



**COURSE OVERVIEW ME0381**

**Mechanical E-Learning Module**

*Pump Selection, Installation, Operation, Performance, Control, Maintenance & Troubleshooting*

**Course Title**

Mechanical E-Learning Module: *Pump Selection, Installation, Operation, Performance, Control, Maintenance & Troubleshooting*

**Course Reference**

ME0381

**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 E-Learning course is designed to provide participants with a detailed and up-to-date overview of pump selection, installation, operation, performance, control, maintenance and troubleshooting. It covers turbomachinery and the fluid and physics basics; the continuity equation, first law of thermodynamics and Bernoulli's principle; the theory of gas compression, Boyle's law, Gay-Lussac's Law, Charles Law, Avogadro's Law, combine gas law and ideal gas law; the classification of pumps and how do centrifugal pumps work?; the centrifugal pumps construction; and the submersible wastewater pumps, immersible pumps, pump impeller and wear ring clearance.

Further, the course will also discuss the centrifugal pumps standards, spectrum, API standards, ANSI standards, NFPA standards and hydrostatic pressure tests; the various types of cavitation; the cavitation prevention; the positive displacement pumps, reciprocating pumps, diaphragm pumps and rotary pumps; the shaft sealing systems for centrifugal and rotary pumps; the pumps shaft sealing device, compression packing, packing rings, mechanical seal components; the basic principles of mechanical seals; and the pressure drop and vaporization as well as mechanical seals balancing ratios.



During this interactive course, participants will learn the mechanical seals configurations; the double seals, tandem seals, multiple seals and mechanical seals materials; the pump and system curves, pump parameters and pump terms; the centrifugal pumps performance curves, head capacity, useful formulas, system curve and pipe fitting head loss; the NPSHa, pump performance and pump materials of construction; the coating technology for pump components; the pump installation and commissioning, pumps piping configuration and pipe strain and its effects on pumping systems; the pump failure modes and the factors affecting pumps reliability; the centrifugal pumps troubleshooting, pump failure analysis and positive displacement pumps troubleshooting; the mechanical seals failure modes, couplings, couplings standards, coupling types and couplings failure modes; the shaft alignment, bearings, hydrodynamic bearings, journal bearings, thrust bearings and friction bearings; the general requirements for bearing materials; the machine vibration monitoring, measurement and analysis; and the faults detected by vibration analysis.

### **Course Objectives**

Upon the successful completion of this course, each participant will be able to:-

- Apply systematic techniques in selection, installation, operation, performance, control, maintenance and troubleshooting of various types of pumps used in process industry
- Discuss turbomachinery including the machines that add energy and extract energy
- Explain the fluid and physics basics covering kinetic energy, potential (gravitational) energy, mechanical energy, pressure energy, thermal (heat) energy and chemical energy
- Interpret the continuity equation, first law of thermodynamics and Bernoulli's principle
- Explain the theory of gas compression, Boyle's law, Gay-Lussac's Law, Charles Law, Avogadro's Law, combine gas law and ideal gas law
- Classify pumps and discuss how do centrifugal pumps work
- Illustrate the centrifugal pumps construction covering casing, shaft, impeller, radial flow type, discharge outlet and seals
- Identify submersible wastewater pumps, immersible pumps, pump impeller and wear ring clearance
- Explain centrifugal pumps standards, spectrum, API standards, ANSI standards, NFPA standards and hydrostatic pressure tests
- Recognize the various types of cavitation comprising of suction cavitation, suction recirculation, discharge recirculation, pumps recirculation, air entrainment and the effects of cavitation
- Prevent cavitation by increasing the suction head, lowering the fluid inlet temperature, decreasing the fluid velocity and reducing the net positive suction head required
- Identify the positive displacement pumps, reciprocating pumps, diaphragm pumps and rotary pumps



- Recognize the shaft sealing systems for centrifugal and rotary pumps
- Determine the pumps shaft sealing device, compression packing, packing rings, mechanical seal components and the basic principles of mechanical seals
- Discuss pressure drop and vaporization as well as mechanical seals balancing ratios
- Carryout mechanical seals configurations and interpret double seals, tandem seals, multiple seals and mechanical seals materials
- Explain pump and system curves, pump parameters and pump terms
- Discuss the centrifugal pumps performance curves, head capacity, useful formulas, system curve and pipe fitting head loss
- Calculate NPSHa, adjust pump performance and apply pump materials of construction covering impellers, casings, shafts and wear rings
- Recognize coating technology for pump components as well as employ pump installation and commissioning and pumps piping configuration
- Discuss pipe strain and its effects on pumping systems
- Operate centrifugal pumps including its start-up and shutdown procedures, describe pump priming and carryout pumps maintenance and inspection and pump spare parts inventory
- Identify pump failure modes and the factors affecting pumps reliability
- Employ centrifugal pumps troubleshooting, pump failure analysis and positive displacement pumps troubleshooting
- Explain mechanical seals failure modes, couplings, couplings standards, coupling types and couplings failure modes
- Discuss shaft alignment, bearings, hydrodynamic bearings, journal bearings, thrust bearings and friction bearings
- List the general requirements for bearing materials and discuss sliding surface bearing failure, different shapes of bearing failure, failure modes and failure cause of a rolling and plain bearings
- Troubleshoot journal bearings, implement predictive maintenance, illustrate rotating machinery failure patterns and discuss machine vibration
- Monitor machine vibration, measure vibration, apply vibration monitoring and analysis and identify the faults detected by vibration analysis

### **Who Should Attend**

This course provides an overview of all significant aspects and considerations of centrifugal pumps for those who are involved in the selection, installation, operation, performance, control, maintenance and troubleshooting of pumps. This includes plant and maintenance engineers, process engineers, maintenance technical staff, production & operation staff and reliability specialists working in a wide variety of process plant environments such as petrochemical, plastics, fertilizers, power utilities, oil, gas and water utilities.




### 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: -


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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.

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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.

### **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 Fee**

As per proposal

### **Course Contents**

- Introduction to Turbomachinery
- What is Meant by Turbomachinery?
- The Main Categories of Turbo Machines
- Machines that Add Energy
- Machines that Extract Energy
- Fluid and Physics Basics
- Energy
- Kinetic Energy
- Potential (Gravitational) Energy
- Mechanical Energy
- Pressure Energy
- Thermal (Heat) Energy
- Kinetic Energy Vs. Temperature
- Chemical Energy
- The Continuity Equation (Conservation of Mass)
- First Law of Thermodynamics (Conservation of Energy)
- Bernoulli's Principle

- Theory of Gas Compression
- Boyle's Law
- Gay-Lussac's (Amonton's) Law
- Charles's Law
- Avogadro's Law
- Combined Gas Law
- Ideal Gas Law
- Course Recap
- Introduction to Pumps
- Definition
- Pumps History
- Chain of Pots
- Classification of Pumps
- Centrifugal Pumps
- How do Centrifugal Pumps Work?
- Conversion of Kinetic Energy to Pressure Energy
- Centrifugal Pumps Construction
- Purpose of Casing
- Casing - Axial-Split Pump Case
- Axial Split Case – Advantages
- Axial Split Case – Disadvantages
- Casing - Radial-Split Pump Case
- Radial Split Case – Advantages
- Radial Split Case – Disadvantages
- Casing – Volute Type
- Casing – Diffuser Type
- Shaft
- Impeller
- Impeller – Open Type
- Submersible Wastewater Pumps
- Impeller – Semi Open Type
- Impeller – Closed Type
- Immersible Pumps

- Impeller – Effect of Impeller Geometry
- Pump Impeller
- Impeller Classification
- Impeller – Axial Thrust
- Classification of Centrifugal Pumps
- Radial Flow Type
- Multi-Stage Impeller
- Double Suction Single Stage Radial Pump
- Balancing Drum
- Cutwater
- Discharge Outlet
- Seals – Wear Rings
- Wear Ring Clearance
- Centrifugal Pumps Standards
- The Centrifugal Pump Spectrum
- API Standards
- API 610
- ANSI Standards
- ANSI Pump - ASME B73.1 Specifications
- NFPA Standards
- NFPA 20
- Hydrostatic Pressure Tests
- 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
- By Reducing the Net Positive Suction Head Required (NPSHR)
- Course Recap
- Positive Displacement Pumps
- Reciprocating - Positive Displacement Pumps
- Double Acting Piston Pump
- Single Plunger Reciprocating Pump
- Three Plungers Reciprocating Pump
- Pressure Pulsation Dampener on the Discharge Side
- Pressure Pulsation Dampener
- Reciprocating Pumps
- Packing
- Positive Displacement Pumps
- Reciprocating Pumps – Bent Axis Piston Pump
- Reciprocating Pumps – Swash Plate Piston Pump
- Variable Displacement
- Diaphragm Pumps
- Reciprocating Pumps – Advantages
- Reciprocating Pumps – Disadvantages





- API Standards
- API 674
- Rotary Pumps
- Rotary Pumps – External Gear Pumps
- Rotary Pumps – Internal Gear Pumps
- Rotary Pumps – Lobe Pumps
- Rotary Pumps – Vane Pumps
- Principles of Operation
- Rotary Pumps – Screw Pumps
- API Standards
- API 676 Positive Displacement Pumps – Rotary
- Shaft Sealing Systems for Centrifugal and Rotary Pumps
- Pumps Shaft Sealing Device
- Compression Packing
- Packing Rings
- Advantages
- Disadvantages
- Mechanical Seals
- Mechanical Seals - Advantages
- Product Loss
- Energy Cost
- Mechanical Seal Components
- Basic Principles of Mechanical Seals
- Mechanical Seal Components – Primary Seals
- Standard Components – Primary Seal
- Mechanical Seal Components – Secondary Seals
- Mechanical Seal Components – Spring
- Basic Principles of Mechanical Seal
- Pressure Drop & Vaporization
- Mechanical Shaft Seal in Operation
- Mechanical Seals
- The Liquid Film
- Primary Seal



- Mechanical Seals - Advantages
- Mechanical Seals - Disadvantages
- Mechanical Seals Balancing Ratio
- The Opening Forces
- Mechanical Seals Configurations
- Single Internal Seal
- Single External Seal
- Discharge Recirculation with Cyclone Separator
- Double Seals
- Tandem Seals
- Multiple Seals: Non-Pressurized Tandem
- Multiple Seals: Tandem
- Face to Face Seal
- Double Seals: Face-to-Face
- Multiple Seals
- Mechanical Seals Materials
- Seal Facing Materials
- Seal Facing Materials - Graphite
- Seal Facing Materials - Stellite
- Seal Facing Materials - Ceramic
- Seal Facing Materials – Tungsten Carbide
- Seal Facing Materials – Silicon Carbide
- Selecting Your Seal Face
- Carbon/Ceramic (Car/Cer)
- Carbon/Silicon Carbide (Car/Sic)
- Silicon Carbide/Silicon Carbide (Sic/Sic)
- Selecting Your Seal and O-Ring Elastomers
- Viton
- EPR/EPDM
- Secondary Sealing Elements Temperature Range
- API Standards
- API 682
- Course Recap

- Pump & System Curves
- Pumps Parameters
- Flow Rate (Capacity)
- Pumps Terms
- Pressure
- "Head"
- Density(P)
- Specific Gravity (S.G.)
- Velocity
- Vapor Pressure (Pvap)
- Net Positive Suction Head (NPSH)
- Net Positive Suction Head Required (NPSHR)
- Net Positive Suction Head Available (NPSHA)
- Power (Water Power)
- Brake Horsepower
- Efficiency
- Centrifugal Pumps Performance Curves
- Head Capacity
- Useful Formulas
- Now in Metric!
- N.P.S.H. Requirement Curves
- Performance of Centrifugal Pumps
- Effect of Fluid Viscosity
- System Curve
- Static Losses
- Open Systems
- Static Losses – Example
- Friction Losses
- Sources of Friction
- Pipe Fitting Head Loss
- System Curve – Steps
- Determine the Flow Rate
- Determine the Static Head



- Determine the Friction Head
- Make a Chart for All Fitting Types
- Calculate Velocity Head
- Perform the Calculation
- System Head Curve Approximating
- System Head Curve
- System & Pump Curve
- Calculating the NPSHA
- Adjusting Pump Performance
- Throttle Control
- Speed Control
- Bypass Control
- Modifying Impeller Diameter
- Pumps Materials of Construction
- Impellers
- Casings
- Shafts
- Wear Rings
- Wear Protection of Pump Components Using Hard Coatings
- Coating Technology for Pump Components
- Glass Flake Coating
- Modified Solvented Epoxy Coating
- Thermosetting Polyurethane Coatings
- Modified Solvent-Free Epoxy Coating
- Course Recap
- Pumps Installation & Commissioning
- Pump Installation
- Pump Location
- 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
- Pump Piping
- About Pipe Strain
- Pump Installation
- Vertically Mounted Sump Pumps
- Course Recap
- Operation of Centrifugal Pumps
- Centrifugal Pump – Startup Procedures
- Pump Priming
- Reciprocating Pump – Startup Procedures
- How to Prime Centrifugal Pump?
- Typical Steps for Pump Priming
- Starting Against a Closed Valve
- Starting Against a Check Valve
- Starting Against an Open Valve
- Shutting Down Centrifugal Pumps
- Centrifugal Pump – Shutdown Procedures
- Centrifugal Pump – Operation Notes
- Variable Speed Drives
- Centrifugal Pump – Undesirable Operation
- Operation at Higher Head
- Operation at Lower Head
- Operation on Higher Suction Lift
- Throttled Operation
- Operation with Strainer/Foot Valve Clogged



- Operation of the Pump with Low Submergence
- Operation with Occurrence of Vortices
- Positive Displacement Pump – Startup Procedures
- Flow and Head Pressure Adjustment
- Series Operation
- Parallel Operation
- Adjusting Pump Performance
- Throttle Control
- Bypass Control
- Modifying Impeller Diameter
- Speed Control
- Pump Regulation and Power Consumption
- Course Recap
- Pumps Maintenance and Inspection
- Daily Observations and Maintenance
- Pump Maintenance
- Monthly Maintenance
- Re-Lubrication
- Replace Stuffing Box Packing
- Mechanical Seals
- Quarterly Maintenance
- Annual Inspection and Maintenance
- Wear Ring Clearance
- Overhaul of Pump
- Checklist
- Predictive Maintenance
- Pump Spare Parts Inventory
- Parts Inventory
- Recommended Spares and Consumable Items
- Spare Pump Inventory
- Pumps Failure Modes & Factors Affecting Pumps Reliability
- Pumps Failure Modes
- Failure Modes





- Erosion
- Erosion Corrosion
- Cavitation Erosion
- Corrosion
- Pitting Corrosion
- Fatigue
- Main Modes of Failure
- 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
- Shaft Failure from Coupling Misalignment
- 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
- Allowing the Pump to Run Dry
- Pumps Shaft Sealing Device
- Packing Rings – Failure Modes
- Centrifugal Pumps Troubleshooting
- Pumps – Troubleshooting
- Typical Failure Modes of Centrifugal Pump Assemblies
- Typical Yearly Repair Summary, Centrifugal Pumps
- Pump Failure Analysis
- Positive Displacement Pumps Troubleshooting
- PD – Rotary Pumps Troubleshooting
- Mechanical Seals Failure Modes
- Coupling
- Couplings – Introduction
- Couplings-The Basics
- Misalignment
- Couplings - Types
- Jaw Coupling
- Grid Coupling
- Tire Coupling
- Gear Coupling





- Diaphragm Coupling
- Heavy-Duty Drive Couplings
- Flexible Disc Coupling
- Comparing Machinery Couplings
- Couplings Standards
- Couplings – Failure Modes
- Shaft Alignment -The Basics
- Alignment -The Basics
- Importance of Alignment
- Straight Edge/Feeler Gage Method
- Rim and Face Alignment Method
- Reverse Rim Alignment Method
- Dial Indicators
- Laser Based System
- Bearings
- Bearings - Introduction
- Hydrodynamic Bearings
- Hydrodynamic Bearings – Working Principle
- Journal Bearings
- Cylindrical Journal Bearings
- Elliptical Journal Bearings
- Multi-Lobe Journal Bearings
- Tilting-Pad Journal Bearings
- Thrust Bearings
- Tapered-Land Thrust Bearings
- Tilting Pad Thrust Bearings
- Equalizing Tilting-Pad Thrust Bearings
- Non-Equalizing Tilting-Pad Thrust Bearings
- Combined Radial and Thrust Bearings
- Friction Bearings (Sliding Friction)
- Sliding Surfaces Bearings (Plain Bearings)
- General Requirements for Bearing Materials
- Sliding Surface Bearing Failure

- Sliding Surface Bearing Failure - Reasons of Bearing Failure
- Different Shapes of Bearing Failure
- Failure Modes
- Oil Starvation
- Scoring
- Overloading
- Overheating
- Improper Machine Component
- Corrosion
- Mis-Assembly
- Failure Causes of a Rolling & Plain Bearings
- Table Plain (Journal) Bearing Failure Modes and their Causes
- Troubleshooting Journal Bearings
- Course Recap
- Predictive Maintenance (PDM)
- Classification of Maintenance Policies
- ISO Definition
- Rotating Machinery Failures Pattern
- Major Parameters Used for Detection of Machine Faults
- Vibration
- What is Machine Vibration?
- Why Monitor Machine Vibration?
- How is Vibration Measured?
- How is Vibration Described?
- Amplitude
- Frequency
- Phase
- What is a Spectrum?
- Vibration Detection Vs. Analysis
- How to Measure Vibration?
- Which Machines Need Monitoring?
- Vibration Monitoring and Analysis
- Advantages of Vibration Analysis

- Limitations of Vibration Analysis
- Equipment Required
- Faults Detected by Vibration Analysis
- Unbalance
- Misalignment
- Angular Misalignment
- Parallel Misalignment
- Distinguishing Unbalance from Misalignment
- Bent Shaft
- Soft Foot
- Mechanical Looseness
- Rotating Looseness
- Blade & Vanes
- Pump Cavitation
- Pump Recirculation
- Gear Faults
- Gear Box Defects
- Sleeve Bearing
- Rolling Element Bearing
- Misaligned Rolling Element Bearing
- Rotor Rubbing
- Belt Drive
- Summary
- Vibration Guideline Chart