Application Guide AG 5/2001

CONDITION BASED MAINTENANCE

- An evaluation guide for building services

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dti
Department of Trade and Industry

BSRIA

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PREFACE

Building services maintenance is predominantly based on a breakdown or time-based strategy, which do not always provide the plant reliability required in critical business environments. Building services are becoming an increasingly vital component of business activity and thus require more sophisticated methods of preventing down-time.

Condition Based Maintenance (CBM) has been widely used in the process industry for many years, but has been slow to mature in building services. CBM provides a means of improving the conventional maintenance regime by evaluating indicative parameters of plant condition such as temperature, vibration, oil condition and power quality.

CBM can enhance fault detection in many plant items, thus potentially reducing failure rates. In addition, potential benefits are gained by providing a greater understanding of plant performance, reduced labour time and repair budgets it can also improve the energy efficiency of many items of plant.

BSRIA has developed this application guide to aid facility managers and maintenance personnel in understanding the basic concepts of each CBM method, indicating the potential applications, capital costs and benefits associated with each method.

The CBM methods covered in this application guide are:

1. Vibration analysis
2. Acoustic emissions monitoring
3. Thermography
4. Wear and oil analysis
5. Power quality monitoring
6. Monitoring via building management systems.

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BSRIA'S CONDITION BASED MAINTENANCE SERVICES

BSRIA provides a wide range of condition based maintenance services.

Surveys

BSRIA offers surveys based upon several different condition monitoring techniques. These are provided as either a single survey or as part of an on-going program of monitoring. Surveys offered include:

- Thermography
- Power quality
- Electromagnetic field
- Acoustic emission monitoring
- Vibration monitoring.

Demonstration days

The demonstration days are aimed at introducing CBM instrumentation and methods to maintenance personnel from an independent organisation. This can be done at the client's preferred location. The demonstration days can include:

- Demonstration of various CBM instrumentation to maintenance personnel
- Demonstration of the types of plant item applicable to different types of CBM instruments.

Training days

Training days can be arranged at BSRIA's or the client's offices to suit the client's requirements. A range of courses is available including:

- Introduction to CBM techniques
- Training in specific techniques: thermography, power quality, vibration, acoustic emissions, etc.

Complete CBM programmes

BSRIA can provide a complete CBM monitoring service to:

- Identify your business-critical machines and equipment
- Set up a CBM programme to cover business-critical machinery and other plant items
- Collect and analyse data and produce reports for the maintenance team.

For more information about how BSRIA can help you contact;
Andrew Martin, Engineering Services Business Manager on Tel: 01344 426511 Fax: 01344 487575 Email: andrew.martin@bsria.co.uk

1 INTRODUCTION

Traditionally, building services maintenance is based on either a breakdown maintenance strategy (BM) where plant is run to failure, or a time-based maintenance strategy (TBM) where plant is maintained at periodic intervals. Both of these methods can be inappropriate in the modern business environment particularly, where building services plant is critical to the business activity. BM does not prevent plant components from failure, which can cause high repair costs. While TBM can prevent a proportion of failures, it can result in maintenance work being carried out when none is necessary. It can even induce failures.

A third type of maintenance - Condition Based Maintenance (CBM) - is increasingly being used. This provides a reliable, cost effective method of monitoring selected working characteristics of plant items, thus reducing failure rates and costs. It also potentially simplifies identification of faults and hence reduces the need for skills.

CBM is a strategy in which a parameter indicative of the machine's condition is monitored. This can be in the form of an on-the-spot assessment, which can give an instantaneous indication of the machine's condition, or in the form of trending (comparing previous plots of vibration with the current plot). Trending requires information to be gathered from the plant item over its operating life at sampling rates that are established from known failure rates, based on manufacturers' data, British and European standards and experience from conventional maintenance strategies. The gathered information is trended over time to establish changes in the selected monitoring parameter, which indicates when a potential failure will occur.

There are many CBM techniques that can be used for building services plant, and understanding their strengths and weaknesses is critical if the correct technique is to be applied. Almost all building services maintenance employees rely on their senses to monitor the condition of plant. Understanding how a particular plant item operates is critical for preventive maintenance. The noises and heat given off while plant is running give an experienced maintenance engineer a good indication of the plant condition. CBM uses these basic indicative parameters, and others, and expands upon selected elements. These may include the vibrations that are produced, the variations in temperatures, the quality of the power supply and the condition of lubricating fluids within plant items to establish changing condition, thus minimising failures.

Used effectively CBM can be an excellent preventative breakdown tool as well as a training aid for understanding the individual behaviour of plant items. This understanding allows preventative measures to be taken when conditions indicating degradation appear, allowing problems to be solved before costly faults and even failures occur. With increasing pressure on maintenance staff, CBM allows more effective use of maintenance resources.

An important part of CBM is record keeping, which allows a history to be built up of plant item condition. This is invaluable in predicting plant behaviour under site conditions.

The frequency at which monitoring takes place, and the implications for time required for maintenance personnel to perform these tasks, is dependent on a number of site-specific factors. These include:

- Type of machine
- Age & condition of machine
- Type of CBM method used
- Operating conditions
- Criticality of machine.

In general, the frequency can be established once the first set of condition monitoring data has been analysed. If the plant item is in very good condition, then this can be as infrequent as once a year. However, if the plant item shows signs of degradation then the frequency should be increased to pick up the rate of change. In general, knowing the condition of the plant item reduces the need for conventional maintenance, as the maintenance requirement can be predicted.

Many techniques can be used to detect changing conditions within similar plant items, as shown below:

Example:

The bearing within a pump is suffering from gradual degradation of its surface, which can be detected in many ways. A thermal imaging camera can be used to detect the rise in temperature around the bearing casing, indicating a problem. Vibration or acoustic emission analysis can be used to detect the change in vibration levels throughout the pump. Alternatively, wear and oil analysis can be carried out at a laboratory to detect changes in the oil and to identify bearing particles.

However, although each of these CBM techniques can identify that there is a problem within the pump, the accuracy of predicting the severity and precise location of the problem varies from technique to technique. All the CBM techniques have the potential to improve the effectiveness of the maintenance regime, regardless of the type used. Understanding and using the strengths of each CBM method will allow an effective CBM strategy to be implemented. Possibly using a combination of techniques.

The principal benefits of implementing CBM include:

1. Expensive and labour-intensive routine maintenance activities are reduced and maintenance scheduling can be improved. This is due to a greater understanding of the operating characteristics of plant items through trending, and quicker assessment of plant condition
2. CBM allows preventive measures to be taken before costly breakdowns occur, allowing a reduction in unscheduled downtime
3. CBM can increase reliability of systems through remote inspection and assessment
4. Energy savings can be achieved through improved operating conditions of plant
5. Machine life can be extended by preventing degradation of internal components
6. Plant items can be tested before handover in the commissioning process.

Table 1 shows some of the main faults detectable with CBM, along with the effectiveness of the different methods. Further information and case studies will be published in BSRIA's *Application of Non-destructive Testing (NDT) in Condition Based Maintenance (CBM) of Building Service*, due out in 2002.

***	Highly effective method, can detect the severity, location and rate of degradation
**	Has a high detection ability, but may have a limited ability to evaluate severity and rate of degradation
*	Can detect fault, but can not evaluate severity and rate of degradation

Table 1
CBM method evaluation

Plant item	CBM method	Faults indicated	Effectiveness
Mechanical			
Pumps & fans	Acoustic emissions	Bearing degradation	***
		Lubricant degradation	**
		Misalignment & imbalance	*
	Thermography	Bearing degradation	*
		Lubricant degradation	*
	Vibration	Bearing degradation	***
		Lubricant degradation	**
		Misalignment & imbalance	***
	Wear & oil analysis	Bearing & lubricant degradation	***
Shafts & rotors	Vibration	Misalignment & imbalance	***
		Bent shafts	**
		Loose components	**
	Acoustic emissions	Misalignment & imbalance	*
Belt drives	Vibration	Misalignment & imbalance	***
		Mismatched belts	**
	Thermography	Misalignment & imbalance	*
		Belt tension	*
Compressors	Vibration	Misalignment & imbalance	***
	Wear & oil analysis	Bearing & lubricant degradation	***
Valves	Thermography	Valves, blockage, wear, leakage	**
	Acoustic emissions	Valves, blockage, wear, leakage	*
Pipework	Thermography	Insulation	***
		Sludge build-up	***
	Acoustic emissions	Leaks (air, vacuums, steam)	**

Table 1 *continued*
CBM method evaluation

Plant item	CBM method	Faults indicated	Effectiveness
Chilled ceilings	Thermography	Blockage	***
		Poor heat transfer	***
Building fabric	Thermography	Faulty insulation	***
		Poor air tightness	***
Boilers	Thermography	Blockage & scaling	***
		Poor circulation	***
Underfloor heating & cooling	Thermography	Poor pipe layout	***
		Blockage	***
Electrical			
Circuit breakers	Power quality	High crest-factors	***
Cables	Power quality	Harmonic current	***
Electrical	Thermography	Faulty switchgear, undersized conductors	***
Transformers	Power quality	Harmonic current	***
	Wear & oil analysis	Fluid leakage	*
		Contamination	***
Variable speed drives	Power quality	High frequency noise	***
UPS	Power quality	Low-crest factor	***
Standby generators	Wear & oil analysis	Fluid leakage	*
Motors	Acoustic emissions	Bearing degradation	***
	Power quality	Harmonic voltage	***
	Vibration	Stator & armature damage	**
		Coupling damage	**
	Thermography	Bearing degradation	*

