COURSE OVERVIEW ME0636
Fundamentals of Pump and Compressor Systems (E-Learning Module)

Course Title
Fundamentals of Pump and Compressor Systems (E-Learning Module)

Course Reference
ME0636

Course Format & Compatibility
SCORM 1.2. Compatible with IE11, MS-Edge, Google Chrome, Windows, Linux, Unix, Android, IOS, iPadOS, macOS, iPhone, iPad & HarmonyOS (Huawei)

Course Duration
30 online contact hours
(3.0 CEUs/30 PDHs

Course Description

This course is designed to provide participants with a detailed and up-to-date overview of the fundamentals of pump and compressor systems. It covers the rotating equipment, turbo-machinery, fluid and physics basics, kinetic energy, potential (gravitational) energy, mechanical energy and pressure energy; the fluid mechanics, the continuity equation (conservation of mass), fluid flow, Bernoulli's principle, calculation basics and vapor pressure; the specific gravity, viscosity, heat transfer and its application, temperature and heat, measuring units of heat and heat transfer fundamentals; the heat transfer application and heat transfer methods; the pumps and its functions; and the advantages of dynamic (centrifugal pumps), rotary pumps and reciprocating pumps.

Further, the course will also discuss the gas compression, Boyle's law, Charles's law, combined gas law and the typical operating regimes of compressors; the dynamic and centrifugal compressor; axial flow compressor, positive displacement compressors, positive displacement rotary compressor, rotary compressor, reciprocating compressor, typical multistage stages layout and liquid ring pump (LRP); the coupling and alignment; the shaft alignment, laser alignment systems, documentations of measurement results, soft foot check and simple measuring procedure; the vibration measurement; and the shaft sealing systems for rotating equipment.

Moreover, the course will also cover the shaft sealing devices, compression packing, gland packing and table of pH values; the mechanical seals and balancing ratio; the various types of shaft seals, seals-liquid film shaft seal, oil sealing system, dry carbon ring seal, labyrinth seals, segmented ring seal and inter-stage seals; the dry gas mechanical seals and mechanical seals failure modes including the importance of lubricating; the temperature monitoring, preventive maintenance (PM), lubrication storage and handling; the effect of temperature on viscosity, grease, hydrodynamic lubrication, methods of supply and hybrid lubrication; the oil analysis, discuss bearings, anti-friction bearings, bearing loads, journal bearings, hydrodynamic journal bearings, journal or plain bearings, tilting-pad journal bearings and thrust bearings; and the tilting-pad thrust bearings, combined radial and thrust bearings, effects of vibration, causes of bearing failure, correct amount of lubricant and fatigue.

During this course, participants will learn the removal and installation of anti-friction bearing; the bearing life, effects of corrosion, primary challenge to bearings in industry, ball and roller bearing, overheating, failure modes, true and false brinelling and normal fatigue failure; the contamination, failure modes, lubricant failure, corrosion, misalignment, loose fits and tight fits; troubleshooting journal bearings; the various types of cavitation; the pumps installation, commissioning and configuration; the pump suction strainer, pump piping strain and the nature of failures and equipment ; the machinery failure; the failure characteristics, causes of failures, failure mechanisms, main modes of failure, pumps failure modes and factors affecting pumps reliability; the basic reasons for pumps failures; the compressors control, surge control and automatic shutdown systems; and the centrifugal pumps troubleshooting, positive displacement pumps troubleshooting and centrifugal compressor troubleshooting.

Course Objectives

The course should serve the following overall learning objectives:-

- Apply and gain a fundamental knowledge on pump and compressor systems
- Identify the types of pumps, compressors, drivers and their common applications and range of operations
- Evaluation and selection of pumps, compressors, and their drivers for long-term efficient operations
- Integrating the pump or compressor units with the upstream and downstream piping and process equipment
- Defining the major life cycle events, such as changes in flows, fluid composition, and operating conditions that can affect equipment selection and operating strategies
- Major design, installation, operating, troubleshooting and maintenance considerations
- Discuss rotating equipment, turbo-machinery, fluid and physics basics, kinetic energy, potential (gravitational) energy, mechanical energy and pressure energy
- Explain fluid mechanics, the continuity equation (conservation of mass), fluid flow, Bernoulli's principle, calculation basics and vapor pressure

- Determine specific gravity, viscosity, heat transfer and its application, temperature and heat, measuring units of heat and heat transfer fundamentals
- Carryout heat transfer application and heat transfer methods and recognize pumps and its functions
- Classify pumps and discuss the advantages of dynamic (centrifugal pumps), rotary pumps and reciprocating pumps
- Discuss gas compression, Boyle's law, Charles's law, combined gas law and the typical operating regimes of compressors
- Describe dynamic compressors and centrifugal compressor and well as configure centrifugal compressors and discuss the advantages and disadvantages of centrifugal compressors
- Recognize axial flow compressor, positive displacement compressors, positive displacement rotary compressor, rotary compressor, reciprocating compressor, typical multistage stages layout and liquid ring pump (LRP)
- Identify coupling and alignment and list the various types of couplings
- Compare machinery couplings and discuss shaft alignment, laser alignment systems, documentations of measurement results, soft foot check and simple measuring procedure
- Perform tolerance check and explain compensation for thermal growth, vertical/flange mounted machines, offset and angle program, cardan-shaft-coupled machines
- Carryout vibration measurement and recognize shaft sealing systems for rotating equipment
- Identify shaft sealing devices, compression packing, gland packing and table of pH values
- Discuss mechanical seals balancing ratio, materials, seal selection factors, the costs of sealing, increasing seal life and the basics of mechanical seals
- Recognize the various types of shaft seals, seals-liquid film shaft seal, oil sealing system, dry carbon ring seal, labyrinth seals, segmented ring seal and inter-stage seals
- Explain dry gas mechanical seals and mechanical seals failure modes including the importance of lubricating
- Employ temperature monitoring, preventive maintenance (PM), lubrication storage and handling
- Identify the effect of temperature on viscosity, grease, hydrodynamic lubrication, methods of supply and hybrid lubrication
- Carryout oil analysis and discuss bearings, anti-friction bearings, bearing loads, journal bearings, hydrodynamic journal bearings, journal or plain bearings, tilting-pad journal bearings and thrust bearings

- Equalize tilting-pad thrust bearings and determine combined radial and thrust bearings, the effects of vibration, causes of bearing failure, correct amount of lubricant and fatigue
- Remove and install anti-friction bearing and discuss bearing life, effects of corrosion, the primary challenge to bearings in industry, ball and roller bearing, overheating, failure modes, true and false brinelling and normal fatigue failure
- Explain contamination, failure modes, lubricant failure, corrosion, misalignment, loose fits and tight fits
- Troubleshoot journal bearings as well as identify the various types of cavitation, the incidents that cause suction cavitation and the effect and prevention of cavitation
- Employ pumps installation, commissioning and configuration and discuss pump suction strainer, pump piping strain and the nature of failures and equipment
- Define machinery failure and differentiate non-repairable versus repairable equipment
- Describe the failure characteristics, causes of failures, failure mechanisms, main modes of failure, pumps failure modes and factors affecting pumps reliability
- List the basic reasons for pumps failures and discuss compressors control, surge control and automatic shutdown systems
- Carryout centrifugal pumps troubleshooting, positive displacement pumps troubleshooting and centrifugal compressor troubleshooting

Who Should Attend

This course covers systematic techniques and methodologies on the fundamentals of pump and compressor systems for those who are involved in the operation, maintenance and troubleshooting of such equipment. This includes rotating equipment and machinery engineers, plant and maintenance engineers and other technical staff involved in turbomachinery management, operation and maintenance. Further, it is suitable for operations, process and process unit contact, mechanical and project engineers.

Training Methodology

This Trainee-centered course includes the following training methodologies:-

- Talking presentation Slides (ppt with audio)
- Simulation & Animation
- Exercises
- Videos
- Case Studies
- Gamification (learning through games)
- Quizzes, Pre-test & Post-test

Every section/module of the course ends up with a Quiz which must be passed by the trainee in order to move to the next section/module. A Post-test at the end of the course must be passed in order to get the online accredited certificate.

Course Certificate(s)
Internationally recognized certificates will be issued to all participants of the course.

Certificate Accreditations
Certificates are accredited by the following international accreditation organizations: -

- USA International Association for Continuing Education and Training (IACET)

  Haward Technology is an Authorized Training Provider by the International Association for Continuing Education and Training (IACET), 2201 Cooperative Way, Suite 600, Herndon, VA 20171, USA. In obtaining this authority, Haward Technology has demonstrated that it complies with the **ANSI/IACET 1-2013 Standard** which is widely recognized as the standard of good practice internationally. As a result of our Authorized Provider membership status, Haward Technology is authorized to offer IACET CEUs for its programs that qualify under the **ANSI/IACET 1-2013 Standard**.

  Haward Technology's courses meet the professional certification and continuing education requirements for participants seeking **Continuing Education Units** (CEUs) in accordance with the rules & regulations of the International Association for Continuing Education & Training (IACET). IACET is an international authority that evaluates programs according to strict, research-based criteria and guidelines. The CEU is an internationally accepted uniform unit of measurement in qualified courses of continuing education.

  Haward Technology Middle East will award **3.0 CEUs** (Continuing Education Units) or **30 PDHs** (Professional Development Hours) for participants who completed the total tuition hours of this program. One CEU is equivalent to ten Professional Development Hours (PDHs) or ten contact hours of the participation in and completion of Haward Technology programs. A permanent record of a participant's involvement and awarding of CEU will be maintained by Haward Technology. Haward Technology will provide a copy of the participant's CEU and PDH Transcript of Records upon request.

- British Accreditation Council (BAC)

  Haward Technology is accredited by the **British Accreditation Council** for **Independent Further and Higher Education** as an **International Centre**. BAC is the British accrediting body responsible for setting standards within independent further and higher education sector in the UK and overseas. As a BAC-accredited international centre, Haward Technology meets all of the international higher education criteria and standards set by BAC.

Course Fee
As per proposal

Course Contents

- Overview of Rotating Equipment
- What is Meant by “Turbo-Machinery”?
- Machines that Extract Energy
- Fluid and Physics Basics
- Energy
- Kinetic Energy
- Potential (Gravitational) Energy
- Mechanical Energy
- Pressure Energy
- Pressure, Gage & Absolute
- Fluid Mechanics
- Flow Trough Pipes
- Example: Pressure Drop
- The Continuity Equation (Conservation of Mass)
- Fluid Flow
- Energy Relationships
- Bernoulli’s Principle
- Calculation Basics
- Vapor Pressure
- Specific Gravity
- Viscosity
- Heat Transfer & its Application
- Temperature and Heat
- First Law of Thermodynamics
- Second Law of Thermo-Dynamics
- The Temperature Units
- Measuring Units of Heat
- Heat Transfer Fundamentals
- Heat Transfer & its Application
- Heat Transfer Methods
- How Pumps Work

- Introduction to Pumps
- Definition
- How do Centrifugal Pumps Work?
- The Function of the Pump
- Definition
- Classification of Pumps
- Reciprocating Pumps
- Dynamic (Rotary) Pumps
- Positive Displacement
- Dynamic
- Advantages of Dynamic (Centrifugal Pumps)
- Advantages of Rotary Pumps
- Advantages of Reciprocating Pumps
- Rotary versus Centrifugal Pumps
- Theory of Gas Compression
- Gas Compression
- Air
- Boyle's Law
- Charles's Law
- Combined Gas Law
- How Compressors Work
- Types of Compressors
- Typical Operating Regimes of Compressors
- 1- Dynamic Compressors
- Centrifugal Compressor
- Centrifugal Compressors Configurations
- Advantages and Disadvantages of Centrifugal Compressors
- Axial Flow Compressor
- Positive Displacement Compressors
- Positive Displacement Rotary Compressor
- Rotary Compressor
- Reciprocating Compressor
- Typical Multistage Stages Layout

- Liquid Ring Pump (LRP)
- Coupling and Alignment
- Couplings - Introduction
- Why are Couplings Needed?
- Couplings
- Couplings - The Basics
- Misalignment
- Rigid or Flexible Coupling?
- Types of Couplings
- Jaw Coupling
- Grid Coupling
- Tire Coupling
- Gear Coupling
- Advantages
- Disadvantages
- Diaphragm Coupling
- Heavy-Duty Drive Couplings
- Flexible Disc Coupling
- Comparing Machinery Couplings
- Misalignment
- Coupling Types
- Shaft Alignment - The Basics
- What Is Shaft Alignment?
- Importance of Alignment
- Straight Edge/Feeler Gage Method
- Rim and Face Alignment Method
- Reverse Rim Alignment Method
- Dial Indicators
- Laser Based System
- Laser Alignment Systems
- Advantages of Single Beam Projected on a Reflector
- Laser Alignment Saves Power
- Laser Alignment Improves Bearing and Seal Life

- Problems Experienced with Laser Systems
- Example of Laser Alignment System (Easy-Laser
- Programs and Functions
- Horizontal
- Soft Foot
- Thermal Growth Compensation
- Tolerance Check
- Measurement Value Filter
- Easyturn
- Cardan
- Vertical
- Machine Train
- Reflock
- Offset and Angle
- Values
- Vibro-Meter
- BTA Digital
- Expandability
- Documentations of Measurement Results
- Save in the Display Unit
- Print
- Transfer Measurement Data to PC
- What the Program Needs to Know?
- Soft Foot Check
- Simple Measuring Procedure
- The Result is Clearly Displayed
- Tolerance Check
- Compensation for Thermal Growth
- Document The Measurement Result Machine Train Program
- Horizontal 9-12-3 Program
- Vertical/Flange Mounted Machines
- Values Program
- Offset and Angle Program

- Cardan-Shaft-Coupled Machines
- Vibration Measurement
- BTA Digital (Only with System D525)
- Shaft Sealing Systems for Rotating Equipment
- Shaft Sealing Devices
- Engineered Sealing
- Compression Packing
- Pumps Shaft Sealing Device
- Packing Rings
- Gland Packing
- Sealing - Introductory Fundamentals
- Shaft Sleeve Damaged by Too Tight Seal
- Table of pH Values
- Advantages of Gland Packing
- Disadvantages of Gland Packing
- Packing Rings Failure Modes
- Mechanical Seals
- Typical Pump – Sectioned
- Mechanical Seal Components
- Basic Principles of Mechanical Seals
- Mechanical Seal Components – Primary Seals
- Mechanical Seal Components – Secondary Seals
- Secondary and Tertiary Seals
- Mechanical Seal Components – Spring
- Spring Drive
- Formed Metal Bellows
- Single Metal Bellows Seal
- Basic Principles of Mechanical Seal
- Film Thickness = Leakage
- Basic Principles of Mechanical Seals
- Film Thickness = Leakage
- Weak Spring Load
- Mechanical Seals

- The Liquid Film
- Primary Seal
- Mechanical Seals - Advantages
- Mechanical Seals Balancing Ratio
- The Opening Forces
- Mechanical Seals Materials
- Seal Facing Materials
- Facing Materials – Stellite
- Seal Facing Materials – Tungsten Carbide
- Selecting Your Seal Face
- Carbon/Ceramic (Car/Cer)
- Selecting Your Seal and O-Ring Elastomers
- Viton
- EPR/EPDM
- Secondary Sealing Elements Temperature Range
- API Standards
- API 682
- Seal Selection Factors and the Costs of Sealing
- Seal Selection
- Factors in Seal Selection
- A Change in Duty Conditions
- Facts about Mechanical Seals
- Seal Costs-The Reality
- Prevention is Better than Cure
- Increase Your Seal Life
- Increasing Seal Life
- Summary
- Centrifugal Compressors Seals
- Shaft Seals
- Inter-Stage Seals
- Types of Shaft Seals
- Shaft Seals – Wet Seals
- Types of Shaft Seals-Liquid Film Shaft Seal

- Oil Sealing System
- Types of Shaft Seals- Dry Carbon Ring Seal
- Shaft Seals – Segmented Ring Seal
- Types of Shaft Seals- Labyrinth Seals
- Shaft Seals – Labyrinth Seal
- Application of Labyrinth Seal
- Inter-Stage Seals
- Labyrinth Seal
- Dry Gas Mechanical Seals
- Centrifugal Compressors – Dry Gas Seals
- Dry Gas Mechanical Seals
- Areas of Applications
- Dry Mechanical Seal
- Spiral Groove Seals
- Spiral Groove Sealing Surface
- Rotating Mating Ring
- Centrifugal Compressors – Dry Gas Seals
- Mechanical Seal and Bearings Arrangement
- Remark
- Why to Use Dry Seal Instead of Wet Seal?
- Dry versus Wet Seals
- No Seal Oil Consumption
- No Gas/Oil Contamination
- No Wear During Rotation
- Mechanical Seals Failure Modes
- Normal Wear Patterns
- Normal Size Wear Track Indicates Good Alignment
- Un-Even Wear Pattern
- Seal Face Heat Cracking or Checking
- Pitting and Corrosion of Seal
- Blistering of the Seal Face
- Vaporization
- Chipping on Outside/Inside Diameter

- Erosive Wear
- Seal Face Wear Patterns
- Intermittent Spots
- No Wear During Rotation
- Energy Loss Comparison
- Lubrication & Bearings
- The Importance of Lubricating
- Why Do We Lubricate?
- Temperature Monitoring
- Objective Four
- Preventive Maintenance (PM)
- Lubrication
- Lubrication Storage and Handling
- Lubrication Storage and Handling – Best Practice
- Indoor Storage
- How a Lubricant Works
- Principles of Viscosity
- Effect of Temperature on Viscosity
- What is Grease?
- Hydrodynamic Lubrication
- Methods of Supply
- Hydrodynamic Lubrication
- Advantages
- Disadvantages
- Hydrostatic Lubrication
- Components of a Hydrostatic System
- Hybrid Lubrication
- Oil Analysis
- What Oil Analysis can Tell You
- On-Site Analysis versus Lab Analysis
- Lab Analysis
- Bearings
- Bearings - Introduction

- Anti-Friction Bearings
- Types of Rolling Elements
- Advantages
- Disadvantages
- Bearing Loads
- Journal Bearings
- Hydrodynamic Journal Bearings
- Hydrodynamic Bearings – Working Principle
- Journal or Plain Bearings
- Advantages
- Disadvantages
- Tilting-Pad Journal Bearings
- Advantages
- Thrust Bearings
- Tilting Pad Thrust Bearings
- Equalizing Tilting-Pad Thrust Bearings
- Combined Radial and Thrust Bearings
- Harmful Temperature Increase
- The Following are the Effects of Vibration
- 1-Improper Installation and Handing
- Describe the Causes of Bearing Failure
- Brinelling
- The Correct Amount of Lubricant
- Fatigue
- Look
- Anti-Friction Bearing Removal and Installation
- Bearing Life
- Bearings Are Designed to Last!
- General Relationships on Bearing Life
- Do Your Bearings Survive Under the Following Conditions?
- Most Bearings Fail Early – Why?
- Performance Criteria and the Correct Grease
- How Much Moisture is Too Much?

- Effects of Corrosion
- The Primary Challenge to Bearings In Industry
- The Facts of Unsatisfactory Bearing Life We have to Deal With
- Ball and Roller Bearing
- Failure Modes
- Overheating
- True Brinelling
- False Brinelling
- Normal Fatigue Failure
- Contamination
- Failure Modes
- Lubricant Failure
- Oil Starvation
- Malfunction in the Lubrication System Oil Seal Failure
- Corrosion
- Misalignment
- Loose Fits
- Tight Fits
- Table Plain (Journal) Bearing Failure Modes and their Causes
- Troubleshooting Journal Bearings
- Cavitation
- Types of Cavitation
- Suction Cavitation
- Incidents that Cause Suction Cavitation
- Inconsistent Tank Levels
- Change in Temperature
- Change in Pressure
- Other
- Recirculation
- Suction Recirculation
- Discharge Recirculation
- Pumps Recirculation
- Effects and Damages from Pump Recirculation

- Corrective Procedures against Pump Recirculation
- Air Entrainment
- Effect of Cavitation
- Reduction in Capacity of the Pump
- Decrease in the Head Developed
- Vibration
- Pitting
- Noise
- Mechanical Deformations
- Prevention of Cavitation
- By Increasing the Suction Head
- By Lowering the Fluid Inlet Temperature
- By Decrease the Fluid Velocity
- Prevention of Cavitation
- By Reducing the Net Positive Suction Head Required (NPSHR)
- Pumps Installation & Commissioning
- Pump Location
- Pump Installation
- Foundation
- Rule of Thumb
- Typical Pump Foundation & Base Plate
- Consequences of Improper Foundation and Grouting
- Check Alignment
- Pumps Piping Configuration
- Suction Piping
- Pump Installation
- Suction Strainer/Filter
- Pump Suction Strainer
- Pump Piping Configuration
- Discharge Piping
- Pump Piping Strain
- Effects of Pipe Strain On Pumping Systems
- About Pipe Strain

- Pump Piping
- What are the Consequences?
- Pump Installation
- Vertically Mounted Sump Pumps
- Nature of Failures & Equipment Failure Patterns
- What is “Machinery Failure”?
- Non-Repairable versus Repairable Equipment
- How Failures Appear?
- Sporadic
- Chronic
- The Failure Characteristics
- “Wear In” Failures
- “Normal Wear” Failures
- “Wear Out” Failures
- Causes of Failures
- Design Failure
- Material Selection Deficiencies
- Manufacturing Defects
- Assembly and Installation Errors
- Excessive Demands
- Human Errors
- The Failure Mechanisms
- Main Modes of Failure
- Ductile Failure
- Brittle Failure
- Metal Fatigue
- Metal Fatigue - Case Study
- Metal Creep
- Metal Creep - Case Study
- Wear
- Adhesive Wear
- Abrasive Wear
- Erosive Wear

- Corrosion
- Corrosion - Case Study
- Corrosion Fatigue
- Pumps Failure Modes & Factors Affecting Pumps Reliability
- Pumps Failure Modes
- Failure Modes
- Erosion
- Cavitation Erosion
- Cavitation Corrosion
- Corrosion
- Pitting Corrosion
- Fatigue
- Main Modes of Failure
- Metal Fatigue
- Factors Affecting Pumps Reliability
- Basic Reasons for Pumps Failures
- Suction Cavitation
- Cavitation
- Symptoms
- Causes
- Remedies
- Pump Recirculation
- Corrective Procedures against Pump Recirculation
- Air Entrainment
- Air Binding
- Reverse Rotation
- Lack of Fluid
- Closed Head Operation
- How Long at Closed Head
- Over-Pumping
- Pump Operation Away from BEP
- Operation Away from BEP Shortens Pump Life
- Pumping Solids/Abrasive in the Wrong Pump

- Wrong Chemicals for the Pump
- Cycling
- Vibration
- Mechanical Causes of Vibrations
- Hydraulic Causes of Vibrations
- Peripheral Causes of Vibrations
- Mis-Alignment
- Pump Alignment
- Imbalance
- Incorrect Wear Rings
- Plugged Vanes
- Pipe Strain
- Why Mechanical Seals Fail
- Allowing the Pump to Run Dry
- Vibration
- Hammering Couplings onto the Shaft
- Operator Error
- Improper Use of, or Completely Omitting Mechanical Seal Flush Plans
- Selecting the Wrong Mechanical Seal or Seal Materials
- Pumps Shaft Sealing Device
- Compressors Control
- Compressors Control- Capacity Control
- Compressors Control-Speed Control
- Recycle Loop
- Throttling the Discharge Line
- Adjustable Inlet Guide Vanes
- Anti-Surge Systems
- Surge Control
- What Causes Surge?
- What Does Surge Do?
- Surge Causes Serious Damage to Compressors
- Controlling Surge
- Possible Causes

- Effect
- Automatic Shutdown Systems
- Centrifugal Pumps Troubleshooting
- Pumps – Troubleshooting
- Centrifugal Pumps
- Typical Yearly Repair Summary, Centrifugal Pumps
- Pump Failure Analysis
- Positive Displacement Pumps Troubleshooting
- PD – Rotary Pumps Troubleshooting
- Mechanical Seals Failure Modes
- Centrifugal Compressor Troubleshooting
- Troubleshooting