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Case study of oil condition monitoring: A practical and effective solution for all tasks, from sample management and analysis to corrective measures

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Summary

An Austrian paper mill successfully implemented an in-house Oil Condition Monitoring (OCM) system to enhance predictive maintenance and minimize equipment failures. By upgrading to era**lab OCM**, a comprehensive solution with advanced analyzers and centralized software, the facility improved sampling efficiency, data accuracy, and maintenance response times. The structured hierarchical asset organization and QR-code-based tracking streamlined the oil analysis process, from planning and sampling to measurement and corrective actions. Automated alerts, historical trend analysis, and proactive decision-making have significantly reduced downtime and improved equipment longevity. This case study highlights the operational and strategic benefits of in-house oil monitoring, demonstrating how digital integration and real-time data access enhance reliability, efficiency, and sustainability in industrial maintenance. Concrete findings and real case examples have already underlined the benefits and usefulness of the investment.

1. Introduction

The relevance and benefits of oil condition monitoring as part of predictive maintenance in industrial environments are undisputed. A wide range of service providers and experts are available to support industrial companies in carrying out the various activities involved, from data analysis to the resulting actions. Alternatively, industrial companies can take responsibility for some parts or the entire process themselves.

By bringing oil condition monitoring in-house, companies get immediate access to results, eliminating the delays associated with third-party providers, and enabling rapid response to emerging maintenance issues, protecting against costly downtime and disruption.

Another benefit of in-house oil condition monitoring is that it fosters a culture of skills development and knowledge retention in maintenance teams. By training staff to carry out oil condition monitoring, the company promotes a deeper understanding of the condition of the equipment and encourages proactive maintenance practices from within. This approach not only improves confidentiality and data integrity, but also ensures a sustainable, self-contained maintenance strategy that adapts and evolves to meet the needs of the organization.

In the following chapters, a specific case study will be used to demonstrate a practical solution.

2. Introduction of the industrial plant

The paper in question mill can look back on a hundred-year history of paper production. The company is specialized in producing high-quality, multi-coated fine papers and label papers, serving premium publications worldwide. Annually, it produces a significant amount of paper and pulp for internal use.

Figure 1: Exemplary representation of a paper machine

Overall, the paper mill exemplifies a blend of historical expertise and modern innovation, contributing significantly to both the local economy and environmental sustainability.
From a sustainability and reliability perspective, a team of several professionals attaches great importance to proactively assessing the condition of the systems. In addition to evaluating vibration data and recording the technical condition of the system, the subject of oil condition monitoring has also been a top priority for many years.

3. Overview of the structure

The entire site has been structured into almost 100,000 objects in a hierarchical structure. It was proven to be most sufficient to have 7 different levels:

- Organization (7)
- Segment (6)
- Site (5)
- Location (4)
- Asset (3)
- Component (2)
- Sampling point (1)

The lowest level "Sampling point" (SP) is the object where potential oil samples are taken, and measurement data is stored. In total there are approximately 65,000 objects in the category of a sampling point. Oil samples are taken at 500 sampling points on a regular basis in frequencies between 6 and 12 months. This is organized in 9 measurement campaigns which also organize sampling sequence, responsibilities and required measurement parameters.

4. Implemented setup

There has been a technical solution in place since 2010. This was upgraded at the end of 2024 with era**lab OCM**, a system for oil condition monitoring developed and distributed by **era**lytics GmbH, a manufacturer of laboratory analyzers based in Vienna, Austria.
More specifically there are four analyzers and one software solution in use:
era**spec oil** – the **portable FTIR spectral lubricant** analyzer for fully automated determination of important parameters for the aging and chemical condition of oil, like oxidation, nitration and water content. Total Acid Number (TAN) and Total Base Number (TBN) can be predicted with a predefined chemometric model. The application for industrial lubricants in the paper mill focuses only on the prediction of the TAN. To improve the chemometric model, 20 samples were added with known reference values.
era**visc X** – the **compact and robust kinematic viscometer** is for testing of high-precision kinematic viscosity and density at any temperature between 15 °C and 100 °C. In this case samples are mainly measured at 40 °C but in some cases the Viscosity Index (VI) is also determined.
era**oil** – the stand-alone **rotating disc electrode spectrometer (RDE-OES)** analyzing wear metals, additives, and contaminants in all kinds of operating liquids, like lubricating oils, fuels, coolants, process water, etc.
For the present application, 26 typical elements are determined with a maximum concentration of 1000 ppm. The typical detection limit (LOD) in the range of 1 ppm is also completely sufficient for practical purposes.
era**count XS** – the **small ISO 4406 laser particle counter** which measures with laboratory precision from a relatively small amount of sample.
era**test ferro** – the **ferrous debris analyzer** for determining the total content of ferromagnetic wear particles in oils and greases.
era**soft OCM** – the **software to support the operator** in essential parts of the management, operation and maintenance of technical facilities. In the area of preventive maintenance, particular significance is attached to oil condition monitoring. The software has been installed on several local clients and the database is located on a central server, where regular backups are also created. Different user levels have been defined to allow user-specific access.

*Figure 2: era**lab OCM** analyzers for in-house oil condition monitoring*

5. Data migration

The existing data from the previous instrumentation was taken over in full and included the following categories:

- Object and master data including structure
- Measurement campaigns with assignment of the sampling points
- Historical samples with measured data in numerical form
- Historical measurement reports as PDF

The transfer of data was provided in the form of comma-separated text files (CSV) and via Microsoft™ Excel files. The import into the database was carried out via the generation of SQL commands with the help of Microsoft™ Excel's feature called Power Query. This function follows the "Extract, Transform, Load (ETL) process" and enables conversion of a wide variety of data into a desired and structured form using the "M" scripting language. The ETL process remains repeatable and can be easily adapted. The data was therefore transferred directly into the database and the PDF files were linked via a relative path.

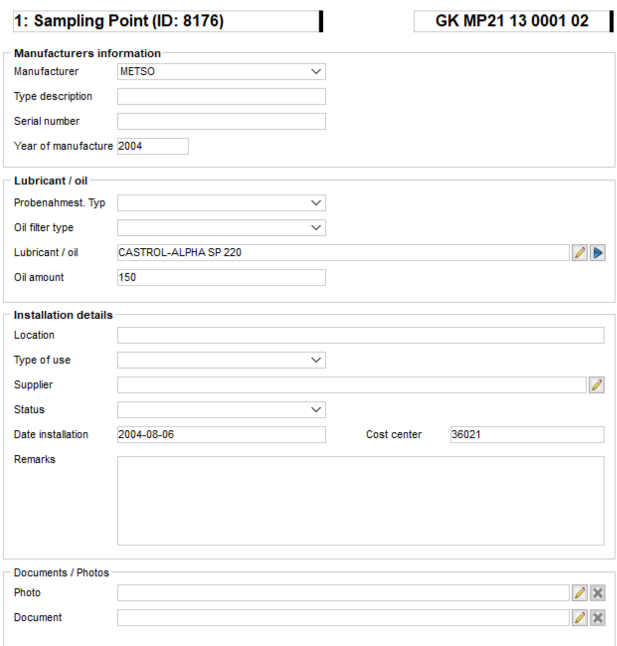

Figure 3: "Gearbox S2BV - 400JP" - Example of a Sampling Point (SP).

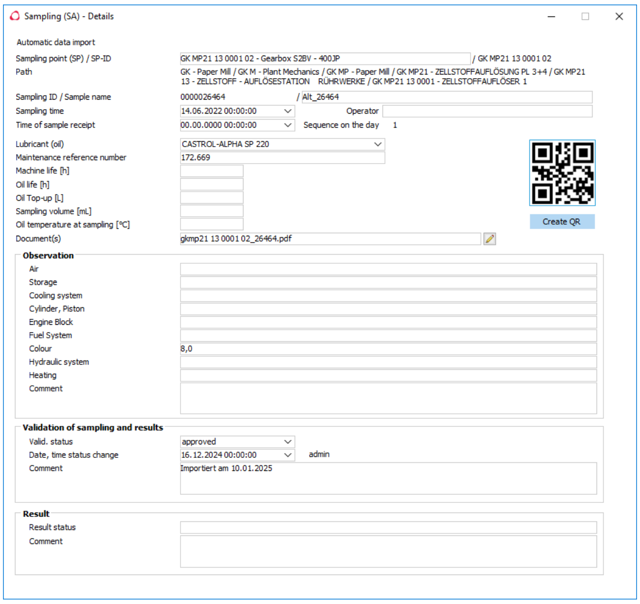

Figure 4: "Gearbox S2BV - 400JP" - Example of a sample taken 14th June 2022 with basic data and a link to a historical PDF report.

6. Oil Condition Monitoring (OCM) process

The paper mill follows a common approach, from planning sampling to defining actions based on the latest results, including historical data and fresh oil information.

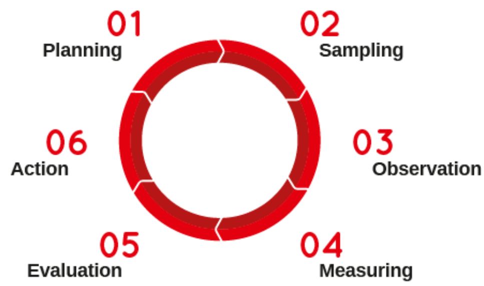

Figure 5: Process of oil condition monitoring

6.1. Planning (01)

Planning is carried out via the nine measurement campaigns, in which the respective sampling points are organized with regard to the planned term, responsibility and frequency. The necessary measurement parameters are defined for the individual sampling point, which can later be displayed via queries about the open measurements.

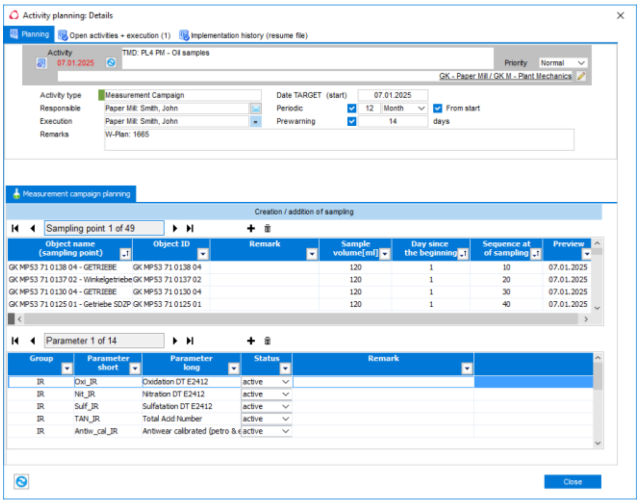

Figure 6: Example of a 'Measurement Campaign' with listed SP

6.2. Sampling (02)

If a measurement campaign becomes due, the responsible operator will be notified via email or in the software. Initial samples will be generated automatically with a new 10-digit Sampling ID and its corresponding QR-code. The sampling labels for the bottles can be printed or a sampling form can be used as an option to note down any required information during the sampling process.

Figure 7: Labels with Sample ID and QR code

6.3. Observation (03)

The whole sampling process is also supported by a mobile device, which is synchronized with the database. This enables the operator to identify the SP and to collect information and observation directly on this mobile device. The procedure takes place via a list that can be filled out step by step. At the end of the sampling process, the mobile device offers the option of photographing the sample bottle and the cap. All data is synchronized between the mobile application and the database as soon as the mobile device gets a network connection. This means that the mobile device can also be used offline in the factory.

6.4. Measurements (04)

As soon as the samples are in the laboratory, measurements can be taken on the measuring devices. Infrared spectroscopy and kinematic viscosity are determined for all samples. Particle counts are usually determined for hydraulic oils and ferromagnetic wear is usually determined for gearboxes. The measurement of elements present with the RDE-OES is not carried out automatically, but on an event-driven basis. The link between measurement results and samples is realized via the Sample ID. Therefore, before performing a measurement the QR code on the sample bottle needs to be scanned by a bar code scanner at the instruments.

*Figure 8: era**visc X** and era**test ferro** with individual bar code scanner*

In the course of processing the measurements, queries can be used to evaluate which planned measurements are still missing.

Sampling Id	Measurement campaigns Name	Sampling time	Validation status Sampling	Measuring instrument group Planned
0000100082	TMD: PL4 PM - Oil samples	01.02.2025	in progress	V
0000100093	TMD: PL4 PM - Oil samples	01.02.2025	in progress	PC
0000100082	TMD: PL4 PM - Oil samples	01.02.2025	in progress	IR
0000100082	TMD: PL4 PM - Oil samples	01.02.2025	in progress	PC
0000100204	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	V
0000100199	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	FD
0000100162	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	V
0000100197	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	FD
0000100204	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	PC
0000100197	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	IR
0000100197	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	V
0000100195	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	FD
0000100195	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	IR
0000100195	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	V
0000100196	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	V
0000100199	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	V
0000100196	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	IR
0000100193	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	FD
0000100193	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	IR
0000100193	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	V
0000100194	TMD: PL4 KAL RD RS - Liste Ölproben	24.02.2025	new	FD

Figure 9: List of samples with parameter groups (instruments) for which measurements are still to be carried out.

6.5. Evaluation (5)

After all measurements are done, the operator reviews the collected dataset. After all measurements are done, the operator reviews the collected dataset. If all the required samples have been evaluated a report will be generated or measured data checked directly in the data window.

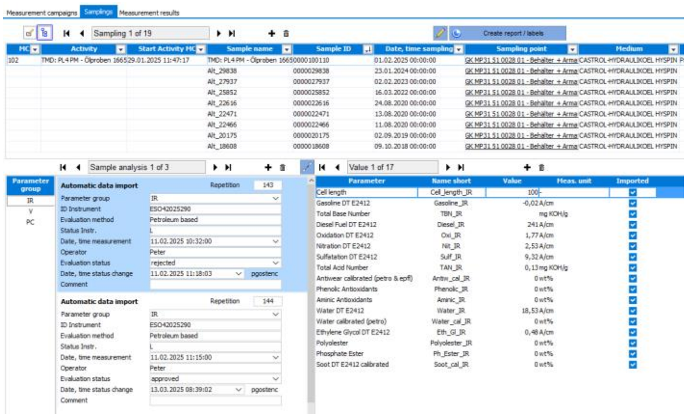

Figure 10: Infrared spectroscopy measurement data with different evaluation status.

At this point reports are typically printed together with historical data and reference values coming from the fresh oil. A report is generated on demand based on the data available in the database. If values exceed any warning or error level, these cells are marked with color.

Lubricant:	CASTROL-HYDRAULIKOEL HYSPIN AWS 46	Sample name:	TMD: PL4 PM - Ölproben 1665 0000100110
Operator:	John Smith	Measurement Campaign:	TMD: PL4 PM - Oil samples
Observation:			
Valid. person:	OCM-Admin		
Valid. status:	approved	Valid. date:	24.03.2025
Comment:			
Result status:			
Result comment:			

Sample ID			Fresh oil	0000100110
Date sampling			23.01.2025	01.02.2025
Time sampling			06:36:06	00:00:00
Date received				
Time received				
Machine life		[h]		
Oil life		[h]		
Oil Top-up		[L]		
Wear				
RDE	Silber	mg/kg	< 1	< 1
RDE	Aluminium	mg/kg	< 1	< 1
RDE	Kalzium	mg/kg	46	52
RDE	Chrom	mg/kg	< 1	< 1
RDE	Kupfer	mg/kg	< 1	< 1
RDE	Eisen	mg/kg	< 1	12
RDE	Mangan	mg/kg	< 1	< 1
RDE	Nickel	mg/kg	< 1	5
RDE	Blei	mg/kg	< 1	< 1
RDE	Zinn	mg/kg	< 1	< 1
RDE	Titan	mg/kg	< 1	< 1
RDE	Vanadium	mg/kg	< 1	< 1
Contamination				
PC	ISO_4um_PC	-	17	19
PC	ISO_6um_PC	-	15	17
PC	ISO_14um_PC	-	11	15
RDE	Kalium	mg/kg	< 1	< 1
RDE	Lithium	mg/kg	< 1	< 1
RDE	Natrium	mg/kg	< 1	< 1
RDE	Silizium	mg/kg	< 1	< 1
IR	Water_IR	A/cm	4,9	7,5
IR	Water_cal_IR	wt%	< 0,01	< 0,01

Figure 9: A section of a typical report with fresh oil and historical data printed in charts

6.6. Actions (6)

In the final step of the oil condition monitoring process actions are defined. Based on all information and measurement data available, the operator defines corrective actions for this component or asset. Based on a selection list, certain categories of activities are recorded at the sampling point level. Finally, the operator can schedule specific actions like 'oil change' to responsible professionals including notification via email and in the software application.

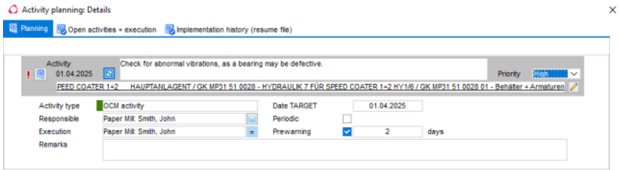

Figure 11: Definition of activities linked to specific objects including responsibilities

After the activity is concluded and marked as done, it is stored in the implementation history for future reference.

7. Specific examples

7.1. Hydraulic unit with the wrong oil

For a hydraulic system - roll transfer - with an oil volume of approximately 250 liters, it was determined that the wrong oil was filled by a service employee. The measured kinematic viscosity of 46 mm²/s with era**visc X** does not correspond to the desired viscosity class of an ISO VG 32. A new oil change is therefore the resulting activity.

Figure 12: Hydraulic system - roll transfer

7.2. A special roll with defective bearings

Outside of the normal sampling cycle, an oil sample from a tank with a huge amount of hydraulic oil for a cooling, hydraulic system and also the bearing lubrication as part of the Nipco-Roll was examined for metal particles. Damage with possible abrasion had already been confirmed, but the technicians wanted to know if the brass bearing could also be affected by abrasion. After the element analysis with RDE-OES (era**oil**) showed an increased copper content of 59 ppm and a zinc content of 44 ppm, damage to the brass bearing was the obvious cause.

Figure 13: Hydraulic system for cooling and bearing lubrication as part of the Nipco-Roll

7.3. Elevated water content in a hydraulic oil

All samples are analyzed by the experts at the paper mill using FTIR (era**spec oil**) as standard. This was also carried out on a hydraulic oil from the airfoil system for the coating machine as part of the 12-month routine. The routine analysis revealed an increased water content of 0.39 wt% or 53.8 A/cm according to ASTM D2412. In the course of a subsequent activity, the seals of the system must be checked and, if necessary, the lubricant must be dried.

Figure 14: Hydraulic system from the airfoil system

8. Conclusion

The implementation of an advanced in-house Oil Condition Monitoring (OCM) system at an Austrian paper mill has proven to be a practical and effective approach for predictive maintenance. By upgrading to the era**lab OCM** system, the facility has successfully enhanced its ability to detect and address potential failures in lubrication systems, thereby improving operational efficiency, reducing downtime, and extending equipment life.

The structured hierarchical organization of assets and the integration of five state-of-the-art analyzers with a centralized era**soft OCM** software solution ensure seamless data acquisition, processing, and analysis. The automated sampling process, QR-code-based tracking, mobile-enabled observations, and synchronized databases improve reliability and accuracy, minimizing human errors. Additionally, the use of ETL-based data migration has facilitated a smooth transition from the previous system while preserving historical data integrity.

The OCM workflow, from planning and sampling to evaluation and corrective actions, ensures a systematic approach to oil analysis. Automated alerts, color-coded reports, and trend evaluations enable maintenance teams to make data-driven decisions efficiently. Furthermore, by incorporating historical and fresh oil data, the system allows for more accurate condition assessments and trend analysis, leading to proactive maintenance strategies rather than reactive interventions.

In summary, this case study demonstrates that in-house oil condition monitoring, supported by advanced analytical instruments and digital integration, delivers significant operational benefits. The approach not only enhances the reliability and sustainability of industrial processes but also fosters a culture of technical expertise within the maintenance team, ensuring long-term adaptability and performance optimization.