

Maintenance Training for Maintenance Technicians, Mechanics and Engineers

Introduction to Principles of Reliability and Precision Maintenance

- Session 1 The Path Toward Reliability – an Overview**
- Session 2 Condition Monitoring in the Context of Reliability**
- Session 3 Principal Causes of Failure in Machinery**
- Session 4 Detection of the Need for Maintenance**
- Session 5 The Language of Vibrations**
- Session 6 Vibration Measurement for Condition Monitoring**
- Session 7 Rolling Element Bearing Testing**
- Session 8 Workshop – Estimating Remaining Safe Bearing Life**
- Session 9 Condition Monitoring Using Thermography**
- Session 10 Condition Monitoring Using Oil Analysis**
- Session 11 Other Condition Monitoring Methods**
- Session 12 Maintenance Planning from CM Reports**
- Session 13 Workshop – Using CM for Reliability Improvement**
- Session 14 Precision Maintenance – An Overview**
- Session 15 The Justification for Precision Maintenance**
- Session 16 Root Cause Analysis – Creative Disassembly**
- Session 17 Machine Overhaul – Fits and Tolerances**
- Session 18 R/E Bearings – Handling, Storage & Installation**
- Session 19 Machine Installation – Alignment**
- Session 20 A Quality System in the Workshop**

This seminar series is structured to provide an awareness of the concepts of **condition monitoring, reliability and precision skills** for Maintenance and Engineering Staff.

Precise precision maintenance skills used with condition monitoring and reliability characterise the relatively few successful programmes where the results show in reliability improvement and reduction of non-routine maintenance expenditure. Regardless of the policies and programmes put forward from the top, plant reliability will always be linked to the approach and effectiveness of the operators and maintenance staff who work on the plant.

OUTCOMES SOUGHT

To raise awareness of the contribution that can be made toward improved plant reliability and reduced maintenance costs, through;

- use of condition monitoring information in understanding machinery operation and performance, and applying this to cost effective maintenance planning
- application of cost effective condition monitoring technologies
- familiarity with Standards relevant to machinery manufacture, overhaul and CM
- appropriate use of Root Cause Analysis methods,
- the appropriate application of Precision Skills on a Plant-wide basis,
- the use of a Quality Information System

SUMMARY

This Awareness course is for trade persons who strip machinery, overhaul and re-install it, and return it to production. It provides a context for the concepts of **condition monitoring, reliability and precision skills**, and demonstrates the impact of trade techniques upon the vibration condition and reliability of plant and machinery.

These are the elements that characterise the relatively few successful programmes where the results show in reliability and the maintenance budget. Regardless of the policies and programmes put forward from the top, these results can only be as good and effective as the tradesperson who works on the plant.

DURATION OF SEMINAR

The seminar is 4 days (2 x two days) and run on-site but this may be adapted to suit the circumstances of attendees, such as shift workers. Frequently it is necessary to run at least two seminars to provide for ongoing plant coverage.

A reduced version of 2 days is possible for **electrical fitters** who do not require the same level of input on issues such as alignment, fits and tolerances.

WHO SHOULD EXPERIENCE THE MAINTENANCE TRAINING

New Plant Maintenance Engineers, Maintenance Technicians, Maintenance Mechanics, Mechanical and Electrical Maintenance Fitters, Artisans and Craftsmen employed in the maintenance of plant and those at the first level of maintenance supervision and maintenance team leaders, particularly where this supervision may involve contractors similarly employed.

COURSE CONTENT

- 1. Towards Reliability**
Maintenance and its Management
Maintenance Methodologies and their Balanced Application
Condition Monitoring in the Context of Reliability Improvement
- 2. Vibration Measurement & Analysis**
Measurable Parameters in Dynamic Systems
The Technology of Vibration Measurement and Analysis
Vibration Measurement Applied to Condition Monitoring
Vibration Analysis for Fault Diagnosis
Vibration Reporting
- 3. Condition Monitoring Technologies**
Using Thermography for Rotating Machinery Monitoring
Oil Condition and Wear Debris Analysis
NDT applied to Condition Monitoring
Performance Monitoring of Machines and Systems
- 4. Rolling Element Bearings**
Bearing Failure Processes
Rolling Element Bearing Condition Assessment
Estimating Safe Remaining Bearing Life.
- 5. Maintenance Systems**
Maintenance Planning based on CM Reports
Managing Condition Monitoring for Reliability Improvement.
Standards for Machinery Acceptance Testing and Balancing
QA. Development of Procedures and Work Instructions
QA. Developing and Implementing Workshop/Contractor Standards
- 6. Failure Processes and Identification of Cause**
The failure processes in machinery and systems
Obtaining data to identify cause of failure.
Root Cause Analysis
- 7. Precision Maintenance;**
The Justification for use of Precision Skills plant wide
Skills Development for Tradespersons
Machine Overhaul – Fits and Tolerances
Balancing
Alignment, preparation and procedures
Implementing Precision Maintenance for Maximum Cost-Benefit
Measuring the Benefits of a Precision Maintenance Programme

Content for a 4-day Maintenance Engineers, Technicians, Mechanics, Craftsmen, Artisans and Trades Course – Version 1

Session 1	The Path Toward Reliability – an Overview	1 hr
Session 2	Condition Monitoring in the Context of Reliability	2 hr
Session 3	Principal Causes of Failure in Machinery	2 hr
Session 4	Detection of the Need for Maintenance	1.5 hr
Session 5	The Language of Vibrations	1.5 hr
Session 6	Vibration Measurement for Condition Monitoring	1 hr
Session 7	Rolling Element Bearing Testing	1.5 hr
Session 8	Workshop – Estimating Remaining Safe Bearing Life	1 hr
Session 9	Condition Monitoring Using Thermography	1 hr
Session 10	Condition Monitoring Using Oil Analysis	1 hr
Session 11	Other Condition Monitoring Methods	1 hr
Session 12	Maintenance Planning from CM Reports	1 hr
Session 13	Workshop – Using CM for Reliability Improvement	1 hr
Session 14	Precision Maintenance – An Overview	1.5 hr
Session 15	The Justification for Precision Maintenance	2 hr
Session 16	Root Cause Analysis – Creative Disassembly	2.5 hr
Session 17	Machine Overhaul - Fits and Tolerances	1.5 hr
Session 18	R/E Bearings – Handling, Storage & Installation	1 hr
Session 19	Machine Installation – Alignment	4 hr
Session 20	A Quality System in the Workshop	1 hr

This course has been run as a 4-day block but this is too long for these people in one session. Better as a 2 x 2-day a couple of weeks to a month apart – see version 2

Content for a 2 x 2-day Maintenance Engineers, Technicians, Mechanics, Craftsmen, Artisans and Trades Course – Version 2

First 2-days

Session 1	The Path Toward Reliability – an Overview
Session 2	Condition Monitoring in the Context of Reliability
Session 3	Principal Causes of Failure in Machinery
Session 4	Detection and Measurement of Machine Faults
Session 5	The Language of Vibrations
Session 6	How a Machinery Vibration Analyser Works
Session 7	Rolling Element Bearing Testing
Workshop	Estimating Remaining Safe Bearing Life
Session 8	Vibration Standards
Session 9	Condition Monitoring Using Thermography
Session 10	Condition Monitoring Using Oil Analysis
Session 11	Other Condition Monitoring Methods
Session 12	Maintenance Planning Based upon Condition Monitoring reports
Workshop	Managing CM for Reliability Improvement

Second 2-days

Session 1	Introduction and Overview to Precision Maintenance
Session 2	The Justification for Precision Maintenance
Session 3	Root Cause Analysis
Session 4	Creative Disassembly
Session 5	Machine Overhaul – Fits and Tolerances
Session 6	Rolling Element Bearings - Selection
Session 7	Alignment
Session 8	Factors Affecting Balance
Session 9	A Quality System in the Workshop

Some companies are not prepared to release Trades for 4 days so we have developed and used a 2-day course – this has been the most widely accepted. See Version 3

Content for a 2-Day Maintenance Engineers, Technicians, Mechanics, Craftsmen, Artisans and Trades Course – Version 3

1.	An Overview	1 hour
	1.1 The Path toward Reliability	
2.	Maintenance Philosophies and Methods	1 hour
	2.1 How might my machine/system fail? How does it fail?	
	2.2 Setting the context for the various maintenance approaches	
	2.3 Risk	
	2.4 Precision/Reliability Improvement	
	2.5 The Balanced Application	
3.	Implementation of the Plant Reliability Process	1 hour
	3.1 Measuring the Benefits	
	3.2 Extent of use and cost	
	3.3 The move from unscheduled to scheduled maintenance	
	3.4 Involvement of all staff and contractors	
	3.5 Review and ongoing improvement – towards reliability	
4.	The Principal Causes of Failure in Machinery	1 hour
	4.1 Functional Failure & Failure Modes	4.3 Resonance
	4.2 Unbalance	4.4 Others
	4.2 Misalignment	
5.	Detection	1.5 hours
	5.2.1 Look, Feel, Listen	5.2.4 Thermography
	5.2.2 Vibration	5.2.5 Performance
	5.2.3 Oil Wear Debris Analysis	5.2.6 NDT
6.	The Language of Vibrations	1.5 hours
	6.1 Fundamentals of Vibration	6.3 Transducers and Instruments
	6.2 Use of Velocity	6.4 Basic Characteristics of Common Faults
7.	Bearings	1 hour
	7.1 Basic monitoring and detection techniques	
	7.2 Care and handling	
8.	Precision Skills	
	8.1 Creative Disassembly - Pre-Shut Checks	2 hours
	Operational Evidence and Wear Patterns	
	Root Cause Analysis	
	8.2 Precision Assembly - Fits and Tolerances	3 hours
	Pre-Alignment Checks and Corrections	
	Factors Affecting Balance	
	8.3 Precision Installation - Base and Structure Integrity	3 hours
	Precision Alignment	
	Acceptance Criteria, Standards, Specifications	

One-Day Precision Maintenance Awareness Course for Maintenance Engineers, Technicians, Mechanics, Craftsmen, Artisans and Trades

Brief Description:

The course will raise the awareness and understanding the maintenance technician and tradesperson has of the effect certain practices have upon the reliability of equipment, particularly rotating machinery. They will better appreciate the contribution they can make toward improved reliability by eliminating causes of premature failure.

Content:

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| 1. Failure | 0.5 hr |
| a. Functional Failure and Failure Modes | |
| b. Principal failure modes | |
| c. The Human Element | |
| 2. The Language of Vibration | 0.5 hr |
| a. Vibration terminology | |
| b. A basic understanding of vibration | |
| c. What is vibration trying to tell us – if we listen? | |
| 3. Vibration and Equipment Failure | 1.5 hr |
| a. Principal sources of vibration | |
| i. Misalignment | |
| ii. Unbalance | |
| iii. Looseness | |
| iv. Fluids | |
| v. Electrical | |
| vi. Others | |
| b. Resonance | |
| i. What is it? | |
| ii. Simple ways to identify it | |
| iii. Dealing with it | |
| c. Vibration measurement and analysis | |
| i. How much is too much? | |
| ii. The effects of excessive vibration – fatigue, wear | |
| d. The benefits of smooth running machinery | |
| 4. Machine Disassembly and Root Cause Analysis | 0.5 hr |
| a. Avoiding a repetition of problems | |
| b. Collecting the evidence of causes of failure | |
| c. Examining the evidence | |
| i. Witness marks | |
| ii. Rolling element bearing tracking patterns | |
| iii. Belt wear patterns | |
| 5. Machine Assembly | 1.0 hr |
| a. Rolling Element Bearings | |
| i. Are you installing a good bearing? | |
| ii. Correct Installation | |



Living Excellence

- iii. Optimising their life in service
- b. Assembly Errors, affecting
 - i. Balance
 - ii. Alignment
 - iii. Looseness
- c. Balancing
 - i. What is Unbalance?
 - ii. Shop balancing and *in situ* balancing
 - iii. Behaviour of Overhung Fans

6. Machine Installation – Alignment related issues **2.0 hr**

- a. What is Alignment?
- b. Alignment Myths and Tolerances
- c. Sources of Misalignment
- d. The importance of Pre-Alignment work for an enduring result
 - i. Foundations and baseplates
 - ii. Soft foot – running and static
 - iii. Pipe strain
- e. Thermal growth
- f. Precision Alignment methods and issues
 - i. Dial Indicators – Reverse Dial method
 - ii. Laser
- g. Issues specific to belt drives

7. Lubrication **1.0 hr**

- a. Methods of lubrication, types of lubricant and additives
- b. Compatibility
- c. How much grease at installation?
- d. How much grease in service, and how often?
- e. The effects of under and over greasing

8. Precision Maintenance **0.5 hr**

- a. Nit-picking or excellence?
- b. The move from Reactive to Proactive
- c. The Benefits