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Keeping Condition Monitoring in Condition: a Manager's Guide

Author: Peter W. Hills, Dip. Man, MBA, FlntNDT, FlntDiag Engs
Managing Director & CEO Mechanalysis (India) Ltd.

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ABSTRACT

For the past forty years Condition Monitoring (CM) has been applied to process plant worldwide in virtually every industry with rotating machinery. India was not slow to adopt this strategy with programmes initiated in the early 1970s. The benefits of improved plant availability, optimised productivity and reduced maintenance costs are well known and reported widely.

India's remarkable economic development has its growing pains. Its lower cost skilled engineers are enticed by overseas employment and those with expertise in condition monitoring are able to attract premium earnings. As a result, many large Indian companies are frustrated at having to keep rebuilding their CM capability and are now resorting to outsourcing their CM services.

This Manager's Guide to keeping Condition Monitoring Programmes in Condition is hoped to act as a reference document. The paper reviews the market forces and history affecting the vendors specialising in condition monitoring. It then examines the key issues end users face when establishing and maintaining their CM programmes. The role the vendors need to play in ensuring long-term support services, product obsolescence and warranties is discussed. It concludes with a preliminary set of benchmarks by which vendors and users can apply for improving India Inc's. profitability through Condition Monitoring.

Keywords: Condition Monitoring, Vibration Analysis, Diagnostics, Acoustic Emission, Interactive Training, Obsolescence, Outsourcing. Beran, Commtest, Holroyd, Mobius, Mechanalysis, Sensorics.

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Keeping Condition Monitoring in Condition; a Manager's Guide

1. INTRODUCTION

In the 21st Century, Condition Monitoring is recognised by process industries as a strategic tool for optimising production and managing maintenance costs. CM comes under many guises: predictive maintenance, machinery health monitoring, proactive maintenance or condition based maintenance etc. Each applies a common approach; that is to detect, trend and analyse machinery condition against pre-determined thresholds. Higher than the norm levels, whether they be from vibration, acoustic emission, motor current analysis, wear debris in oil or thermal hot spots, are then analysed and related to the machine or process root cause failure mode. In the case of vibration analysis, the diagnostician is able to identify specific faults on rotating machinery such as unbalance, misalignment, mechanical looseness, gear meshing, bad bearings, resonance, etc. Preventing unscheduled plant outages offers significant productivity advantages and reduced maintenance costs.

Any programme of work is generally people dependent, condition monitoring (CM) is no exception. Vibration based CM on rotating machinery commenced in India during the early 1970s with one of the first computerised system for automatically trending data at GNVFC Baruch circa 1984/5 supplied by IRD Mechanalysis. Other complimentary techniques such as practical oil debris analysis, infra-red thermography etc soon followed. Today CM is accepted and operated across most Indian industry. Management has invested in people, hardware and software; the essential staff training and continues to upgrade facilities as a strategic business driver.

Despite these positive developments, Indian and perhaps global industry have progressively faced significant challenges over the last 10 years in maintaining their CM programmes effectively. The prime reason is continuity of expertise due to a high attrition of specialist CM engineers. Market forces and restructuring of equipment providers have also caused a diminution of practical expertise and early product obsolescence thereby frustrating the all important end users.

This paper addresses some of the main issues a company and Manager currently faces in **Keeping Condition Monitoring in Condition**.

2. MARKET FORCES

Vibration monitoring is the most widely applied condition monitoring technique in India and is the focus of this paper. We have seen that in the case of the original equipment manufacturers (OEMs) of vibration CM, there has been the greatest restructuring of this industry. The main pioneers were IRD Mechanalysis, Bentley Nevada, SPM, Bruel & Kjaer and Schenck. With the advent of the PC in the early 1980s, a revolution took place. Prior to this, the accepted practice was to use bulky vibration analysers alongside rotating machinery measuring amplitude, frequency and phase to diagnose faults on-site. The hand held computerised data collector, that captures and downloads data on a personal computer soon displaced the earlier 'portable' analysers. Now vibration analysis is mainly done at a computer terminal.

In the late 1980's several new entrants arrived on the scene: Palomar, CSI, Diagnostic Instruments, Entek etc. after seeing the original pioneers struggle to transition their businesses from hardware to software based. The first indications of large companies moving into the condition-monitoring sector came from SKF who first had some relationship with SPM in the 1970s. They then switched and acquired Palomar and Dymac of USA, as well as several service companies and around year 2000 Diagnostic Instruments of UK. With the break up of the former USSR, B&K and Schenck almost collapsed financially since much of their business depended on the former eastern block countries. Their banks played a key role in their operations, by forcing them together, halting R&D spend with the result that they lost momentum.

The next to enter the fray was Emerson, the \$15B process control company; they acquired the then successful CSI of USA to focus on their interpretation of plant asset management. Rockwell Automation soon followed the competition acquiring the merged Entek IRD but then progressively dismantled this global brand and respected team of core competence. The last independent player, Bently Nevada, was sold to General Electric. Like the others, this change has resulted in key staff departing. Further, major designers and manufacturers of steam and gas turbines are now seeking alternative turbine supervisory instrumentation (TSI) suppliers due to a fear that their machine performance data may find its way to GE, their competitor.

The result of these industry structural changes is that the development of Condition Monitoring techniques has dramatically slowed in the 21st Century. B&K and Schenck have almost bowed out of the portable vibration data collector market. Both SKF and Rockwell now source instruments from the same supplier with no internal core competence in instrument development of their own. CSI products are largely unchanged and remain at the high price end of the market. Bently Nevada seem to be primarily interested in their integrated system for machinery protection than true CM. All these changes have seen a combination of customer frustration, reduced product support and more especially lost core competence from most of the original suppliers. Often vendor sales staff know less about CM than the customers they are serving!

Perhaps the most serious fallout from the structural changes of the market is the premature obsolescence of many of the established instruments, excessively priced spares and repairs, abandoned commitments of former supplier's spares guarantees and simply a "take it or leave it attitude."

However, the positive outcome of the CM business realignment is that those more nimble and creative suppliers have transformed or entered the market with cost competitive products. New products are now available that either match or exceed those from the pioneers who appear to be abandoning their original business model. Mechanalysis (India) Ltd. (former Joint Venture partner of IRD) is one that is now a 100% independent Indian owned operation, recognised as a Manufacturing System Integrator who is totally focused on vibration based condition monitoring technology.

The return to rugged, easy to use instruments with controls and operating menus common across the range augers well for new and existing users as shown in this figure.



3. THE CM STAFF CHALLENGE

For a CM programme to be successful, data must be collected at regular intervals. In many industries, this may not be a problem but the following can and does frustrate a CM programme:

1. Expertise often rests in the hands of a few CM Engineers who are dedicated and largely self-taught. We are now seeing many of these Engineers job hopping to the highest bidder
2. In the offshore industry personnel change about every three weeks and if not properly planned can disrupt the programme.
3. In the marine industry, ships crew will change after a voyage and the fresh crew needs to be able to continue the programme.
4. Contract labour, that is common in places such as the Middle East, have to prove their skills. In the case of CM, this is often difficult to verify.
5. Companies offering CM contract services need benchmarking. They need to be audited so that they provide suitably skilled and experienced engineers.
6. In the Defence services, short tours of duty mean that staff must undergo continuous training programmes. They also face similar problems as the marine and offshore industry
7. A company setting up an in-house CM will require its operatives to be adequately trained before the programme becomes effective. Good training is an investment in people as long as they stay with their employers
8. Internationally accepted qualifications have recently been established to ISO18436 but few training vendors in India are audited to operate to the new standards. Further, these formal qualifications are only just becoming accepted in Europe and USA, Asia Pacific etc.

India has widely embraced Condition Monitoring and in many instances are ahead of other countries in establishing internal CM Cells. However, the investment in CM staff and facilities are starting to become a management headache. Skilled CM Engineers are realising the value of their unique skills and are prone to moving to more lucrative payers, especially in the Middle East. This turnover in staff results in lost expertise, interruptions or total collapse of the CM Programme.

Like many western countries, some large companies with international operations are now outsourcing their CM services. They use either local or international CM Consulting Service companies to undertake their routine data collection and analysis.

These services work well as long as the contractor has sufficient depth of expertise as well as proper functioning equipment with back up units in case of defective or damaged items that can be quite common in the industrial environment.

4. OPERATING A CM PROGRAMME

While many users of CM are skilled in the basic technology, when it comes to utilising the full power of the product, we find considerable deficiencies. Lack of training, personal application or poor transference of skills is very common at user sites. Further, the basics of the technology and concept of the CM programme are frequently over looked as time passes. Attention should be given to the following:

SET UP	COMMENTS
What to measure	Prioritise machinery. Undertake Root Cause Failure Analysis of Machines and Process. What impact on production if a machine fails? Cost the down time and repair
Where to measure	Mainly at bearing points or best signal position. Use fixed studs where possible. Understand shortcomings of hand held & magnetic mount signal transmission
What units to measure in	Relate to machine speeds, bearing types and root cause analysis. Velocity is common. For variable machines and low speeds use Acoustic Emission
What standards and machinery classification to apply	Apply ISO ISO2372-1 / BS4675-1 Machine Classes: I, II, III, IV etc.
When to measurement	1, 2, 3 or 4 weeks. Any interval greater is not providing a proactive maintenance capability
What range and Fmax to select	Understand the likely harmonics of a test point. Sometimes it is useful to take both low and high Fmax to get better resolution for analysis
Applying band alarms etc	Refer to ISO2372 for Alarm Level Creation Essential for more complex machinery but still appropriate for all types to track unbalance, alignment and bearing condition. Just taking overall readings does not justify a computerised data collector
Commissioning & Training	Invest in thorough commissioning and set up to get an early return from the investment. Training needs to be undertaken regularly as well as referring to interactive methods

The 'Proven Method' developed by Technical Associates of USA is an excellent guide since this is based on many years of machinery analysis of thousands of applications. It is also the basis of most training programmes offered today.

The modern Condition Monitoring software packages are now truly user friendly with easy to apply tools that guide the user to set up the machine data base against ISO standards as listed above.

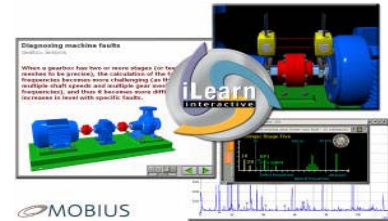
Once a programme has been operated for some time housekeeping becomes a necessity and this again is often overlooked. When machines are replaced with new, then archive the old machine data and set up a new profile. Machine Test Points that have been abandoned for various reasons should be removed from the routine programme. Do not retain old data for data's sake. Either archive it or remove it completely. Audit your CM data base, all machine measurements should have regular trend points, we often see two samples over one year; this is a waste of technology.

5. MAINTAINING SKILLS FOR EFFECTIVE CM

As stated, the success of a CM programme depends on the continuity of the staff involved. High performers will be promoted and the vacancy needs filling. It is therefore important that backup staff are trained and given the opportunity to practise the technology regularly. However, not just any training should be undertaken but a properly structured learning programme that is not product specific. Generic training in vibration technology has more worth than those vendors who only provide product specific training.

Apart from classroom training, interactive training from a CD is now available from Mobius iLearn. Standard and Professional training levels are offered for individual self-learning or on a network.

The interactive CD is an excellent investment enabling staff to hone their diagnostic skills. It also enables users to import vibration data and help diagnose as part of the learning process. Training knowledge is retained and costs are thus reduced.



6. CM EQUIPMENT MAINTENANCE

CM equipment vendors should adopt the Customer Support Process of:

Getting you Started

Keeping you Going

Taking you Further

Getting you started involves supplying equipment, commissioning, training end users and perhaps setting up the machine data base and alarm levels.

Keeping you going is a technology-based activity. Support services are essential to maintain equipment so that continuity of data acquisition is not disrupted. Portable instruments used in condition monitoring are generally carried around the plant, up and down ladders and to rather inhospitable areas. While they are designed to meet most hostile environments, they can be contaminated with corrosive gases and bumped or at worst dropped. Cables are consumable items that will need replacing from time to time. Selection of the appropriate instrument must be based on the ability of the vendor to have comprehensive local service and repair facilities. The vendor should also be in a position to hire out replacement products as and when needed.

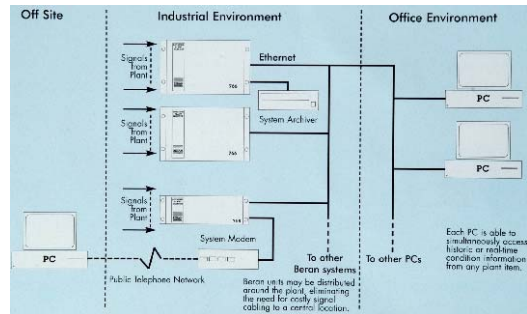
A key requirement for CM is to ensure that test equipment is properly calibrated to traceable standards in accordance of ISO9000. Such certifiable calibrations should be done annually at a proven facility as shown in the figure below:



Full Frequency Sensor Digital Calibration Facility

Taking you further will usually be applied once local expertise is established and more complex tasks and applications are addressed.

It may also involve acoustic emission (Holroyd Instruments Ltd UK) on-line surveillance (Commtest vbOnline) and networked multi-channel diagnostic systems (such as Beran Instruments UK). Where critical machinery system integration with base equipment is a key driver (see Figure), information and not data is distributed plant wide for operational decision making.



7. WARRANTIES

As modern electronics become better designed and manufactured, their reliability continues to improve. The market place is seeing warranty periods extended beyond the traditional one year. In the case of sensors, two years and beyond is common and vibration analysers and data collectors five years is now available from Commtest Instruments. Mechanalysis manufactured velocity sensors come with three years warranty and its partner Sensonics offers extended product warranty. This is not simply a marketing ploy but a reflection of the confidence suppliers have in their equipment along with proven design and in-service performance.

8. PRODUCT OBSOLESCENCE

System Life Cycle is an essential business driver today, especially where consumer electronics like PCs and mobile phones etc are often considered obsolete in just three years! When managers select a CM System, they will want one that is sustainable and provides long-term user value. The facts of modern life are that all computerised diagnostic systems will have a limited life. However, this should not be applied to the prime machinery protection system measuring for warning and alarm/shutdown. Buyers must insist on spares and maintenance support from 10 to 15 years as a basic supply requirement.

It is commonplace in India to see tenders specify that product support should be for 20 and in some instances 30 years. However, it is almost impossible for most suppliers to comply with the 20 year support commitment especially those fully dependent on a digital signal processor (DSP) platform. Processors become obsolete very quickly and we have seen in India (due to company takeovers) how some have abandoned their support commitments years before normal obsolescence. Systems with integrated circuits are however more sustainable in the long run and should not be discounted.

A responsible company will have a written Obsolescence Policy that should state the following:

1. After the last product of the particular model, we will support the product fully for say 10 years (spares and maintenance)
2. One year before the product is due to be declared obsolete (9th year), the vendor should write a letter to all known customers and advise of the product status. This should give them time to order support spares or upgrade to a latter version.

3. End users must confirm receipt of the Obsolesce Notice and indicate their requirements or otherwise.
4. For the whole year from notification of the Obsolescence Period, the Vendor should retain spares and provide maintenance support.
5. One year after the obsolescence notice period, the vendor is at liberty to scrap any remaining materials in stock.

It is believed that the above policy statement is fair to both parties. The practice of posting a notice on the vendor's web site is not acceptable as it assumes the concerned people will see the statement.

9. OUTSOURCING CONDITION MONITORING

Outsourcing CM can be an effective business strategy for many organisations but it is also fraught with risk. It seems these days that anyone with a meter can claim to be a consultant! Apart from the main industry players, who provide equipment and services, the independent CM contractor needs to be carefully audited. The contractor must show evidence that they have modern equipment with back up instrumentation that has been calibrated according to ISO9000. While they may have acquired 'analysis skills' in the plant, that is not enough. Condition Monitoring Contractors will need to adopt a "consultant" mindset. They must understand their clients' business and their production processes. Providing a service that is inclusive of how they can best add value to their clients' businesses must be their prime consideration.

For major annual contracts where data is collected regularly and reported externally there is an inherent risk. If either party terminates the contract, the Client only has hard copy records and not the raw data. It is logical for the Client to purchase the CM software so that they 'own' their CM data. This enables them to refer to machinery trends at any time. It also means they can dictate standards and quality of measurements.

10. OPERATING CM BENCHMARKS

It has been recommended that CM should have a set of benchmarks like any other business in the competitive world. The question is how can this be achieved as results are not in the public domain such as a set of company accounts. There are few organisations tracking CM performance and it is only through National Conferences such as NCCM where partial results are reported. Therefore, it is suggested that metrics be developed internally to address a Condition Monitoring Programme's effectiveness, the following are recommended to start the CM Benchmarking Process:

1. Is CM taking a holistic view of equipment condition?
2. What is the success rate of predicting equipment failures?
3. Current and future ability for accurate failure prediction?
4. Measure the cost of Condition Monitoring; is it going up or down?
5. Is CM improving equipment and component reliability; how to measure this?
6. Is CM optimising plant equipment performance; what productivity gains?

11. CONCLUSIONS

The Condition Monitoring industry has undergone a revolution in the past 10 years; mergers have diluted the pioneer's original portfolio or virtually destroyed some of the original vendors. However, competition has brought transformed and new players to the market with lower cost solutions and in many cases better supportable technology.

CM has been used by Indian Industry for over 30 years and continues to grow as its benefits are recognised and proven. As a tool providing objective assistance to engineering for improved machinery performance analysis there is no doubt. However, CM skills are not mainstream and so the attrition rate for staff continues to be high as they are attracted to greener fields. In certain industries such as marine, staff turnover, as a relieving necessity, interrupts the continuity of a CM programme.

The need for greater attention towards training engineers in CM whether by lectures or interactive self-learning processes is a pressing need. This will ultimately benefit all parties so that Companies are not held to ransom by 'job hoppers' and a programme's continuity will result in improved plant availability.

CM system implementation and set up must be done thoroughly; a 3 day hands on training course cannot achieve this. Clients should invest in proper programme implementation and cease assuming that such services must be free.

Selection of CM equipment is only part of the decision process; the vendor's ability to provide proven support services including traceable calibration as well as a clearly published Obsolescence Policy is needed.

Outsourcing CM services is a viable option but Clients should fully audit the vendor and then retain any computerised data captured.

Condition Monitoring offers huge productivity benefits as long as it operates in good condition!

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Mechanalysis (India) Limited

Reg. Office: 47-48 Jolly Maker Chambers II, Nariman Point, Mumbai, 400 021, India
Tel.: +91(22)2202 7430 Fax: +91(22)2285 0480 www.mechanalysisindia.com