Cost Effective Maintenance

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1 Synopsis

Cost Effective Maintenance Management is a goal for many companies. An obvious step to achieving cost effective maintenance includes selecting the appropriate maintenance strategy.

Areas often neglected include defining availability and reliability requirements, measuring performance correctly or even identifying assets satisfactorily. Factors such as fault and failure modes, criticality and information management also need to be considered. Using the wrong maintenance technique can waste time, money and resources, and often has no effect on improving or maintaining availability.

The following are covered in this paper:

- What are key stages in setting up a maintenance program
- What factors allow measurement of cost effectiveness
- What are some of the common areas of weakness companies overlook

2 Introduction

Cost Effective Maintenance Management is a goal for many companies. Obvious steps to achieving cost effective maintenance include selecting appropriate maintenance strategies and techniques.

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"You cannot manage what you cannot measure"

– Attributed to Bill Hewlett (1930-2001), Co-founder of Hewlett-Packard

Many organizations try to carry out maintenance without implementing or managing some of the above key stages. They may then use Key Performance Indicators (KPIs) in their attempt to quantify the cost effectiveness of their chosen approach, but unless each stage has been carried out effectively, they usually find it difficult or impossible to measure the effectiveness of their maintenance.

One of the most cost effective maintenance techniques is condition based maintenance, but it is often implemented incorrectly, and therefore it's effectiveness cannot be measured.

3 Setting Up a Maintenance Program

When setting up a maintenance program, a number of key stages must be carried out. These key stages are shown in Figure 1 below.

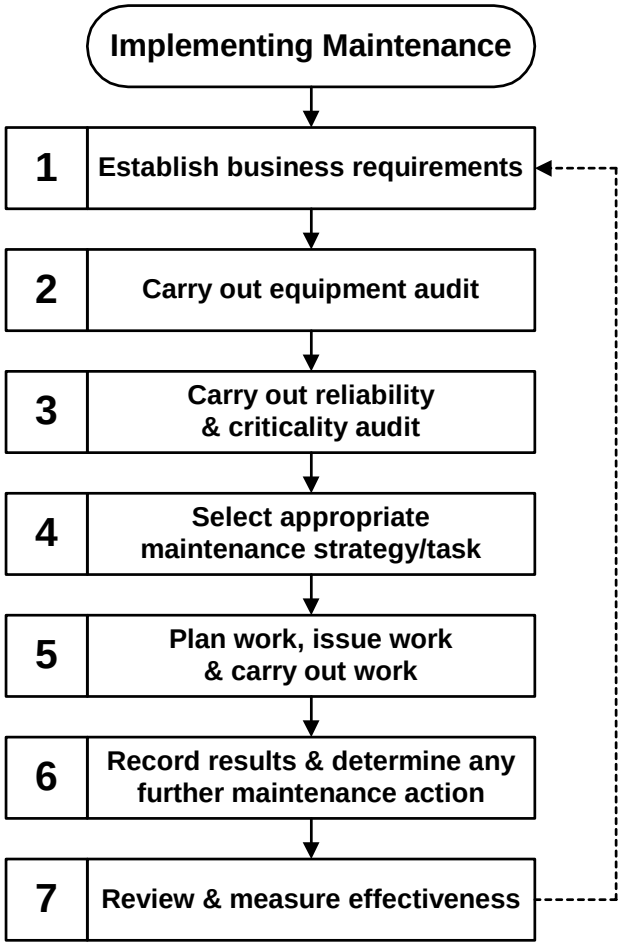

Figure 1 – Overview of Typical Maintenance Implementation Stages

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4 Making Maintenance Measurable

Setting up a maintenance management system which can then be measured as to its cost effectiveness depends on carrying out the key stages shown in Figure 1. Each stage has a number of steps which are necessary for the subsequent steps, and different phases of implementation to be assessed.

The following quotations are appropriate to highlight the importance of being able to measure the effectiveness of any process.

"Until you can measure something and express it in numbers, you have only the beginning of understanding"

– William Thomson [Lord Kelvin (1824-1907)]

"You cannot manage what you cannot measure"

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A typical example of some of the detail steps in each stage is shown in Figure 2. The right hand columns, under the heading "phase" show the four main phases of the process.

These are:

- Initial set-up
- Routine operation
- Obtaining useful KPIs
- Optimisation and Review

The measurements or key performance indicators shown in Figure 2 can only be measured if the set-up and routine steps have all been carried out. For example, if assets are not labelled adequately and uniquely, issued work and feedback cannot be done properly.

Example Detail of Typical Maintenance Management Set-up			Phase			
Step		Detail	Set up	Routine	KPI	Optim.
1		**Establish business requirements**				
	1.1	What is the required availability	y			y
	1.2	What is the required reliability	y			y
	1.3	What is the expected life of the assets	y			y
	1.4	What is the available budget	y			y
2		**Carry out equipment audit**				
	2.1	Identify assets & sub-assets	y			y
	2.2	Create & test asset codes	y			y
	2.3	Label assets & sub-assets	y	y		y
	2.4	Update database	y	y		y
3		**Carry out reliability & criticality audit**				
	3.1	Estimated availability & reliability [1]	y			y
	3.2	FMECA, FMEA, FTA, Root cause failure analysis [2]	y			y
	3.3	Maintenance history, pareto analysis, reliability databases [3]	y			y
4		**Select appropriate maintenance strategy/task**				
	4.1	Condition monitoring task	y			y
	4.2	Inspection task	y			y
	4.3	Preventive maintenance task	y			y
	4.4	Corrective maintenance task	y			y
	4.5	Re-design	y			y
5		**Plan work, issue work & carry out work**				
	5.1	Create/update job catalogue	y			y
	5.2	Estimate/update resources	y			y
	5.3	Create/update check-off lists	y			y
	5.4	Schedule CBM, PPM, corrective or breakdown maintenance		y		y
	5.5	Issue & allocate work		y		y
	5.6	Carry out work		y		y
6		**Record results & determine further action**				
	6.1	Record results		y		y
	6.2	Diagnose faults		y		y
	6.3	Re-schedule work		y		y
	6.4	Initiate further work		y		y
	6.5	Feedback results		y		y
7		**Review & measure effectiveness**				
	7.1	Failure rate, MTBF, MTTR, Downtime [4]			y	y
	7.2	Availability & reliability			y	y
	7.3	Percentage CBM, PPM, Corrective, Breakdown etc			y	y
	7.4	Spares used			y	y
	7.5	Actual budget expended			y	y

Figure 2 – Example Detail of Typical Maintenance Management Set-up

5 Benchmarking

Benchmarking focuses on certain processes and evaluates their relative performance and is a useful technique to highlight areas of strength and weakness in an organisation. A recent benchmark carried out for a large organization with multiple contracted maintenance teams had the following areas of weakness highlighted:

- KPI's were not performance related and needed review
- There was no Common Asset Register
- Lack of / Inconsistent Sub-Asset Identification
- Lack of Asset Criticality, Priority or Scale Factor
- Lack of Availability of Technical Information
- Lack of Maintenance Check-off Lists
- No Verifiable Manpower Resource Estimates
- Limited Feedback of Work Done
- Difficult to Assess PPM Completion Rates
- No Failure Rate Analysis
- Leakage of Maintenance Data
- Little Scope for Maintenance Improvement

Although there was also a lack of a common Enterprise Resource Planning (ERP) or Computerized Maintenance Management System (CMMS), some of the above shortfalls needed rectifying before implementing which led to the following recommendations.

- Review KPI's
- Identify and Label Assets and Sub-Assets
- Carry out Criticality Review
- Produce Generic Maintenance Check-off Lists
- Estimate Manpower Resource Requirements
- Improve Technical Library
- Provide CMMS / ERP

6 Condition Based Maintenance

One of the most cost effective maintenance techniques is condition based maintenance. However it should be implemented and managed carefully.

The development of International Standards in the field of condition monitoring and diagnostics has led to a more formal approach to implementation. The parent Condition Monitoring Standard is ISO 17359 [5]. It concentrates on guidelines for condition monitoring and has an implementation flow diagram which contains the stages shown in Figure 3 below.

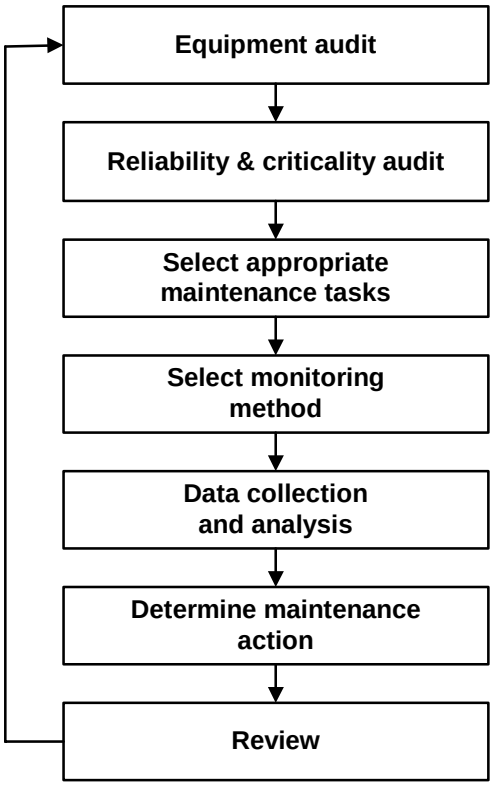


Figure 3 – ISO 17359 Implementation Stages

This is similar to Figure 1, and again, effectiveness can only be assessed if each stage is carried out properly. For example: assets must be clearly identified, codified and labelled, and the feedback of information must be done correctly.

A series of International Standards are being developed relating to Condition Monitoring and Diagnostics, including related training and accreditation standards. Techniques now being covered include vibration monitoring, thermal imaging, acoustic emission and Tribology. An overview of the latest status of current standards is shown in Figure 4.

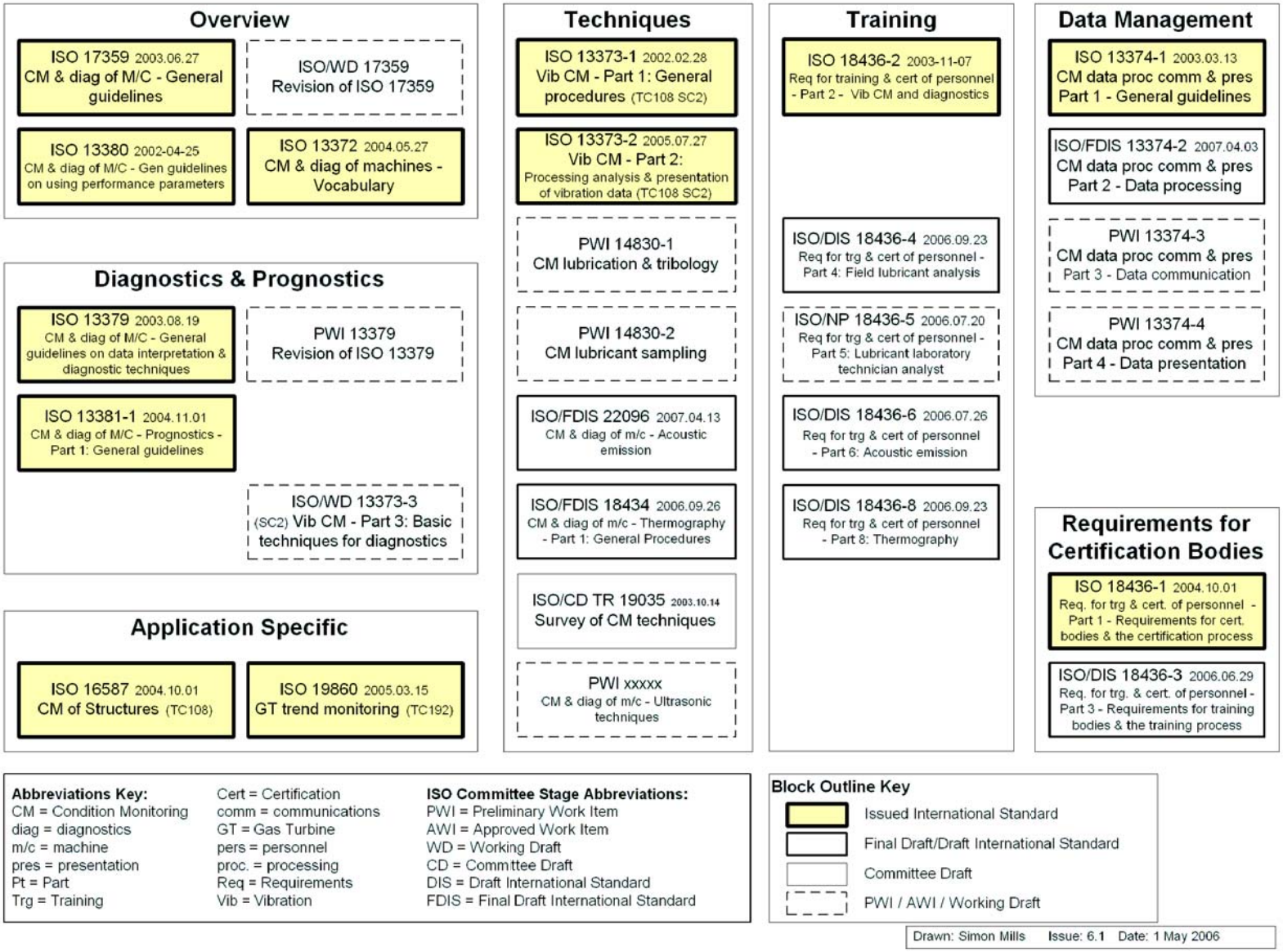


Figure 4 – Overview of ISO condition monitoring standards

7 Training

A number of organisations are now involved in producing accredited training certification material. Examples of some commercial training materials developed to support maintenance management and ISO training and certification are shown in Figure 5 below:[6]

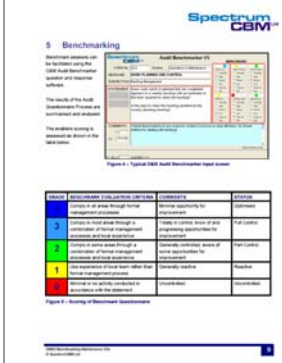
Cover	Example Content	Cover	Example Content
			
Cover	**Example Content**	**Cover**	**Example Content**
			
Cover	**Example Content**	**Cover**	**Example Content**
			

Figure 5 – Examples of Accredited Training Materials

8 Conclusion

To achieve cost effective maintenance, it is first necessary to implement a maintenance program using a staged process containing key detail steps. The process should ensure that all key steps are followed.

Without clear definition of requirements, achievements and feedback, measurement is not possible.

Measurement of effectiveness through monitoring key performance indicators is only possible if each stage has been completed.

Without measurement, management and optimisation is not possible.

9 Abbreviations

CBM = condition based maintenance
CM = condition monitoring / corrective maintenance
CMMS = computerized maintenance management system
ERP = enterprise resource planning
PPM = planned preventive maintenance
FMEA = failure modes and effects analysis
FMECA = failure modes effects and criticality analysis
FTA = fault tree analysis
KPI = key performance indicator
MTBF = mean time between failure,
MTTR = mean time to repair,
Optim. = optimization

10 References

1	IEC 60300-3-1	Dependability management - Part 3: Application guide
		- Section 1: Analysis techniques for dependability: Guide on methodology
	IEC 60300-3-11	Dependability management - Part 3: Application guide
		- Section 11: Reliability centred maintenance
	IEC 61078	Analysis techniques for dependability - Reliability block diagram method
2	BS 5760-5:1991	Reliability of systems, equipment and components.
		Guide to failure modes, effect and criticality analysis (FMEA and FMECA)
	IEC 60812	Analysis techniques for system reliability
		- Procedure for failure mode and effects analysis (FMEA)
3	FARADIP.5	(FAilure RAte Data In Perspective) http://www.maint2k.com
	FARADIP.3	Technis, 26 Orchard Drive, Tonbridge, Kent, TN10 4LG, UK
4	HB 10007	Reliability, Maintainability and Risk, Dr David J Smith, Butterworth-Heinemann
5	ISO 17359:2003	Condition monitoring and diagnostics of machines - General guidelines
6	AV Technology Ltd:	www.avtechnology.co.uk