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Improving Rotating Equipment Reliability and Machinery Health Training Course

This 3-day course explains the methods and techniques for outstanding rotating equipment and mechanical plant reliability.

Introduction to Rotating Equipment and Machinery Reliability:

1. The Causes of Rotating Machinery Failures

1.1. True Cost Of Failure

1 Financial impact of downtime
2 Understanding risk and consequence
3 Preventing defects and failure

1.2. Know The Process, Physical, Chemical Properties And Characteristics

1 Process condition disruptions and process effects on components
2 Corrosion, erosion and wear
3 Material and product internal build-up

Exercises & or Case Studies
1 Equipment material of construction selection exercise

1.3. Supporting Structure, Foundations, Strength, Rigidity

1 Attenuation of vibration
2 Dissipating operating loads and forces
3 Preventing equipment deformation

Exercises & or Case Studies
1 Removing soft-foot activity

1.4. Fatigue And Failure Modes

1 Ways shafts fatigue and their causes
2 Ways bearings fail and their causes
3 Ways seals fail and their causes

1.5. Bearing Failures

1 Fluctuating loads and forces
2 Lubrication condition
3 Tell-tale bearing failure signs

Exercises & or Case Studies
1 Bearing failure case study

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2. Precision Maintenance for Rotating Equipment and Machines

2.1. Reliability, Availability, Maintainability, Safety (RAMS)

1 Impact of special and common cause variation on RAMS
2 Precision maintenance for rotating equipment
3 Accuracy Controlled Procedures

2.2. Balanced Shafts, Balancing Standards

1 Causes of out-of-balance
2 Engineering standards and limits for balancing
3 Mechanical balancing

Exercises & or Case Studies
1 In-situ shaft balancing case study

2.3. Shaft Alignment

1 Effects of shaft misalignment
2 Standards and limits for alignment
3 Methods of precision shaft alignment

Exercises & or Case Studies
1 Shaft alignment case study

2.4. Rotating Equipment Vibration

1 Allowable vibration severity
2 Bearing vibration causes
3 Machinery vibration isolation

2.5. Lifting Maintenance Performance (To have additional focus)

1 Measuring maintenance outcomes and KPIs
2 Maintenance Quality Systems for RAMS
3 Using visual management to control performance

3. Optimising Reliability – Fundamentals of Condition Monitoring and Predictive Maintenance:

3.1. Condition Monitoring Methods For Rotating Equipment

1 Tribology and lubrication analysis
2 Thermography
3 Rotating equipment non-destructive testing
4 Operating performance monitoring

3.2. Bearing Vibration Analysis

1 Vibratory condition based monitoring
2 Vibration signatures
3 Vibration analysis

Exercises & or Case Studies
1 Bearing vibration signature analysis case study

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3.3. Tribology and Lubrication Overview

1 Wear particle analysis
2 Properties of lubricants
3 Sustaining lubricant health

3.4. Thermography

1 Temperature signature analysis
2 Mechanical equipment
3 Electrical equipment

3.5. Maintenance Strategy Mix (To have additional focus)

1 The PM - PdM - Breakdown mix
2 Total Productive Maintenance (TPM) and Operator driven reliability
3 Precision Maintenance

Exercises & or Case Studies
1 Select a maintenance strategy mix activity

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Rotating Equipment and Machinery Reliability Continuous Improvement:

1. Design of Rotating Equipment and Machines

1.1. Strength of Materials for Shafts and Rotors

1 Metallurgy - stress and stress raisers
2 Metal fatigue
3 Bending and deflection of shafts

1.2. Horizontal Shaft Design, Vertical Shaft Design

1 Axial and radial loads
2 Shaft and equipment expansion considerations
3 Shaft manufacture, diameter and tolerances

Exercises & or Case Studies
1 Design a shaft

1.3. Bearing Design And Selection, Radial And Axial Bearings

1 Roller bearings and plain bearings – uses and limitations of each
2 Bearing lubrication and selection
3 Bearing housings and construction

Exercises & or Case Studies
1 Select a bearing for the shaft exercise

1.4. Lubrication Selection

1 Properties of lubricants
2 Lubricant operating environment
3 Lubricant life-extension additives

1.5. Shaft Seals – Methods, Types, Designs, Process Effects

1 Seal design overview
2 Seal failure modes
3 Seal selection

1.6. Vibration Prevention and Isolation (To have additional focus)

1 Basics of spring/damper systems
2 Natural frequency
3 Machinery vibration isolation

Exercises & or Case Studies
1 Perform a simple vibration isolation calculation

2. Root Cause Failure Analysis Procedure

1.7. Root Cause Failure Analyses (RCFA)

1 RCFA fundamentals
2 The RCFA process

3 Developing and implementing solutions

1.8. Finding the Evidence and Proof

What specifically will be covered:
1 Operating and maintenance records and analysis
2 Creative disassembly
3 Importance of keeping accurate records and history

1.9. Applying RCFA in the Workplace

What specifically will be covered:
1 Cross-functional teams
2 The 5 Whys method
3 Operator and maintainer buy-in for improvement

Exercises & or Case Studies
1 RCFA exercise

3. Design Screening (Component Function) Examples

1.10. Design, Operation and Cost Total Optimisation Review

What specifically will be covered:
1 Life cycle operating cost
2 Cost impact calculations
3 Design review and optimisation

Exercises & or Case Studies
1 Failure impact cost analysis exercise

1.11. Risk Reduction Strategies in Design

1 Understanding and measuring risk
2 Chance vs. consequence risk reduction methods
3 Applying risk reduction during design

1.12. Lifting Lifetime Reliability (to have additional focus)

1 Equipment reliability overview
2 Measuring reliability: for components – Weibull; for systems - Crow/AMSAA
3 RCM/FMEA fundamentals

Exercises & or Case Studies
1 FMEA exercise

4. Management of Rotating Equipment and Machines

1.13. Reliability of Systems

What specifically will be covered:
1 Series and Parallel systems
2 Implications for series systems
3 Implications for parallel systems

1.14. Instigating Rotating Equipment Operational Excellence

1 Necessary Asset Management systems
2 Documentation requirements
3 Training and up-skilling of personnel

Exercises & or Case Studies
1 Asset Management Strategy exercise

1.15. Rotating Equipment Integrity Management

1 Statutory, Safety, Operating and Maintenance Standards
2 Documentation and Record Keeping requirements
3 Auditing and Analysis of operating management systems

1.16. Rotating Equipment Reliability Improvement Strategy

1 Setting Equipment Performance Specifications
2 Selecting best practice methods to achieve the performance objectives
3 Developing and managing workplace best practice processes

Exercises & or Case Studies
1 Develop the vision, objectives and strategies to achieve rotating equipment operating and maintenance excellence

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Overview of Course Activities and Exercises

Equipment material of construction selection exercise

Participants will wear the equipment 'designer's hat' and be taken through several operating scenarios where material selection for long equipment service life is critical. They will have the opportunity to identify failure modes and apply good engineering practice to select materials that suit the operating conditions.

Removing soft-foot activity

In this mini-workshop the attendees will learn the method used to remove soft-foot problems. A simple scenario is provided where they experiment with the technique. As part of the exercise they develop a precision maintenance procedure to correct the soft-foot problem.

Bearing failure case study

An example of several bearing failure types will be presented and investigated to identify the failure causes. Analysis will be conducted with the group to highlight what could have been done to prevent the failures or to extend bearing life. The purpose is to learn good bearing care practices so attendees can apply them in their workplace.

In-situ shaft balancing case study

Attendees are taken through the process of in-situ shaft balancing of a shat and rotor by application of the method on an example from a workplace situation. The example provides understanding of how the procedure is applied and transfers knowledge of the critical issues that

need to be met to ensure out-of-balance vibration is kept within internationally recognised standards.

Shaft alignment case study

Attendees are taken through the process of shaft alignment by application of the method on an example from a workplace situation. By working through the requirements of a reverse-dial indicator shaft alignment Attendees will have detailed exposure to the key factors that produce a good shaft alignment result.

Bearing vibration signature analysis case study

Bearing vibration analysis is explained through examination of a bearing vibration signature from a rotating equipment item. Attendees will learn to identify various types of information recorded about the working environment of the bearing contained within the vibration signature.

Select a rotating equipment maintenance strategy mix activity

Attendees identify and develop an understanding of the various maintenance strategies available for the care of rotating equipment. They do an exercise to select a sound mix of strategies for rotating equipment in various situations and environments.

Design a shaft

A more thorough appreciation of the limitations and lifetime impacting constraints that affect rotating equipment is gained by going through the process of designing a shaft to be used in a rotary equipment item. The shaft will be put under a variety of loading and stressful situations and their effects on it are modelled mathematically in simple and clear presentations.

Select a bearing for the shaft exercise

To gain a fuller understanding of the maintenance and operating issues and requirements facing rotating equipment owners the Attendees are taken through a bearing selection process for the shaft previously designed. They will be taken through the various considerations and design decisions made by designers and they will learn how the original design choices affect the use and care of the bearing and equipment throughout its operating life.

Perform a simple vibration isolation calculation

Attendees are taken through a simple process of identifying the necessary vibration separation requirements to prevent vibration transmission from rotating equipment to the structures in contact with it. The exercise explains the choices and issues that need to be addressed to minimise transmitted vibration.

RCFA exercise

A simple situational failure will be investigated to help Attendees understand the application and usefulness of Root Cause Failure Analysis. The use of RCFA and its methodology will be explained and then applied in a simple example. Attendees will learn the process involved in conducting an RCFA and how to trace the failure evidence back to the root cause.

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FMEA exercise

The shaft design and bearing selection made previously will be put through a Failure Mode and Effects Analysis. The will Attendees apply the FMEA method to identify the most suitable operating practices and maintenance strategies for the preservation of equipment function and to promote long operating life.

Failure impact cost analysis exercise

Attendees will be introduced to the method of defect and failure true costing. This technique highlights the massive impact suffered by an operation when a failure occurs. The method provides Attendees with powerful new tool to find financial evidence of the cost of poor practices and to justify changes to poor practices in order to recover the moneys now wasted.

NOTE: *If you need more detailed information on this training course or its content please contact us directly with your request.*