COURSE OVERVIEW ME0487
Maintain Turbines - Fundamental (E-Learning Module)

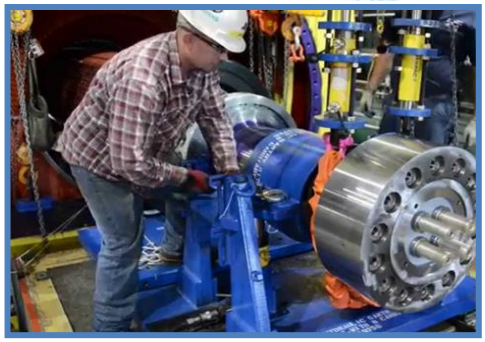
Course Title
Maintain Turbines - Fundamental (E-Learning Module)

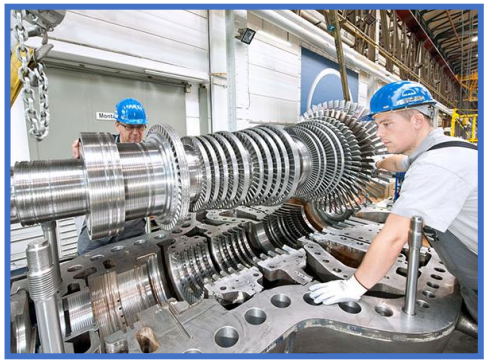
Course Reference
ME0487

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 fundamental knowledge of turbine maintenance. It covers the basics of fluids mechanics, thermodynamics, heat transfer, combustion and steam generation; the fluid flow, Bernoulli's principle, vapor pressure, specific gravity, viscosity and the effect of temperature on viscosity; the gas compression, Boyle's law, Charles's law and Combined gas law; the heat transfer, temperature and heat, factors influencing heat flow and the application of heat transfer; the heat transfer methods; and the conduction, convection, radiation and temperature units.

Further, the course will also discuss the boilers and combustion, flame temperature, stoichiometric ratio, reversible cycles with ideal gases and actual gas turbine cycles; the steam turbine stage designs, steam turbine cross section and the physical principles of steam turbines; the classification, types and components of steam turbines; the shaft sealing, labyrinth seals versus carbon seals and the failure mechanisms of steam turbines; the general-purpose steam turbines for petroleum, chemical and gas industry service as per API 611 and API 612 standards; and the steam turbine governor types and the objectives and functioning of governors.

Moreover, the course will also cover the journal bearings, thrust bearings, hydraulic control systems and turning gear; the gas turbines and its applications; the actors affecting gas turbines performance; the gas turbine cycle, regenerative cycle, cogeneration cycle, combined cycle and gas turbine model designation; the gas turbine components and its functional description; the axial-flow compressors inlet guide vanes (IGV), variable inlet guide vane system, compressor bleed valves, axial-flow compressors exit guide vanes (EGV) and axial-flow compressors diffuser; the combustors, combustion section, combustion liner, combustors fuel nozzles and combustors spark plugs; and the combustors flame detectors, combustors transition piece, combustion process, power turbine and development of gas turbines.

During this course, participants will learn the lubrication systems and the role of lubricants, purpose, function and basic system components ; the oil sampling and testing, oil analysis, oil quality analysis and wear particle analysis; the operation and maintenance, pulse cleaning system inspection and proactive methods to extend the life time of the pulse cleaning filters; the gas turbine failure statistics, gas turbine failure modes and GT components failure consequences; the major factors influencing maintenance; the NDT techniques for gas turbines components inspection and gas turbines inspection intervals; the five-step troubleshooting approach; the gas turbine compressor washing system including the cause and effects of fouling; and the fouling, methods of cleaning fouled compressor and off-line washing, on-line washing and compressor cleaning systems.

Course Objectives

At the end of this course, the Trainee will be able to:-

- Apply and gain a fundamental knowledge on turbines maintenance
- Explain the various types of turbines used at own location
- Describe the operating principles of the various types of turbines at own location
- Use the appropriate tools and equipment to maintain turbines and auxiliary systems
- Describe the operating parameters of each Turbines at own location and the importance of maintaining performance -within those parameters
- Describe the function of individual turbines components and auxiliary systems
- Explain the maintenance requirements for the turbine gearbox
- Evaluate and interpret performance and integrity data of turbines
- Recognize and respond to abnormal conditions and take appropriate corrective action
- Discuss the basics of fluids mechanics, thermodynamics, heat transfer, combustion and steam generation
- Determine energy, kinetic energy, potential (gravitational) energy, mechanical energy and pressure energy
- Recognize pressure, gage and absolute, thermal (heat) energy, chemical energy, fluid mechanics and the continuity equation (conservation of mass)

- Explain fluid flow, Bernoulli's principle, vapor pressure, specific gravity, viscosity and the effect of temperature on viscosity
- Discuss gas compression, Boyle's law, Charles's law and Combined gas law
- Interpret heat transfer, temperature and heat, factors influencing heat flow and the application of heat transfer
- Employ heat transfer methods and discuss conduction, convection, radiation and the temperature units
- Measure the units of heat and explain heat transfer fundamentals, thermodynamics, temperature and heat and operating principles
- Describe evaporation, boiling, condensation, steam generation, steam attributes and the enthalpy of evaporation or latent heat (hfg)
- Discuss the saturated steam tables, dry steam and its fraction, combustion or controlled explosion and combustion processes
- Explain boilers and combustion, flame temperature, stoichiometric ratio, reversible cycles with ideal gases and actual gas turbine cycles
- Illustrate steam turbine stage designs and identify the rotating blades, fixed nozzle and steam turbine staging arrangements covering impulse (rateau stage), impulse (curtis stage) and reaction
- Describe steam turbine cross section and the physical principles of steam turbines
- Explain the theory of operation of steam turbine as well as classify steam turbine comprising of condensing, non-condensing (backpressure), extraction and induction
- Identify the types of steam and the components of steam turbines
- Differentiate shaft sealing, labyrinth seals versus carbon seals and discuss the failure mechanisms of steam turbines
- Discuss the general-purpose steam turbines for petroleum, chemical and gas industry service as per API 611 and API 612 standards
- Recognize grand sealing system, labyrinth seals, modes of operation and gland steam condenser
- Explain lube oil system, jacking oil system and turbine instrumentation and control systems
- Identify the steam turbine governor types and the objectives and functioning of governors
- Recognize journal bearings, thrust bearings, hydraulic control systems and turning gear
- Discuss gas turbines and its applications and types including heavy industrial/frame gas turbines and aeroderivative gas turbines
- Classify gas turbines and identify the factors affecting gas turbines performance

- Illustrate the gas turbine cycle, regenerative cycle, cogeneration cycle, combined cycle and gas turbine model designation
- Discuss the gas turbines for the petroleum, chemical, and gas industry services as per API 616 standards and the recommended practice for packaged combustion gas turbines in accordance with API RP 11PGT standards
- Define maintenance terms like the downtime, reliability and availability as well as identify auxiliary power unit (APU) and thrust reversal
- Identify the gas turbine components and its functional description including the compressor section, axial-flow compressors, compressor extraction and compressor surge
- Determine axial-flow compressors inlet guide vanes (IGV), variable inlet guide vane system, compressor bleed valves, axial-flow compressors exit guide vanes (EGV) and axial-flow compressors diffuser
- Recognize combustors, combustion section, combustion liner, combustors fuel nozzles and combustors spark plugs
- Discuss combustors flame detectors, combustors transition piece, combustion process, power turbine and development of gas turbines
- Interpret lubrication systems and the role of lubricants, purpose, function and basic system components
- Carryout oil sampling and testing, oil analysis, oil quality analysis and wear particle analysis
- Recognize fuel supply system, gas fuel supply system, liquid fuel supply system, diffusion combustion system, gas fuel operating modes, venturi liner assembly and hybrid chambers DLN systems
- Describe turbine air inlet system, gas turbines air filters, consequences of poor inlet filtration and the various types of gas turbines air filters
- Carryout operation and maintenance, pulse cleaning system inspection and proactive methods to extend the life time of the pulse cleaning filters
- Discuss gas turbines air filters and fuel economy and turbine exhaust systems
- Employ gas turbine maintenance and review gas turbine failure statistics, gas turbine failure modes and GT components failure consequences
- Identify the major factors influencing maintenance and apply NDT techniques for gas turbines components inspection and gas turbines inspection intervals
- Troubleshoot gas turbines in a professional manner and apply the five-step troubleshooting approach covering observing, defining problem area, identifying possible causes, determining most probable cause and testing and repair
- Discuss gas turbine compressor washing system including the cause and effects of fouling
- Detect fouling, carryout methods of cleaning fouled compressor and perform off-line washing, on-line washing and compressor cleaning systems

Who Should Attend

This course provides an overview of all significant aspects and considerations of gas and steam turbines for plant managers, operating staffs from power plants, engineers, researchers, operators and those involved in the maintenance and repair of HRSG systems, plant life assessment, extension, failure analysis and material behaviour.

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.

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

- Basics of Fluids Mechanics, Thermodynamics, Heat Transfer, Combustion & Steam Generation
- Energy
- Kinetic Energy
- Potential (Gravitational) Energy
- Mechanical Energy
- Pressure Energy
- Pressure, Gage & Absolute
- Thermal (Heat) Energy
- Chemical Energy
- Fluid Mechanics
- Flow Trough Pipes
- Example: Pressure Drop
- The Continuity Equation (Conservation of Mass)
- Fluid Flow
- Energy Relationships
- Bernoulli's Principle
- Vapor Pressure
- Specific Gravity

- Viscosity
- Effect of Temperature on Viscosity
- Theory of Gas Compression
- Gas Compression
- Air
- Boyle's Law
- Theory of Gas Compression
- Charles's Law
- Combined Gas Law
- Heat Transfer
- Temperature & Heat
- Heat Transfer & Its Application
- Factors Influencing Heat Flow
- Heat Transfer Methods
- Conduction
- Convection
- Radiation
- The Temperature Units
- Measuring Units of Heat
- Heat Transfer Fundamentals
- Thermodynamics
- Temperature & Heat
- First Law of Thermodynamics
- Second Law of Thermodynamics
- Operating Principles
- Laws of Thermodynamics
- Evaporation
- Boiling
- Condensation
- What is Steam
- How Steam is Generating
- Dry Steam versus. Wet Steam
- Steam as a Source of Power

- Steam as a Source of Heat
- Direct Steam Heating
- Indirect Steam Heating
- Steam Attributes
- Definition of Terms
- Enthalpy of Evaporation or Latent Heat (hfg)
- The Saturated Steam Tables
- Dry Steam & its Fraction
- The Steam Phase Diagram
- Combustion or Controlled Explosion
- Combustion Processes
- Boilers and Combustion
- Ignition Temperature
- Flame Temperature
- Combustion
- Flash Point
- Auto Ignition Temperature
- Fire Point
- Flame Temperature, Stoichiometric Ratio
- Operating Principles
- Newton's First Law of Motion
- Newton's Second Law of Motion
- Newton's Third Law of Motion
- Reversible Cycles with Ideal Gases
- Actual Gas Turbine Cycles
- The Combined Cycle (Brayton-Rankine)
- Steam Turbines Overview
- Steam Turbine - Introduction
- Introduction
- History
- Why Steam Turbines?
- Normal Operation & Speed Control 5
- Steam Turbine Stage Designs

- Rotating Blades
- Fixed Nozzle
- Steam Turbines
- Steam End
- Casing and Steam Path
- Steam Turbine – Theory of Operation
- Steam Turbine Staging Arrangements
- Impulse (Rateau Stage)
- Impulse (Curtis Stage)
- Reaction
- Multi-Staging
- Summary of Impulse and Reaction Stage Characteristics
- Steam Turbine Cross Section
- Steam Turbines Physical Principles
- Impulse & Reaction Turbines
- Steam Turbine – Theory of Operation
- Classification of Steam Turbines
- Condensing
- Non-Condensing / Back Pressure
- Extraction
- Induction
- Single and Double Flow
- Reheat and Non-Reheat
- Type of Steam
- Components of Steam Turbines
- Casing and Steam Path
- Steam End
- Steam Turbines Seals
- Shaft Sealing, Labyrinth Seals versus Carbon Seals
- Mechanical Labyrinth Seals
- Shaft Seals
- Carbon Packing
- Steam Turbines – Failure Mechanisms

- Moving Blades
- Nozzles
- Rotors
- Nozzles / Blades
- Valve Failure
- Steam Seal Failure
- Steam Turbines Standards
- API Standards
- API 611
- API 612
- Steam Turbines and Auxiliaries
- Introduction
- Impulse Turbine
- Reaction Turbine
- Gland Sealing System
- Labyrinth Seals
- Modes of Operation
- Gland Steam Condenser
- Lube Oil System
- Jacking Oil System
- Turbine Instrumentation & Control Systems
- Speed Governors
- Steam Turbine Governor Types
- Objectives & Functioning of Governors
- Pressure Governors
- I&C Main Components
- General Layout
- Turbine Supervisory Instrumentation (TSI)
- TSI – Bently Nevada
- TSI – Eddy Current Sensors
- TSI – Casing Expansion
- TSI – Differential Expansion
- TSI – Axial Shift

- TSI – Absolute Vibration
- TSI – Relative Vibration
- TSI – Eccentricity
- Standard Measurements
- Control System – Main Functions
- Control System – Control Room
- Control System – Speed Acquisition
- Control System – E/H Converters
- Control System – Valve & Safety Device Tests
- Control System – Operating Data Counter
- Control System – Safety System
- Journal Bearings
- Thrust Bearings
- Hydraulic Control Systems
- Turning Gear
- Introduction to Gas Turbines
- What is a Gas Turbine?
- Why Gas Turbines?
- Gas Turbines Applications
- Types of Gas Turbines
- Heavy Industrial / Frame Gas Turbines
- Aeroderivative Gas Turbines
- Industrial versus Aero-Derivative Gas Turbines
- Gas Turbines Classifications
- Factors Affecting Gas Turbines Performance
- External Factors Affecting Gas Turbine Performance – Ambient Temperature
- External Factors Affecting Gas Turbine Performance – Relative Humidity
- Gas Turbines Key Terms
- ISO Conditions
- Firing Temperature
- (Compressor) Pressure Ratio
- Heat Rate
- Thermal Efficiency

- Heat Rate & Thermal Efficiency
- Gas Turbines Cycles
- The Gas Turbine Simple Cycle
- Compressor Section
- Combustion Section
- Turbine Section
- The Regenerative Cycle
- The Cogeneration Cycle
- The Combined Cycle
- Gas Turbines Model Designation
- Gas Turbines Standards
- API Standards
- API 616
- API RP 11PGT
- Maintenance Terms and Definitions
- Downtime
- Reliability
- Availability
- Auxiliary Power Unit (APU)
- Thrust Reversal
- Gas Turbine Components and Functional Description
- Gas Turbines Components
- Compressor Section
- Axial-Flow Compressors
- Bernoulli's Theorem
- The Main Components of an Axial Flow Compressor
- Case
- Rotor
- Stator
- Compressor Extraction
- Axial Compressors Compressor Surge
- Axial-Flow Compressors Inlet Guide Vanes (IGV)
- Variable Inlet Guide Vane System

- Axial-Flow Compressors Bleed Valves
- Compressor Bleed Valves
- Axial-Flow Compressors Exit Guide Vanes (EGV)
- Axial-Flow Compressors Diffuser
- Axial-Flow Compressors
- The Back-Work Ratio
- Axial-Flow Compressors Function Description
- Combustors
- Combustion Section
- The Three Major Types of Combustors
- Tubular (Single Can)
- Can Annular
- Annular
- Film Cooling of the Liner
- Combustion Liner
- Combustors Fuel Nozzles
- Combustors Spark Plugs
- Combustors Cross Fire Tubes
- Combustors Flame Detectors
- Combustors Transition Piece
- Transition Piece
- Nozzle & Transition Piece Assembly
- The Combustion Process
- Power Turbine
- Power Turbine Function Description
- Turbine Nozzle
- Turbine Stationary Nozzles
- Turbine Rotor
- Turbine Stage Velocity Triangles
- Gas Turbine Power Balance
- Overall Efficiency
- Development of Gas Turbines
- Lubrication Systems

- Role of Lubricants
- Purpose and Function
- Basic System Components
- Oil Reservoir
- Oil Pumps
- Oil Filters
- Oil Cooling/Warming
- Oil Selection, Sampling and Testing
- Lube Oil Selection
- Oil Sampling and Testing
- Oil Analysis
- Oil Quality Analysis
- The Benefits of Oil Analysis
- Reasons for Oil Degradation
- Contamination
- Oxidation
- Thermal Breakdown
- Additive Depletion
- Visual Test
- Physical Appearance and Odor
- Lubrication Properties
- Viscosity
- Viscosity Monitoring and Trending
- Viscosity Test
- Oxidation Test
- Rotating Pressure Vessel Oxidation Test (RPVOT)
- Acidity (TAN)
- Total Acid Number
- Water Content
- Recommended Oil Sampling Frequencies
- Wear Particle Analysis
- Wear Metal Analysis
- Particle Classifications

- Wear Particle Analysis
- Types of Debris Shape Found in Oil
- Used Oil Elemental Analysis
- Elements and Their Sources
- Test Schedules
- Recommendation Action
- Fuel Supply System
- Gas Turbine Fuel Systems: Purpose
- Gas Fuel Supply System
- Components
- Control System
- Liquid Fuel Supply System
- Liquid Fuel Stop Valve VS1
- Fuel Pump
- Bypass Valve Assembly
- Flow Divider
- Atomizing Air System
- Dual Fuel Nozzle
- Fum
- Introduction
- Diffusion Combustion System
- Premixed Combustion System
- Operating Modes - Gas Fuel
- Liner Assembly – Venturi
- DLN Systems Hybrid Chambers
- Inlet Bleed Heat (IBH)
- Transferless DLNX1 Gas Fuel System Flows
- Turbine Air Inlet System
- Gas Turbines Air Filters - Introduction
- Consequences of Poor Inlet Filtration
- Foreign Object Damage
- Erosion
- Fouling

- Types of Gas Turbines Air Filters
- Static versus Pulse Filters
- Operation and Maintenance
- Gas Turbines Air Filters and Fuel Economy
- Turbine Exhaust Systems
- Exhaust System
- Gas Turbine Maintenance
- Philosophy of Maintenance
- The Objectives of Modern Maintenance
- The Three Basic Categories of Maintenance Practice
- Gas Turbine Failure Statistics
- Gt Components Failure
- Crack Initiation
- Crack Propagation
- Failure
- Gt Components Failure Consequences
- Major Factors Influencing Maintenance
- Cyclic Effects (Startup/Shutdown/Trips)
- Firing Temperature
- Fuel Type
- Ge Maintenance Interval for Hot Gas Path Inspection
- Gas Turbine Maintenance
- Running Inspection
- Standby Inspection
- Standby Inspection - Borescope Inspections
- Borescope Inspections
- Borescope Access
- Borescope Image
- Maintenance Inspections
- Shutdown Inspection
- Combustion Inspection
- Hot Gas Path Inspection
- Major Inspection

- NDT Techniques for Gas Turbines Components Inspection
- NDT Techniques for Inspection
- Visual Inspection
- Dye Penetrant
- Primary Advantages
- Primary Disadvantages
- Eddy Current Testing
- Ultrasonic Testing
- Radiographic Inspection
- Gas Turbines Inspection Intervals
- Gas Turbines Troubleshooting
- What Is Troubleshooting?
- Troubleshooting Defined
- Machinery Troubleshooting
- The 5 Step Troubleshooting Approach
- Gas Turbine Compressor Washing System
- The Cause and Effects of Fouling
- Typical Causes of Gas Turbines Compressor Fouling
- The Direct Effects of Gas Turbines Compressor Fouling
- The Detection of Fouling
- Methods of Cleaning Fouled Compressor
- Off-Line Washing
- Advantages
- Disadvantages
- Results of Cleaning
- Compressor Cleaning Systems
- On-Line versus Off-Line Washing
- Important Tips