www.CMDGlobal.org

Learning Guide 2025

Exponential Learning Experience …

ROTOR BALANCING

www.CMDGlobal.org

Focus on theoretical and practical aspects of rotor balancing, which helps participants to identify and correct any imbalance problem

First Day

- **Rotor Imbalance:**
  - What is imbalance, what causes of Imbalance
  - Static / Dynamic / Coupled imbalance
  - Dynamic Balancing methods
  - Units for expressing Imbalance ; Vector
  - Imbalance and it's vibration effect
- **Basic concepts of Vibration diagnosis**
  - Diagnosis of imbalance
  - Interpretation of mechanical imbalance with phase measurement and resembling symptoms like bent shaft, looseness, eccentricity & misalignment
- **Understanding the types of Imbalance :**
  - Static or force Imbalance ; Couple Imbalance
  - Quasi-static Imbalance; Dynamic Imbalance
- **Classification of Rotor: Rigid / Flexible rotors**
- **Consideration on Critical speed (resonance) of rotors**
- **Four run balancing method** *without phase measurement*
- **Single plane vector balancing**
- **Two plane-balancing techniques**
  - Plane separation, Cross effect, Influence co-efficient method, Trim balancing
- **Balancing overhung rotors**
  - Single plane vector method; Static couple method
- **Multi plane balancing**
  - Deflection & distortion; Static-couple derivation
- **Imbalance correction – addition / removal**
  - Radius and weight relationships

Second Day:

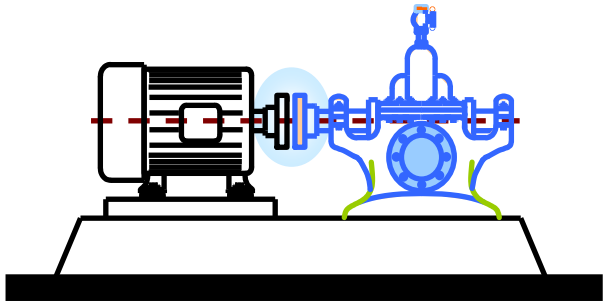
- **Introduction to field (in-situ) balancing**
  - Advantages and requirements
- **Selection criteria for sensor**
- **Field balancing instrumentation and techniques**
- **Practical considerations for phase measurement**
  - Strobe light; Photocell; Phase convention
- **Factors affecting field Balancing**
  - Resonance, balancing speeds, balancing instrumentation, other vibration sources etc
- **Balance Tolerances**
  - Balancing Standards - ISO, API, Navy, VDI etc
  - Permissible residual Imbalance ; Balance quality grades
  - Vibration severity charts
  - Shop Balancing Criteria (ISO 1940 balancing tolerance)
- **Balancing Machines**
  - Rotor support systems; Hard versus soft bearing machines
  - Balancing machines, speeds and instrumentation
  - End-drive adapters; Balancing arbors
- **Imbalance correction methods** – *Practical issues*

Course Code: CMD-RB

Certificate of Training will be issued by Center for Machinery Diagnostics

SHAFT ALIGNMENT

– Fundamental



www.CMDGlobal.org

Misalignment is the common failure mode in any rotating machinery and it causes premature bearing, seal failures. Our training program focus on fundamental aspects of misalignment and concepts of various corrective methods,

First Day

Causes of Misalignment and it's effects

Diagnosing Misalignment and corrective means
Symptoms of Parallel and Angular Misalignment

Alignment Methods and Procedures Methods,
Pre-alignment Checks – coupling error, soft foot etc
Rough Alignment Methods – Straight edge

Dial Gauge Techniques
- Face-and-Rim Method
- Reverse-indicator Method
  - Graphical Calculations method
    Practical Demonstration…

Optical and Laser Alignment Systems

Second Day

Continuation …

Coupling types – Rigid / Flexible coupling
Lateral & Torsional vibration symptoms

Concerns of Alignment
• Poor Foundations • Bent Shafts • Soft Foot • Bar Sag • Thermal Growth • Pipe Strain • Alignment Tolerances

Other alignment methods
- Bearing Alignment
- Gear Alignment
- Pulley (Belt Drive) Alignment
- Vertical Shafts • Self alignment

Review of misalignment, alignment tolerances, pre-alignment checks, base and foot problems (including soft foot), precision alignment, reverse dial and rim/face dial indicator methods, laser alignment, thermal distortion etc

Course Code: CMD-SA
Certificate of Training will be issued by
Center for Machinery Diagnostics

RESONANCE

www.CMDGlobal.org

Focus on theoretical and practical aspects of RESONANCE related vibration phenomena such as system natural frequency and critical speed, which helps participants to understand the complex vibration problem during installation / repair / modification /maintenance

First Day

- Elements of mechanics
- A simple dynamic system / Degrees of Freedom
- Relationships
  - Stiffness vs. Displacement
  - Damping vs. Velocity
  - Mass vs. Acceleration
  - Kinetic and Potential energy concept
- Undamped Vibrations
- Forcing Frequency and Resonance
- Mobility, Transmissibility and Damping
- **Rotor Dynamic Principle:**
  - Classification of rotor – Rigid & Flexible rotor
  - Design criteria
  - Mode shapes
- **Basic concepts of Vibration diagnosis**
  - Diagnosis of resonance
  - Interpretation with phase measurement
  - Excitation due to residual imbalance, mis-alignment bent shaft, looseness, eccentricity & misalignment
- **Understanding the types of resonance :**
  - System Resonance / Critical Speed

Second Day:

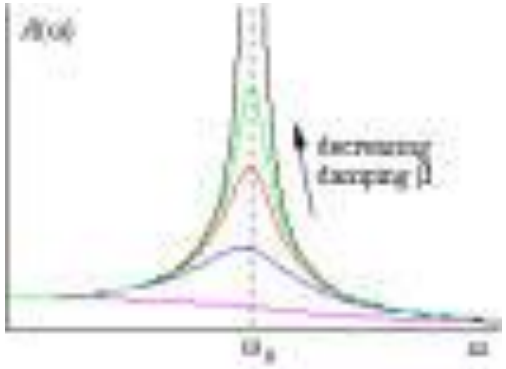
- Calculation of Natural frequency for beams, shafts etc
- Design considerations on critical equipment.
- Equipment acceptance/ repair verification test.
- De-tuning / Vibration control measures
- Operational Deflection shape studies

Identification of Natural frequency:

- **Impact hammer / bump test**
- **Transient – Coast up / Coast down vibration studies**
- **Vibration Data: Bode / Polar / Nyquest Plots etc**
- Case studies on Resonance phenomena

Course Code: CMD-RS

Certificate of Training will be issued by
Center for Machinery Diagnostics



ELECTRICAL SIGNATURE ANALYSIS

– Fundamental

www.CMDGlobal.org

Electrical Signature Analysis (ESA) is emerging successful condition monitoring techniques to assess the health condition of electrical motors / Generators to detect impending failure on rotor, stator and air gap related faults.

The objectives of the Trainings are

1. To build confidence by providing useful information and practical hands-on exposure.
2. An understanding of motor management and motor diagnostic needs
3. An understanding of the technology capabilities by reliability and maintenance.

Application of motor diagnostic technologies for quality assessment / repair prediction

First Day:

- Basic electrical principles / Electric motor principle
- DC / AC motor theory and design / Variable frequency drives
- Fundamentals on current signature analysis
- Causes and effects of: broken rotor bars, uneven air gap eccentricity, shorted turns in stator windings, shaft/coupling misalignment, stator core vibration characteristics and problems

Second Day:

- Transducer selection
- Signal processing concepts and issues
- Measurement methods and techniques
- Potential failure modes – stator / rotor defects
- Eccentricity – Static / dynamic eccentricities
- Prediction of fault severity and interpretation means
- Co-relation between current and vibration monitoring
- Analysis of case histories

Who should attend: Plant managers, safety and reliability engineers, maintenance personnel, motor manufacturers and motor repair shop personnel.

Course Code: CMD-ESA

Certificate of Training will be issued by
Center for Machinery Diagnostics

ULTRASONIC TESTING

– Airborne / Structure borne Techniques

www.CMDGlobal.org

Ultrasonic testing is widely acceptance among the engineering, operations, safety, quality control, and maintenance departments in several industries including aerospace, health, petrochemical, manufacturing, and the military. The technology has wider application in Maintenance filed also to detect air borne ultrasound such as leakages, electrical partial discharge and structural borne ultrasound such as leakage etc.

The objectives of the Trainings are

- to promote maintenance personals confidence in ultrasonic testing cum inspections,
- to provide a better understanding of the technology and its applications,
- to attain knowledge and expertise in structure and airborne ultrasound, and

to uphold the unique and significant place of airborne ultrasound in Predictive Maintenance Programs, Energy Management and Quality Control.

First Day:

- Principles of Sound / Ultrasound
- Types of Sounds, Wavelength, Mediums, Sound Waves
- Airborne Ultrasound Equipment Construction and Characteristics / Testing Methods
- Indications and Types of Leaks / Principles and Techniques in Leak Detection and Location
- Disruptions in Electrical Flow / Types of Electrical Discharge
- Effects of Stray Electrical Discharge
- Principles and Techniques in Corona, Tracking and Arcing Inspections

Second Day:

- Principles of Structure borne Ultrasound Testing Method
- Valves and Steam Traps / Effects of a Defective Component
- Principles and Inspection Methods for Valves and Steam Traps
- Stages of Mechanical Failures / Inspection of Rotating Mechanical Equipments
- Integrated Acoustic study with Vibration Monitoring program
- Predictive Maintenance and Asset Management

Who should attend: Plant managers, safety and reliability engineers, maintenance personnel, pipe / valve repair shop personnel.

Course Code: CMD-UST

Certificate of Training will be issued by
Center for Machinery Diagnostics

ROOT CAUSE FAILURE ANALYSIS

What causes failure? Why failure occurs? Where failure originate? When failure occurred? How to prevent / avoid failures?

RCFA training focus on Failure identification, Description, Cause analysis and Avoidance methods

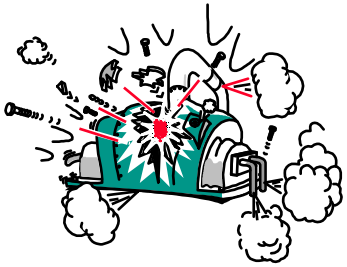
- Equipment, component design, function, integrity, Redundancy.
- Testing, validation
- Maintenance methods

What might fail or could be wrong?
What effect this failure would have?
What might cause the failure?
What needs to be done to prevent it?

First Day:

Fore noon: Failure identification, typical failure mechanisms, identify potential failure modes including log book records, maintenance history documentation.

After Noon Session: Failure description: The criteria for failure analysis. Use of flowcharts, critical incident, spider charts, purpose, application matrices and checklists.



www.CMDGlobal.org

Failure Mode and Effects Analysis (FMEA) is a logical technique used to identify and eliminate possible causes of failure. The technique requires a sequential, disciplined approach by engineers to assess systems, equipment or maintenance procedure in order to establish the modes of failure and the effects of failure on the system, product or process.

This is to ensure that all possible failure modes have been fully identified and ranked in order of their importance. The FMEA discipline requires the engineers to document their evaluation with regard to the failure mode, effect and criticality.

The analysis work can be applied at any stage; design, procurement, test, installation or operation and repair / maintenance phase
For maintenance function, the study may be performed on the complex system or equipment or various sub-system /assemblies, component.

Second Day

Cause analysis tools, histograms, pareto charts, scatter charts, relations diagrams and affinity diagrams..

Develop potential solution and present for actionable cost effective solution, compare benefits and cost effectiveness of all prevention options

Course Code: CMD-RCFA

Certificate of Training will be issued by Center for Machinery Diagnostics

VIBRATION TECHNOLOGIST (BASIC)

www.CMDGlobal.org

First Day:

Review on Maintenance Methods
1. Principles of Vibration, Basic Vibratory Motion, Period, Frequency, Amplitude: Peak, RMS, Parameters: Displacement, Velocity, Acceleration Units: Unit Conversions.
Time and Frequency Domains, Vectors, Modulation, Phase, Natural Frequency, Resonance, Critical Speeds
2. Data Acquisition: Instrumentation, Dynamic Range, Signal to Noise Ratio, Transducers, Sensor Mounting

Second Day:

Continuation…of Data Acquisition, Mounted Natural Frequency, Do and don't practices
3. Signal Processing, FFT Application
4. Condition Monitoring, Baseline Assessments, Trending, Deterioration/ wear, Prediction of failure

5. Equipment Knowledge
Electric Motors: AC, DC. VFD
Pumps, Fans, Steam Turbines, Gas Turbines, Compressors
Reciprocating Machinery
Rolling Mills, Paper Machines
Machine Tools, Structures, Piping
Rolling Element / Journal Bearings, Gears, Couplings, Belts

Certificate of Professional competency will be issued to successful participants.
The Certificate will be issued jointly by
The Vibration Institute of India and Center for Machinery Diagnostics

Third Day:

6. Reference Standards: Rathbone Chart, Blake Chart, API, Hydraulic Institute, NEMA ISO 10816 / 7919

7. Fault Diagnosis of imbalance, Mis-alignment Mechanical Looseness etc

Reporting and Documentation
Corrective Action
Dynamic Balancing
Shaft Alignment
Case Studies

Practical Demonstration

Forth Day:

Other CM Technologies:
Sound & Ultrasonic Analysis
Electrical Motor Current Analysis
Infrared Thermography,
Question and Answer

Examination for
TVII Vibration Technologist Certificate

*Participants seeks professional certification

Course Code: CMD-VTB

INFRARED THERMOGRAPHY TECHNOLOGIST (BASIC)

www.CMDGlobal.org

First Day:

Review on Maintenance Methods

Principles of Infrared, Electromagnetic waves
Difference between Visible & Infrared wave
Temperature measurement, Temperature scales
Conversion of temperature
Principles of Heat Transfer
Conduction, Convection - natural & forced and Radiation
Matters: Solid/ Liquid / Gas

Second Day:

Continuation…of Heat Transfer
Emittance, Reflectance, and Transmittance
Importance of Emissivity for Qualitative temperature measurement.
Do and don't practices,
Application Principle: : Qualitative and Quantitative techniques

SYSTEM Knowledge

ELECTRICAL SYSTEMS
Transmission Lines, Distribution Lines, Substations / Transformers
Bus Duct / Switchgear

MECHANICAL SYSTEM
Rotating equipment / Power transmission components - coupling
Fluid flow applications including steam systems, heat exchangers etc.

Other applications – Medical,

Third Day:

Implementation of PdM Program on Infrared Thermography
Selection & application camera, Lens Selection / Use of Filters
Optimising the Image

Reporting and Documentation
Documentation of Survey, Report preparation, Corrective Action
Rectify thermal anomaly

Case Studies

Discussion and Practical Demonstration

Fourth Day:

Other CM Technologies:
Vibration Analysis, Ultrasonic Analysis, Electrical Power Quality
Question and Answer

Examination for **Thermography Technologist Certificate***

Certificate of Professional competency will be issued to successful participants.

The Certificate will be issued by Center for Machinery Diagnostics

Course Code: CMD-IRTB

*Participants seeks professional certification

Our course contents follows the training requirement of **ISO/CD 18434** - Condition monitoring & diagnostics of machines using thermal imaging – General guidelines and **ASNT SNT-TC-1A**

VIBRATION DIAGNOSIS SPECIALIST LEVEL I

www.CMDGlobal.org

First Day:

Vibration charecterstics
Spring-Mass Systems , Characteristics of Vibration
Natural Frequency Time and Frequency Domains
Vectors, Modulation, Phase
Natural Frequency, Resonance, Critical Speeds

2.Transducers –
Choosing a Transducer
Types of Vibration Transducers
Transducers - Mounting Locations and Techniques
Selection Criteria, Amplitude of Vibration , Frequency
Environmental Limitations , FFT Data Collectors
Real-Time Spectrum Analyzers

Second Day:

3 Data Acquisition Instrumentation, Dynamic Range,
Signal to Noise Ratio, Transducers, Sensor Mounting
Mounted Natural Frequency, Do and don't practices

4. Signal Processing
Analog to digital conversion, FFT Application, FFT Parameters
(Lines, Resolution, Frequency Range), Sampling method
Window function, aliasing issues, Types of Averaging
Oerlap Processing, Bandwidth

5. Date Interpretation :
Synchronous versus Subharmonic, Synchronous versus Harmonic
Nonsynchronous Modulation, Interpretation of Phase angle

Third Day:

6. Fault Diagnosis
Mass im-balance, Misalignment / Bent Shaft, Soft Foot /
Mechanical Looseness, Rolling Element Bearings
Gearbox Fault Diagnosis, Electrical Motors defect
Pump & Fan Problems

Case Studies
7. Reference Standards, Rathbone Chart, Blake Chart, API
Hydraulic Institute, NEMA, ISO 10816 / 7919

Reporting and Documentation
Corrective Action - Dynamic Balancing, Shaft Alignment

Fourth Day:

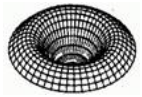
Field Visit: Process or Power Plant or Utility plant

Examination for **Vibration Diagnosis Specialist Level I** Certification

Certificate of Professional competency will be issued to successful participants jointly by
The Vibration Institute of India & Center for Machinery Diagnostics

Course Code: CMD-VDS1

Prerequisite: Proficiency in **Vibration Technologist (Basics)**
Training associates: The Vibration Institute of India



INFRARED THERMOGRAPHY DIAGNOSIS SPECIALIST LEVEL 1

www.CMDGlobal.org

First Day

Introduction on Thermal and Infrared Physics
The nature of Heat and Temperature Heat Transfer Mode Review

Conduction fundamentals;
Fourier's Law; Conductivity & Resistance basics;
Convection fundamentals; Newton's Law of cooling;

Radiation fundamentals; Film Co-efficient / film resistance basics;
Stephan Boltzmann Law (concept); Radiosity Concepts;
Reflectance, transmittance, absorbance, emittance
Radiometry and imaging; Spatial resolution concepts;
Error potential in radiant measurement

Second Day

Infrared Equipment Operations
Thermography defined; How IR images work;

Equipment overview & features; Operation of equipment
Select the perspective; Image area and lens selection;

Use of filters; Image Optimisation
Infrared image and documentation; Clarity (spatial focus);
Thermal focus; Dynamic range

Third Day

Infrared Equipment Operations Continued …
Understanding and dealing with reflections; convection
Support data collection;
Environmental data collection - emittance;
Surface reference temperature;
Instrumentation system for infrared inspections
Practical session Temperature measurements / emissivity measurements Compensation for distance and small object size;

Field quantification

Fourth Day:

Infrared Application Overview
Electrical inspections; Mechanical inspections; Furnace inspections
Detecting thermal anomalies in:
Thermal resistance - insulation / Thermal capacitance - roof moisture surveys
Physical state - gas/liquid, liquid/solid vessel levels
Fluid flow - tube blockages / Friction - bearings, gears, belts
Exothermic/endothermic condition
Electrical resistance, insulation voids
Software – Over view, Data base setup etc /Case Study Discussion

Fifth Day

Industrial Visit – Process or Power Plant or Utility plant
Certificate of Exam on Infrared Thermography Diagnostic Specialist
The Certificate will be issued by Center for Machinery Diagnostics

Course Code: CMD-IRTDS1

Prerequisite: Infrared Thermography Technologist (Basics)

* Our course contents follows the training requirement of **ISO/CD 18434** - Condition monitoring and diagnostics of machines using thermal imaging – General guidelines and **ASNT SNT-TC-1A**

www.CMDGlobal.org

Singapore
Malaysia
Indonesia
Middle East
India

- 2025-

CENTER FOR MACHINERY DIAGNOSTICS
84, TOH GUAN ROAD EAST, #03-01, **SgWX**
SINGAPORE – 608501
+65-8700 2124 / +65-8298 4664
e-mail: Learning@CMDGlobal.org

www.CMDGlobal.org

ε - **Exponential Learning Experience …**