SUCCESSFULLY IMPLEMENTING CONDITION BASED MONITORING SYSTEM IN INDUSTRY

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Abstract: There is an increasing need for utilities to optimize their expenditure in an increasingly liberalized market. One of the ways to achieve this is through condition-based monitoring instead of the normal time-based maintenance. Condition-based monitoring could help to reduce both maintenance as well as unplanned interruption cost. The overall goal is to reduce the Life Cycle Costs (LCC) by application of condition based monitoring.

This paper offers a "Step – by – Step" method which may be used to implement a Condition based Monitoring (CBM) program. It presents a compilation of the implementation procedure used by several industry.

Starting with equipment oriented predictive maintenance the paper moves on the more comprehensive and cost effective concepts of CBM.

Along the way I will compare and contrast on – line monitoring versus off – line test procedures, will discuss how the various CBM procedures work on different types of equipment, and finally I will present the step – by – step approach that should allow the asset owner to optimize the investment placed into maintenance program.

Key Words: Reliability,effectiveness, Databases, CBM, Operational excellence

1.0 INTRODUCTION

Condition Monitoring is taken to mean the use of advanced technologies in order to determine equipment condition and potentially predict failure. Condition Monitoring is most frequently used as a Predictive or Condition-Based Maintenance technique. CBM adds two enormously important dimensions to classical predictive maintenance. First, CBM deals with the entire system as an entity. This holistic approach to maintenance represents a major shift from the piecemeal methodologies of the past. While CBM can still be implemented "one step at a time," it realizes its greatest potential when applied consistently and evenly across the entire range of system maintenance concepts.

The second added dimension is the concept of ignoring or extending maintenance intervals. PDM trending techniques have been used historically to confirm maintenance decisions that would previously have been based on expert opinions. While this approach may often find problems not otherwise identifiable.

CBM on because of its systemic approach, usually decreases long term maintenance costs. After all of the various criteria are entered into the CBM model, and the analysis is performed, the results can cause the

maintenance interval to be decreased, maintained or increased. In other words there is an actual possibility that maintenance costs will go down based on an increased time interval between shutdowns.

In this paper I will outline some of the key business parameters and issues which are driving change in the industry, summarize some of the resulting trends, as I see them, and then draw some conclusions regarding the implications of these trends for the organizations employing Condition Monitoring techniques.

The focus of this paper is on Vibration Monitoring technologies, but many of the issues, opportunities, trends and implications are similar across the other areas of Condition Monitoring technology.

2.0 ASSET EFFECTIVENESS: THE DRIVER FOR CHANGE IN CONDITION MONITORING

In my view, the business need that is likely to dominate the industrial maintenance scene, at least for the first part of this century, is Asset Effectiveness - the need to extract maximum profits from the minimum investment in plant and equipment. . Whatever changes occur within the field of Condition Monitoring will, in the long run, only be sustained if they successfully address real business needs. How do we achieve this through the use of Condition Monitoring technologies? In one of five ways:

- By improving Equipment Reliability through the effective prediction (and then avoidance) of equipment failures
- By minimizing downtime through the integrated planning and scheduling of repairs indicated by Condition Monitoring techniques with those indicated by other techniques.
- By maximizing component life by avoiding the conditions that reduce equipment life (for example, by ensuring ongoing precision alignment, minimal lubricant contamination etc.)
- By utilizing Condition Monitoring techniques to maximize equipment performance and throughput
- By minimizing Condition Monitoring costs

The size of the benefits on offer to an organization by utilizing Condition Monitoring techniques in each of the ways outlined above varies, depending on the organization.

3.0 THE NEED FOR CONDITION BASED MONITORING SYSTEM

A holistic view of equipment condition requires the effective integration of:

- Condition Monitoring inspection results (including all Condition Monitoring techniques used - Vibration Analysis, Oil Analysis, Thermography etc)
- Visual inspection results
- Fixed-interval "Preventive" maintenance actions, and
- Equipment performance monitoring

The need for Condition Monitoring System can be summarized below:-

Business Need 1 - The need to predict equipment failures

Business Need 2 - The need for a holistic view of equipment condition

Business Need 3 - The need for greater accuracy in failure prediction

Business Need 4 - The need to improve equipment and component reliability

Business Need 5 - The need to optimize equipment performance

4.0 IMPLEMENTING CONDITION BASED MONITORING SYSTEM — PHASE 1

One of the very attractive aspects of CBM is the fact that it can be implemented in a relatively inexpensive, step-by-step approach. Because CBM is based on the equipment oriented concepts of PDM, it can be applied gradually — one system at a time. Eventually the entire power system is included in the program and cost savings begin to multiply.

4.1 Safety Procedure Review

Any major change in system maintenance or operations should include a thorough review of safety procedures as given in Table 1.

Table 1 - Safety program review elements

Safety Equipment	proper selection, testing up-to-date, readily available
Safety Procedures	in compliance with current national and local standards
Safety Training	all personnel thoroughly trained and familiar with all applicable safety standards - OSHA compliance the **minimum** standard
Safety documents	up-to-date and in compliance

4.2 Data Collection and Storage Procedures

Maintenance data and its uses are among the key differences between classical and modern maintenance methods. In the past, maintenance results from any given interval were reviewed and filed. Little, if any, attention was paid to comparison or trending.

Trending and statistical analysis are the fundamental building blocks of CBM. Comparing data absolute values, and perhaps more importantly, comparing data deviations via statistical analysis provide information never before available. Obviously, a statistically relevant database is required.

The platform chosen for the record keeping system should be one of the commercially available personal computer relational database programs. Some companies opt for a spreadsheet program; however, I recommend against this. Most spreadsheet programs are long on computations power and short on database manipulation abilities. Since database files (tables) will readily import into a spreadsheet for analysis, use the database.

The table structure should be as general as possible, and it should be done in two, linked database files. This allows for a variety of types of equipment as well as future modifications.Each field in the results database is linked to the appropriate test field in the master. This relatively simple structure allows access to the data for analysis and review. For easiest results, an user interface may be programmed to allow simple data entry.

4.3 Equipment failure and outage information

To help with the risk assessment portions of the CBM program, a compilation of outage data needs to be compiled. This information can include such items as type of outage, cause, length, cost (estimated if necessary), date, and other such data. For power systems with relatively little outage data a manual listing is probably adequate; however, computerizing (using the same database as the test results data) is recommended.

Outage information may be used to prioritize the implementation sequence of the CBM program. Obviously, equipment with a high failure record and/or a high value to the operation, should be enrolled in the program first.

4.4 Equipment database

The equipment database will be developed in parallel with the other databases. If desired, the equipment database may be linked to the master maintenance database . It may also be incorporated in the master maintenance database; however, more flexibility is realized if they are kept separate.

4.5 Preliminary budget and plan

The final step for phase 1 is the establishment of a preliminary plan and a budget. The preliminary plan should include the steps shown in Table 2.

Table 2 - Test results database

Field #	Linked to	Result	Comments
1 2 3 4	4 5 6 etc	2 4.5% 1	Dimensions of result depend on specific test

Emphasize that this plan is preliminary. You should expect changes as the actual program Implementation begins. For example, some equipment, such as low and medium voltage circuit breakers, are not as readily predicted as other such as transformers. Because of this, you may decide to drop detailed statistical analysis in favor of a less rigorous approach.

5.0 IMPLEMENTING CONDITION BASED MONITORING SYSTEM — PHASE 2

Now it is time to begin in earnest. The information garnered in Phase 1 will be put to work as a living, active Condition Based Maintenance Program.

5.1 Develop detailed evaluation criteria and methods

Based on the test result data gathered in Phase 1, the development of control chart strategies, and/or other statistical evaluation techniques should be begun. The exact nature of which strategies should be used may not be immediately apparent. Two options are available as shown in Table 3.

Table 3 - Evaluation criteria options

1. Contract with a CBM consultants for statistical criteria implementation
2. Start simple. Use graphical trending in a spreadsheet.

Contracting with a qualified CBM consultant who can assist you in the selection and implementation of appropriate strategies. Starting simple with a commercially available spreadsheet may not be as rigorous or technically satisfying as more sophisticated statistical analysis, it may well provide a satisfactory compromise between competing technical and economic factors.

5.2 Finalize recommended maintenance procedures and intervals

This is one area that is very easy to overkill. Remember that maintenance procedures can be added as needed in future intervals. The opinions and observations of skilled technicians along with the ambient environmental conditions are extremely important in the overall evaluation.

5.3 Test reporting forms and/or software

Test forms have been around for as long as electrical equipment. Virtually ever test technician has, at one time or another, created his/her own form. Two basic approaches are now available — Printed paper forms and direct computer entry.

5.4 Printed paper forms

Such forms are available from a number of sources. The major limitations of preprinted forms is the need for modification and manual transfer of data into the various computer databases described previously.

5.5 Direct computer entry

If a user-friendly interface for the database has been designed, a mini-version may be taken into the field by the maintenance technicians. After each test, the technician can keyboard the results directly into the computer. The information can then be electronically downloaded into the main maintenance PC either via diskette or via a company local area network.

As another option, if the necessary translation software is available, the test results may be loaded directly into the computer from the test equipment. This approach is especially effective when the test is actually performed under computer control. Commercially available “bridge” software is being developed in many parts of the industry to allow such transfers.

6.0 CONCLUSION

Implementation of CBM has been delayed in many companies by the perception that it is expensive, difficult, or both. In this paper, we have shown that CBM is, in fact, not difficult to implement. Nor need it be initially expensive. A measured, methodical development plan can allow the maintenance team to implement and quickly realize the ultimate values of Condition Based Maintenance.

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