Condition And Performance Monitoring For Compression Machinery Is Available

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A new approach is available that offers practical, cost-effective monitoring of reciprocating, centrifugal and screw compressors. It is changing the way these assets are managed and providing higher cash flow, increased reliability and lower maintenance costs. Companies that operate gas compression equipment generally share the following objectives:

- High equipment availability,
- High reliability,
- Maximum throughput,
- High efficiency,
- Low maintenance cost, and
- Emissions and safety compliance.

Most personnel involved in the operation, maintenance, and management of these assets recognize that monitoring the performance and condition is required in order to truly achieve these objectives. They would agree that "you can't improve what you don't measure." Yet many of these same people recognize that they do not have an effective monitoring program – or maybe, no program at all.

The reasons for this situation are many and varied. For some companies it is simply not a corporate priority — perhaps for historical reasons. But others choose not to pursue a comprehensive monitoring program because they perceive, or may have experienced, practical difficulties:

- Costs of software/hardware (not just the initial purchase, but the ongoing maintenance and upgrading);
- Staffing issues (dedicated technical specialists must be recruited and/or trained; a senior reliability engineer; one or more technicians need to be involved);
- Staff turnover (which cripples a program);
- Challenges compounded by equipment in multiple, possibly remote, locations;
- Getting sufficient value from the program.

Despite these challenges, many companies continue to execute successful condition and performance monitoring programs. They have found that the benefits more than offset the costs and practical difficulties. Recently, new approaches to condition and performance monitoring address these issues while significantly reducing overall monitoring program cost.

Condition and performance monitoring programs for compression machinery cover a range of scope and intensity.

Scope

This refers to the characteristics to be measured which includes performance factors like throughput, various efficiency measures, energy cost, etc.; condition measures involving vibration, oil analysis, bearing temperatures, and the like; and indicators intended to ensure that loads and stresses on components due to current deployment are sustainable, such as rod loads and rod load reversal in reciprocating compressors.

Unfortunately, there is no single technology or process that is comprehensive in scope. For example, both vibration analysis and lube oil analysis are widely regarded as important components of a monitoring program – but they are very different technologies and procedures. As a side note, this fact has tended to turn the various types of monitoring into "silos," limiting the benefit that would come from a single program that is comprehensive in scope.

The scope of monitoring programs for centrifugal compressors, reciprocating compressors, screw compressors, gas turbines, reciprocating engines, and electric motors include some, or all, of:

- Front-line surveillance including inspection by operators to identify obvious problems; data collection via paper log sheets or hand-held data collectors; and automatic collection by a control system.
- Lube oil analysis including periodic oil samples by plant/station personnel, and analysis for oil properties and wear metals by a specialist laboratory.
- Vibration analysis including analysis of vibration signatures to detect mechanical degradation, usually a periodic inspection and occasionally online, real time for large, critical equipment.
- Engine and compressor inspections using specialized analyzers (analysis of resonant vibration vs. crankshaft angle, P-V curves; and portable, periodic or online, continuous).
- Infrared temperature including bearing temperatures, reciprocating compressor valves, and electrical switch gear.
- Analysis of operating parameters including

key indicators developed from processing operating data and normalized measures, deviations from baselines, trends, etc.

Ultimately, scope is defined by what equipment is to be included in the program and, on each piece of equipment, what measures are needed. The latter determines the data that must be collected from that machine and therefore which technologies will be utilized.

Intensity

This term refers to the frequency at which data is collected, the frequency at which data is analyzed, and the depth of the analysis. At this time and for the foreseeable future the state of the art is such that complete analysis ultimately involves a person. Computers can, and do, assist greatly with data reduction, analysis, presentation and reporting, but human interpretation and development of recommendations is required. So, the frequency at which data is analyzed through to development of recommendations is limited by practical considerations.

Data collection frequency can be quite high when the collection is automated. However, experience has shown that hourly data collection is generally adequate for the purposes being discussed here. Things that go wrong within a shorter time frame are handled by the machinery protection system. Operating data collected manually, either on paper log sheets or in hand-held data collectors, is often done daily, or once per shift. Vibration signatures and lube oil samples are usually collected monthly, though vibration data is sometimes collected more frequently when warranted. These frequencies are usually adequate to provide early indication of normal machinery component wear.


Compressor being built.

The depth of analysis should be whatever it takes to develop the desired measures of performance, condition and stresses, ideally in "real time." However, there will be some compromise, based on what data is available and how frequently. The analysis activity must include effective reporting with recommendations; this requires human involvement and places a constraint on the timeliness. Also, tracking of issues (unresolved issues, new issues, newly resolved issues) is a critical aspect of a successful program — and not that easy to do.

Program effectiveness is a function of both scope and of intensity. In principle, the broader

the scope and the greater the data intensity, the greater the benefit. However, at some point, the incremental costs for the program start to overtake the incremental benefits. In addition, we simply encounter practical limits to manpower. There is no exact methodology to determine the "right" scope and "right" intensity for your machinery. There is lot of industry experience to draw from, but caution is advisable — there are a lot of differing views. Consulting an independent reliability specialist, internal or external, is worthwhile.

Remote Monitoring

A unique challenge for gas compression machinery assets is that they are often widely dispersed. This makes it impractical and prohibitively expensive to have monitoring and rotating equipment specialists nearby to monitor the equipment.

Thus, it is now becoming the norm to have the machine data analyzed remotely – often by third-party machinery analysis companies. For a monthly fee per machine, the supplier takes on the data analysis, reporting findings and developing recommendations. The operating company must still own the program and have it integrated into internal processes, and also be an active participant in certain aspects. This outsourcing practice has significantly reduced the monitoring cost by centralizing analysis using expert systems/consultants. Considering just the analysis of operating parameters, vibration and lube oil, an outsourced program typically works like this:

- Operating data snapshots from the control system are saved on a minute or hourly basis. New Web-based SCADA systems are now available for remotely located sites.
- Operating data is automatically processed and interpreted by third-party machinery specialists. Alerts and recommendations are sent to the operators to avoid mechanical failures and to improve operations.
- Plant/station personnel collect vibration data once per month using equipment and training supplied by the analysis team; vibration data is forwarded to the analysis team via the Internet.
- Analysis team performs vibration review and develops recommendations on any immediate items.
- Plant/station personnel collect oil samples once per month using materials and training supplied by the analysis team; oil samples go to an analysis laboratory by the most expedient method.
- Analysis team interprets oil analysis results and develops recommendations for any immediate items.
- Each month, the analysis team develops additional higher level measures and issues an action oriented report — may include fleet management measures, optimization metrics, and emissions reporting. Recommendations for improvement are included.
- Plant personnel provide feedback on unresolved issues, new issues, and newly resolved issues.
- Analysis team tracks, and updates, unresolved issues, new issues, and newly resolved issues.
- Operating and maintenance personnel access reports and results, and provide feedback via Web interfaces.

Programs of this sort have proven effective in a number of different scenarios. While they still require commitment and dedication, many of the roadblocks are reduced, or eliminated. The probability of realizing the potential benefits is higher than with the typical internal, distributed program.

The Payback

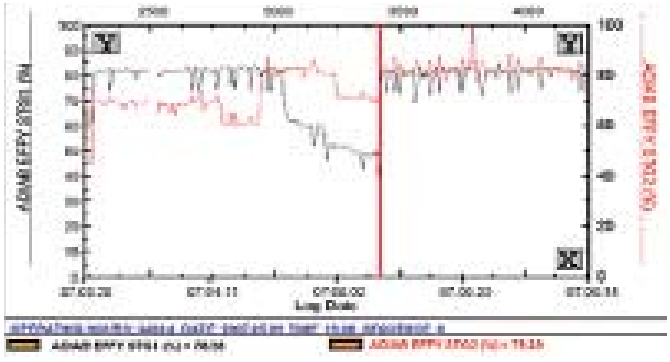
As shown from the various examples in this article, the payback is significant due to high availability and reliability of compression assets, early warning of problems avoids costly (and unplanned) downtime, lower maintenance costs, and consistent, easy to use and easy to manage monitoring program, where the vast

amount of raw data is converted to simple recommendations for the operations team.

Along with the advantages mentioned earlier, programs of this sort are increasingly popular in the compression industry because of two recent factors:

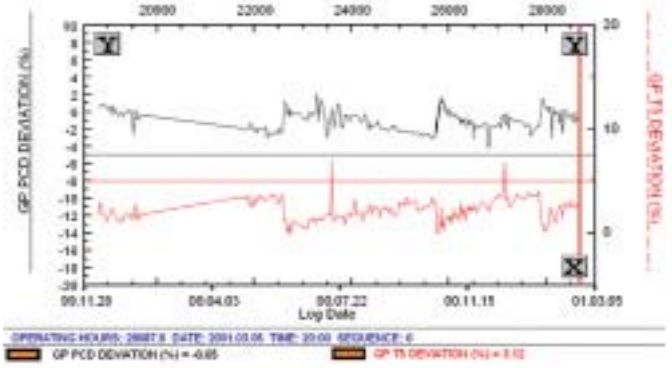
- The shortage of trained rotating and machinery experts, combined with the challenge of locating these people in the field;
- The dramatic improvement in Web-based monitoring programs. Outsourcing the data analysis is now possible from any location in the world and the cost has fallen due to improved SCADA, telecommunications, and centralized machinery consultants.

Remote Monitoring Examples.



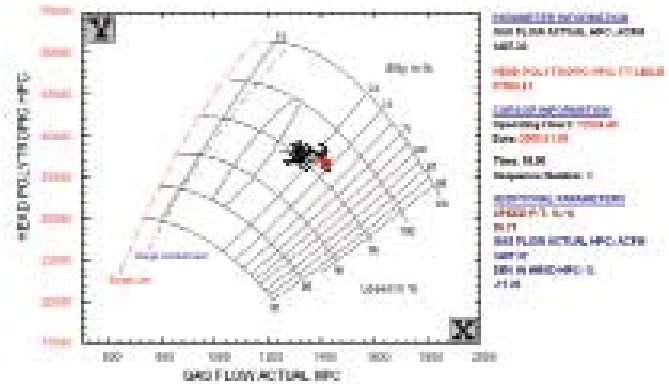
Example 1: Reciprocating Compressor Optimization

Monitoring program found efficiency of both stages of a reciprocating compressor trending down. Recommendation for correction was made and efficiencies restored. Unit throughput increased 10% — a substantial increase in cash flow.



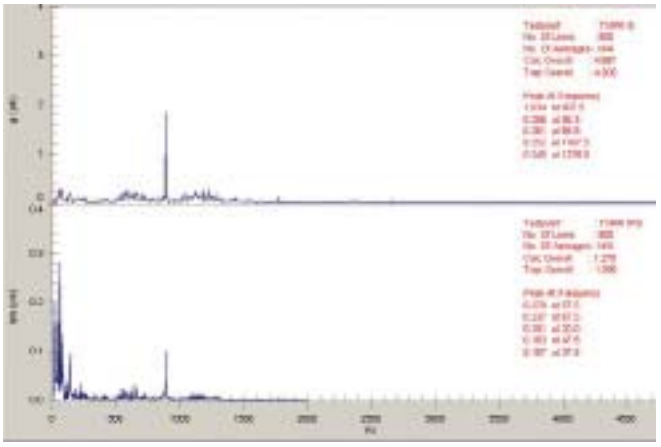
Example 2: Analysis Deviation in Operating Parameters

Monitoring gas turbine performance to schedule blade washes – compressor discharge pressure and turbine inlet temperature are monitored vs. the relevant baselines. Blade washes are planned as deviations become significant.



Example 3: Efficiency Monitoring

Centrifugal compressor performance is evaluated against baseline wheel curves for the particular unit. This unit had an 11% deviation in head at the point shown, likely due to impeller fouling, impeller wear and/or increased clearances.



Example 4: Vibration from Turbocharger

Vibration signatures from a turbocharger on a large engine showed increasing signs of distress.

Replacement was recommended. The recommendation was not followed. A major failure followed, resulting in $350,000 in repair costs plus lost production. ***P&GJ***

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