ODR and PdM?

Having moved from hydrocarbon processing to gas transmission compressor station operations we were quite taken aback by the commitment to automation in the pipeline industry and the resulting low manning levels. We remember stations with three 25 MW gas turbine driven compressor trains with three people on site – a multi-craft foreman, a mechanic and an instrumentation-digital specialist. This station would be operated in telemetry mode from a remote location. Anybody who is familiar with this environment must be rather surprised to hear people in the process industries talk about Operator Driven Reliability (ODR). They might be tempted to ask: Is there any other kind?

In all industries, reliability-focused companies recognize the critically important role of equipment or process operators. Best-in-Class companies are, therefore, poised to pursue ODR initiatives. Operator contributions are necessary because operators are the first to notice deviations from normal operation. They, the operators, are best equipped to understand the interactions between process and equipment behavior.

Some time ago we stated in this column that operators need training. Their responsibilities and accountabilities must be defined and "institutionalized." Institutionalizing means that their job functions and actions, their responses and the implementation steps they follow must become mandatory routines as opposed to optional routines. More than two decades ago, plants in California and Texas experimented with this concept; they called it the multi-skill approach and assigned operators certain ODR tasks.

ODR is nearly always part of a generally applied maintenance plan: a distinct group of activities that makes things happen, rather than simply suggesting what should happen. In the Handbook of Industrial Engineering, author Ralph Peters[1] outlines a number of common-sense steps. He strongly recommends starting with an overall strategic maintenance plan like TPM (Total Productive Maintenance), RCM (Reliability Centered Maintenance) and asks that the interested entity include defined goals and objectives for ODR within this plan. A top-notch reliability-focused facility would understand that ODR is a deliberate process for gaining commitment by operators to extend and augment an existing maintenance program by enabling operators to become actively involved in basic maintenance activities. Here are some examples:

- Keeping equipment clean and properly lubricated
- Keeping fasteners tightened
- Detecting and reporting symptoms of deterioration
- Making minor repairs and being trained to do them
- Assisting maintenance in making selected repairs
- Assuring communicating between maintenance, operators, and the rest of the total operation to gain commitment and internal cooperation
- Having teams evaluate/determine the best methods for operator cleaning, lubrication, inspection, minor repairs, and level of support during repairs
- Developing written procedures for operators and include them in quality and maintenance guides
- Evaluating the current predictive and preventive maintenance procedures

[1] See Peters, Ralph W., "Maintenance Management and Control," (in Handbook of Industrial Engineering," John Wiley & Sons, New York, 2001, pp.1585-1623)

and include those that the operator can do as part of ODR

Current ODR programs use electronic clipboards and software that allow critical operational information to be shared easily among all plant personnel. More sophisticated systems incorporate decision-support software system or DSS to equip an operator with immediate access to troubleshooting routines, maintenance advice and proposed remedial actions.

Connecting the foregoing to compressor operation, it would be well to integrate traditional proactive approaches, namely predictive maintenance (PdM), with ODR.

The term predictive maintenance is used to describe a range of technologies that help to detect incipient machinery faults before they can become a problem, allowing for maintenance personnel to order parts in advance, schedule manpower, and plan multiple repairs during a scheduled down-time. After a repair, PdM technologies are used to ascertain repair quality and close the repair cycle.

PdM systems for rotating and reciprocating equipment today apply a full array of sensor technologies, industrial computers, analytical and data management software to capture, trend, and diagnose vital information on operating conditions of machinery. Operators can be and already are part of this by using simple instruments to make first pass assessments of operating parameters such as vibration, temperature, pressure, lubrication viscosity, and others.

In the context of compressor operations, two PdM technologies have emerged as especially noteworthy: ODS analysis and lubricant analysis.

Operating Deflection Shapes (ODS) Analysis

Excessive vibration in machine bases, housings, and components can contribute significantly to the degradation of machine performance and premature end of service life. Operating deflection shapes (ODS) analysis provides an insight into the movements and associated problems of machinery as a function of frequency.

ODS is performed with a machine at its normal operating condition. It investigates the machine’s vibration response at a specific time or frequency. Both amplitude and phase information are collected at various locations on the structure and, using analysis software, the vibrating “shape,” or response of the machine, can be animated. These animations show the analyst “how” the machine is moving during normal operation; it allows an immediate assessment as to how much a machine is moving, where it is moving the most, and in which areas the deflection modes are present.

ODS data acquisition requires the same technical skills used for logging vibration trend measurements. In the past, measurements defining structural deformations required a basic knowledge of modal analysis and an understanding of its practical applications. With new advanced software and hardware systems, a machine ODS survey can be made following a defined measurement sequence using analysis software packages and structured procedures.

Lubricant Analysis

As another important component of PdM, lubrication inspection and analysis can help detect a problem and identify the cause. Not all lubrication inspections have to be performed in a laboratory and could be therefore, added to the ODR task inventory.

Clarity and water contamination can be observed in a standing sample; ferrous materials such as metal dust and filings, can be detected using a magnet drawn up the side of a glass jar containing lubricant diluted with a solvent; flow and discoloration can be noted in a bull's eye sight glass; and viscosity can be monitored using simple on-site tools.

Beyond these routine surveillance tasks lubricant analysis should target at least three critical areas:

• ***Machinery wear particles.*** In reciprocating compressors and splash-lubricated gear boxes, both having limited oil inventories, small wear debris can be measured by standard emission spectroscopy techniques. If there is a predominance of babbit bearings, Rotrode Filter Spectroscopy (RFS) is advisable.

For machines with rolling element or steel gear component wear as the primary failure modes, the appropriate method is Direct Reading Ferrography (DRF).

• ***Contamination.*** Selection of an analytical method for contamination will depend on the machine, lubricant, and environment. Contamination can be present in four different forms: gaseous, fluid, semi-solid, or solid. Test methods are usually selected according to the probability with which a specific contaminant may enter the machine's lubricating system or be produced within the machine.

• ***Lubricant degradation.*** Six standard lube oil analyses are required[2] for large inventory oil systems used for turbomachinery:

Appearance
Dissolved water
Flash-Point
Viscosity
Total Acid Number (TAN)
Additive content

When changes from degradation - not contamination - occur, the lubricant is overdue for changing, as sludge and varnish have begun to form in the machine. These changes should be considered "condemning" limits.

[2] H.P. Bloch and F.K. Geitner, *Practical Machinery Management for Process Plants*, Vol. 2, *Machinery Failure Analysis and Troubleshooting*, 4th Ed., Butterworth-Heinemann an Imprint of ELSEVIER, Amsterdam, New York, Heidelberg, London, Paris, Singapore, Sydney, Tokyo, 2012, pages 263-267.

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