Condition-based maintenance holds potential for improving equipment reliability, performance

By Karl Faller, TI-Data

Editor's note: This is the first in an occasional series exploring cutting-edge technology and procedures, both within our industry and in others. These articles are published under the auspices of the IADC Future Technology Subcommittee, which is part of the IADC Advanced Rig Technology Committee. Future Tech vice chairman is Frank Springett of National Oilwell Varco.

In this article, Karl Faller, president of TI-Data, discusses an equipment maintenance system used extensively in other industries. While its applications in the drilling industry are increasing, the editors and the FT Subcommittee saw real benefit in providing more information on condition monitoring to a broader audience. Comments are welcome, pro and con!

Condition Based, Automated	Calendar Based, Ad Hoc
Proactive, predictive, as-needed	Preventive, Reactive, more costly
Based on operating condition	Calendar, Time, Task Based
Prioritizes actions	Limited Effectiveness
Mitigates unplanned events	All Events Treated the Same
Avoids catastrophe	Too much time on lesser priorities
Excellent success history	Failure rates, NPT stagnant
Makes the job easier, less manpower	Labor intensive
Ideal	Status Quo

CB/CBM maintains machinery based on its measured physical condition, not on the clock, calendar or running meters. Studies show that companies can use this practice to reduce costs and improve efficiency, according Karl Faller, TI-Data.

IN THE CURRENT economic environment, the need to reduce costs and improve performance of the asset base has never been greater. Drilling contractors have large capital assets that need to be managed efficiently.

While dayrates have increased substantially over the past few years, O&M costs have accelerated geometrically. Currently, dayrates are dropping and some existing long-term contracts are being renegotiated downward. It's difficult, if not impossible, to force an equivalent drop in O&M costs.

Condition monitoring/condition-based maintenance (CM/CBM) is a recognized "best practice" proven in the aerospace, aircraft and nuclear industries, all of which involve large capital investments and a "never can fail" operating environment. The purpose of CM/CBM is to eliminate the root cause of failures and anticipate the needs of the equipment. Repairs can be planned before they turn into major failures. Removing or eliminating unnecessary repairs/replacements from the work schedule manages maintenance more efficiently.

Asset performance management is optimized by developing CM/CBM systems based on reliability-centered maintenance (RCM).

Simply stated, CM/CBM is the philosophy and practice of maintaining machinery based on its measured physical condition, not on the clock, calendar or run-time meters. Maintenance is prioritized and scheduled based on the actual condition of the equipment in its operating environment. CM/CBM predicts how long equipment can continue to operate and when maintenance is needed, and indicates root cause of potential failures.

It maximizes the interval between scheduled maintenance services according to the equipment's condition, not broad-based statistical averages. It provides early warning of deterioration before failure, avoiding unplanned downtime and collateral damage. It maximizes useful asset life and eliminates premature replacement of functional components.

Establishing "just-in-time" maintenance and repairs based on machine condition maximizes asset performance, prolongs effective operating time, minimizes repair costs and eliminates the consequences of unplanned downtime. It reduces overall maintenance costs and maximizes financial returns.

A "BEST PRACTICE"

CBM manages for asset optimization. Studies by respected independent organizations have established it as a best practice and provided proof of its effectiveness.

The **Aberdeen Group** has done extensive studies on a large number of companies in manufacturing, processing and production. The company studies the practices of "best-in-class" companies; the top 20% performers in their industry based on peer-accepted key performance indicators (KPIs).

The studies show that top-performing companies develop corporate cultures of reliability and leverage investments in advanced asset performance management, including CM/CBM and RCM, to improve operational performance by asset availability, utilization and flexibility. They achieve exceptional results in terms of reducing maintenance costs and improving operation efficiency of the equipment.

The US Defense Department embraced RCM and CM/CBM decades ago and has proven its value through experience. Confidence in CM/CBM is so high that it is a specification in major equipment systems contracts. The F-35 Lightning II (Joint Strike Fighter) aircraft under development is being designed with a goal of no scheduled maintenance. Maintenance tasks will be entirely driven by condition monitoring.

MACHINE CONDITION

Condition monitoring uses direct monitoring, usually incorporating sensors, to provide data on the operating condition of critical assets. This determines the actual mean time to failure or loss of efficiency of critical equipment. It combines real-time or near real-time sensor data with operational and environmental factors to define true condition.

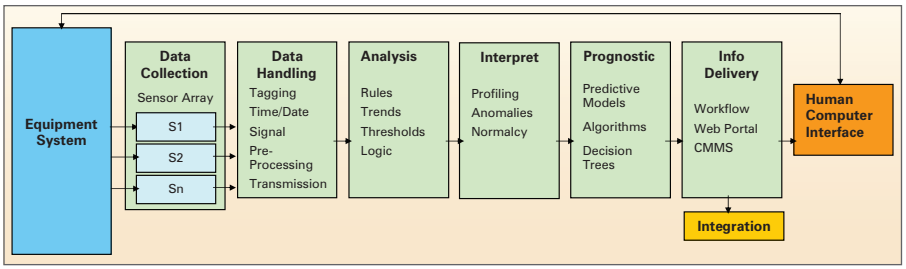
The Information Audit is the first step. An extensive audit – including RCM analysis, failure mode and effects analysis (FMEA), and asset criticality analysis – and a study of current practices will provide an understanding of failure, incipient failure, collateral damage and root cause.

Understanding failure occurrences requires an intimate understanding of the physics and engineering of the components. The study can find and define relevant indicators and enable design of instrumentation to collect relevant data.

From the data, algorithms can be developed to build equipment profiles, define normalcy, interpret conditions of interest and provide an overall understanding of the health or condition of the equipment. By monitoring the condition of components and interpreting relevant data from multiple indicators, failures can be prevented or warned about in advance.

IN DRILLING ENVIRONMENT

Drilling contractors are neither innovators nor early adaptors of CM/CBM. They are behind other asset-intensive industries in deploying this practice. It is not practical to engage CM/CBM for all critical assets in the drilling contractor environment. The system should be designed to identify and monitor the most critical assets where financial and safety values are highest. Performing an information audit categorizes assets according to criticality and failure history. CM/CBM design is applied to the top quarter of the quadrant, i.e., highest critical assets with the highest frequency of failure.



A CM/CBM system typically includes sensors, data handling, analysis and info delivery.

A CM/CBM system involves developing an asset management program that drives toward reducing scheduled maintenance and implementing interoperability of asset data across the enterprise.

Most drilling contractors engage in some form of CBM for specific components or problems. Use of infrared, thermal, UV guns; oil analysis; common instrumentation on equipment (oil pressure, engine temperature, etc) and other tools are found in maintenance practice with favorable results. In general, however, industry practice does not collect condition data for sharing and integrating into a holistic maintenance or asset management system.

Making the paradigm shift from reactive and preventive maintenance to a CM/CBM system for the most critical assets could be the single most important change to the management of the asset structure in the drilling contractor industry. CBM will positively impact uptime revenue and maintenance cost, and improve performance.

Drilling contractor senior management needs to build a culture of reliability. According to a recent survey, limited resources and management's lack of understanding of maintenance strategies are two of the most often cited barriers keeping organizations from implementing a more comprehensive asset management program.

Traditionally, the OEM position is that they deliver a "perfect" product when it leaves the factory. If it fails, it is usually attributed to end user actions (environment, improper installation, abuse, neglect, etc). Drilling contractors and OEMs need to collaborate using root cause information and build condition-generating information into the machinery to support CM/CBM.

PREVENTIVE MAINTENANCE

Preventive maintenance (PM) is widely practiced throughout the drilling contractor industry. It is an accepted management practice with an extensive support infrastructure. For the most part, it is calendar/time-based. Based on studies conducted by consultants and university labs over many years, time- or age-based is realistically the cause in only 11-14% of machine failures.

Some shortcomings of preventive maintenance compared to CM/CBM are:

- Calendar/time-based on historical statistical averages.
- Does not utilize integrated condition or operational data.
- Effectiveness in reducing costs is limited.
- Some inefficiencies due to time spent on lesser priorities.
- Does not mitigate unplanned incidents.

Wherever practical, the most critical assets should be monitored for condition rather than calendar/time-based preventive maintenance.

Comparatively, CM/CBM provides ease of use for end users:

- Directives, action plans (PMs) based on actual condition, not the calendar
- Efficient, eliminates guesswork.
- Eliminates secondary failure caused by PMs being skipped.
- Optimizes management of precious human resources.
- Eliminates human error and inconsistency.

INFRARED FOR INSPECTIONS

Transocean is integrating mechanical inspection, using the FLIR infrared system to troubleshoot, as a form of condition monitoring. One example is in monitoring the hydraulic accumulators used to stabilize their drilling equipment in the water.

In one case, on a rig with 20 accumulators, it became evident through the display of the FLIR systems camera that the bag on one of these units was exhibiting distinctly different thermal characteristics compared with the others. Further inspection revealed that the bag was full of hydraulic fluid rather than nitrogen. It had a substantial leak and, as a result, the accumulator was not doing its dampening job.

Although there were other accumulators to compensate for this failure, the problem would not have been picked up by the naked eye. Thermal imaging has become a vital part of Transocean's predictive maintenance procedures.

CASE HISTORY

The centrifuges of a water plant contain three bearings each. OEM specification calls for replacing the bearings annually. The plant was experiencing one or two failures on bearings before the annual replacement date, causing massive downtime and collateral damage.

A CM/CBM system was installed that monitors the bearings (vibration and

lubrication). Over the next few years, there were one or two failures detected in bearings less than one year old. Replacement was scheduled at a convenient time, and there was no collateral damage. The average life of the other bearings was two-plus years.

In essence, the original PM schedule of replacing the bearings annually was 100% incorrect. The benefit from eliminating the cost of unplanned failures and more than doubling the life of the bearings delivered a return on investment of over 10 times the cost of the system.

PROVEN BENEFITS

CM/CBM systems minimize unscheduled breakdowns and ensure that equipment is in acceptable condition. Problems are identified before they become serious, and asset management is elevated from using statistical averages to understanding real-time condition. Benefits include:

- Increased uptime/reduced downtime.
- Reduces/eliminates unplanned failures.
- Reduces overall maintenance costs.
- Improves equipment performance, KPIs.
- Increases asset life.
- Enables early repair.
- Reduces/eliminates collateral damage.
- Prioritizes actions and makes the job easier.
- Increases efficiency of maintenance management.

SYSTEM ARCHITECTURE

A CM/CBM system typically includes:

- Sensors/devices, instrumentation, other data feeds.
- Data handling (collection, processing, transmission, conditioning, formatting).
- Expert analysis, interpretation of data.
- Information delivery and workflow, including integration into computerized maintenance management system (CMMS) and other applications.

CB/CBM CONCLUSIONS

- It is a proven best practice for optimizing asset management.
- It maintains machinery based on actual measured physical condition.
- It prioritizes repairs according to greatest need and highest downside risk.
- It reduces overall maintenance costs.
- Assets with the highest criticality should be monitored for condition.
- It makes the job easier and more efficient for end users.
- It has proven benefits of uptime, extended asset life, better performance and reduce cost.

CM/CBM systems are evolving rapidly in other industries as newer technologies are developed. Nano-technologies are applied to create a new generation of self-powered sensors that can monitor minute changes in condition such as corrosion.

Many drilling contractors are studying and testing CM/CBM. The IADC Advanced Rig Technology Committee's Future Technology Subcommittee is studying the relevance and impact of technologies that can improve reliability and performance of equipment.

Article references are available online at www.DrillingContractor.org.

Karl Faller is president of TI-data, a technology and systems integration group specializing in the design, installation and management of condition monitoring systems for the upstream energy industry. He can be reached at kfaller@ti-data.com.