotating machinery in an industrial plant. It requires the adoption of a unified system of monitoring hardware, software, and analysis system support. Within this unified system, the unique criticality and failure modes of each machine should dictate the appropriate monitoring hardware used on it; from portable data collectors to continuous and online.

Among the metal companies surveyed, more than half have shown an inclination to adopt plant-wide condition monitoring in the near future, and a few have already started on that path. Plant-wide condition monitoring offers increased equipment reliability—holistically—to enable proactive insights that improve planning on an operation-wide scale. Likewise, the benefits of plant-wide condition monitoring systems are greater in magnitude and scale as compared to other localized, critical equipment condition monitoring efforts.

AI, ML and IIoT forging the future

The rising adoption of cloud and AI-based condition monitoring will usher in the use of novel capabilities and Industry 4.0 technologies, such as the industrial internet of things (IIoT), machine learning (ML), artificial intelligence (AI), and advanced analytics, to make metal processing safer and more efficient.



Interconnecting equipment through cloud and other communication technologies allows for effective cloud-based proactive maintenance.

Metal manufacturers taking the lead with AI, ML, and IIoT-based condition monitoring systems have shown an 18% increase in their gross profit, with savings of up to $2 million USD per year, thus paving the way for the increased adoption of industry 4.0 enabled condition monitoring systems. Likewise, with the help of plant-wide condition monitoring incorporated with IIoT solution, production managers can schedule and execute proactive maintenance on key machinery. One of the ways it can be done is via vibration sensors which estimate motor vibration frequency and temperature.

Bently Nevada condition monitoring system

In metals manufacturing, reliability and optimization are the keys to a successful future. Unreliable assets have enormous consequences. Industry studies show that the average facility spends approximately 5% of its Replacement Asset Value (RAV) on maintenance each year. In comparison, best performers spend 60% less—just 2% of RAV—while enjoying better uptime, efficiency, and profitability. It is not about simply spending less on maintenance but about working differently—working smarter—to achieve more reliable steel production operations.

For over 60 years, Bently Nevada condition monitoring system has been enabling customers to run plant operations smoothly with minimal unplanned downtime. Bently Nevada solutions combine advanced hardware, intelligent software, and trusted service and support—providing a broader, connected view of operations. These systems enable metal industry operators to mitigate operational risk, enhance the safety of operations, and reduce maintenance costs.

Condition monitoring systems vary by application and operational details. A catastrophic failure in a metal plant can impact an estimated 10% of daily production. By implementing condition monitoring systems, these catastrophic failures can be eliminated, saving close to $500,000 USD per day in maintenance costs.

Metal industry operators leverage the capabilities of Bently Nevada to make real-time, condition-based decisions for proactive maintenance programs, enabling a 5-10x cost reduction compared to unplanned and reactive outages. Cybersecurity solutions are available to ensure that metal plant systems are up-to-date and protected from ever-evolving threats.

Reduce maintenance costs by **5-10x**	Save approx. **$500,000 USD per day** in maintenance costs	**60%** reduction in maintenance cost as a % of RAV

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As those in metals manufacturing pivot their gaze to the advancing proactive asset reliability landscape, Bently Nevada can assist in navigating the pathway to reduced maintenance cost, improved profitability and enterprise-wide reliability.

Appendix:

[1] https://www.bakerhughesds.com/condition-monitoring-steel-and-metal-production

[2] https://www.ndt.net/article/wcndt00/papers/idn135/idn135.htm

 # Maintenance cost as a % of replacement of asset value (RAV):

SMRP (Society for Maintenance and Reliability Professionals) defines that the metric - Maintenance Cost as a % of Replacement of Asset Value (RAV) - allows comparisons of the expenditures for maintenance with other plants of varying size and value, as well as to the benchmarks. The RAV is used in the denominator to normalize the measurement given that plants vary in size and value.

Please contact us at Bently.com to speak with a subject matter expert about your metal 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™ to discuss their painpoints around revenue decisions. MarketsandMarkets has 850 fulltime analysts and SMEs tracking global high growth markets following the Growth Engagement Model (GEM). Their 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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