



COURSE OVERVIEW EE0135-4D

Electric Motors & Variable Speed Drives

Selection, Applications, Operation, Diagnostic Testing, Protection, Control, Troubleshooting & Maintenance

Course Title

Electric Motors & Variable Speed Drives: *Selection, Applications, Operation, Diagnostic Testing, Protection, Control, Troubleshooting & Maintenance*

Course Date/Venue

September 09-12, 2024/Boardroom, Warwick Hotel Doha, Doha, Qatar

Course Reference

EE0135-4D



Course Duration/Credits

Four days/2.4 CEUs/24 PDHs

Course Description



This practical and highly-interactive course includes various practical sessions and exercises. Theory learnt will be applied using our state-of-the-art simulators.

It is estimated that electrical drives and other rotating equipment consume about 50% of the total electrical energy consumed in the world today. The cost of maintaining electrical motors can be a significant amount in the budget item of manufacturing, oil, gas, petrochemical and power industries. This course gives you a thorough understanding of electrical motor's working, maintenance and failure modes and gives you the tools to maintain and troubleshoot electrical motors and variable speed drives.



Maximum efficiency, reliability, and longevity of the various types of motors and variable-speed drives are of great concern to many industries. These objectives can only be achieved by understanding the characteristics, selection criteria, common problems and repair techniques, preventive and predictive maintenance. This course is a MUST for anyone who is involved in the selection, applications, or maintenance of motors, and variable-speed drives. It provides the latest in technology.



The course covers how this equipment operate and provides guidelines and rules that must be followed for a successful operation. Their basic design, operating characteristics, specification, selection criteria, advanced fault detection techniques, critical components as well as all maintenance issues are covered in detail.





You will gain a fundamental understanding of the installation, operation and troubleshooting of electric motors. Typical applications of electric motors in oil, gas, petrochemical, power, manufacturing, materials handling, process control are covered in detail. You will learn the basic steps in specifying, installing, wiring and commissioning motors. The concluding section of the course gives you the fundamental tools in troubleshooting motors confidently and effectively.

This course is designed to provide participants with a comprehensive understanding of the various types variable-speed drives. Participants will be able to specify select, commission and maintain these equipment for their applications. The excellent knowledge and skills that participants gained in this course will help their companies in achieving reduced capital, operating and maintenance costs along with increase in efficiency.

Course Objectives

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

- Apply proper techniques on selection, application, operation, diagnostic testing, protection, control, troubleshooting and maintenance of electric motors and variable speed drives
- Gain an in-depth knowledge on electrical machines and discuss their devices, symbols and circuits
- Enumerate the electric motor types and demonstrate how to operate and perform their functions
- Discuss the construction, operation and performance of 3-Phase AC induction motors
- Emphasize the importance of motor speed control and become familiar with power electronic converters
- Protect and select AC converters, motors & control system and conduct installation & commissioning of AC variable speed drives
- Identify the sources of electromagnetic compatibility (EMC) and analyse & test the different types of motor failure
- Carryout predictive maintenance techniques such as the vibration analysis
- Conduct machinery faults diagnosis & correction using vibration analysis and corrective measures
- Apply bearing failure analysis and discuss the importance of lubrication & oil analysis program

Exclusive Smart Training Kit - H-STK®



Participants of this course will receive the exclusive “Haward Smart Training Kit” (H-STK®). The H-STK® consists of a comprehensive set of technical content which includes **electronic version** of the course materials conveniently saved in a **Tablet PC**.



Who Should Attend


This course provides an overview of all significant aspects and considerations of electric motors and variable speed drives for engineers and other technical personnel who are in charge of selection, application, operation, diagnostic testing, protection, control, troubleshooting or maintenance of motors and variable speed drives.

Course Certificate(s)

Internationally recognized certificates will be issued to all participants of the course who completed a minimum of 80% of the total tuition hours.

Certificate Accreditations


Certificates are accredited by the following international accreditation organizations: -

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The International Accreditors for Continuing Education and Training (IACET - USA)

Haward Technology is an Authorized Training Provider by the International Accreditors 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 2018-1 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 2018-1 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 Accreditors 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 **2.4 CEUs** (Continuing Education Units) or **24 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.





Course Instructor(s)

This course will be conducted by the following instructor(s). However, we have the right to change the course instructor(s) prior to the course date and inform participants accordingly:



Mr. Pan Marave, PE, MSc, BEng, is a Senior Electrical & Instrumentation Engineer with over 40 years of extensive experience in Oil, Gas, Petrochemical, Refinery & Power industries. His expertise includes Circuit Breaker, HV Switchgear Maintenance, HV/LV Electrical Authorisation, Basic Electricity, Electrical & Special Hazards, Personnel Protection, HV/LV Equipment, Motor Controllers, Electrical Switching Practices, Emergency Planning, Safety Management, Safety Instrumented Systems (SIS), Safety Integrity Level (SIL), Emergency Shutdown (ESD); DCS, SCADA & PLC; Measurement (Flow, Temperature, Pressure); Process Analyzers & Analytical Instrumentation; Process Control, Instrumentation & Safeguarding; Process Controller, Control Loop & Valve Tuning; Industrial Distribution Systems; Industrial Control & Control Systems, Power Systems Protection & Relaying; Earthing, Bonding, Grounding, Lightning & Surge Protection; Electric Power Substation & Systems; Electrical Engineering Principles; Motor Control Circuit; Electrical Fault Analysis; Electrical Networks & Distribution Cables; Circuit Breakers, Switchgears, Transformers, Hazardous Areas Classification and Detailed Engineering Drawings, Codes & Standards. Furthermore, he is also well-versed in Microprocessors Structure, Lead Auditor (ISO 9000:2000), ISO 9002, Quality Assurance, and Projects & Contracts Management.

Presently, Mr. Marave is the **Technical Advisor of Chamber of Industry & Commerce** in Greece. Prior to this, he gained his thorough practical experience through several positions as the **Technical Instructor, Engineering Manager, Electronics & Instruments Head, Electrical, Electronics & Instruments Maintenance Superintendent, Assistant General Technical Manager and Engineering Supervisor** of various international companies such as the **Alumil Mylonas, Athens Papermill, Astropol** and the **Science Technical Education**.

Mr. Marave is a **Registered Professional Engineer** and has **Master and Bachelor** degrees in **Electrical Engineering** from the **Polytechnic Institute of New York and Pratt Institute of New York (USA)** respectively. Further, he is a **Certified Instructor/Trainer, a Certified Internal Verifier/Assessor/Trainer** by the **Institute of Leadership & Management (ILM)** and an active member of the **Technical Chamber** and the **Institute of Electrical and Electronics Engineer (IEEE)** in Greece. He has presented and delivered **numerous international** courses, conferences, trainings and workshops worldwide.

Course Fee

US\$ 5,000 per Delegate. This rate includes H-STK® (Haward Smart Training Kit), buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Accommodation

Accommodation is not included in the course fees. However, any accommodation required can be arranged at the time of booking.





Training Methodology

All our Courses are including **Hands-on Practical Sessions** using equipment, State-of-the-Art Simulators, Drawings, Case Studies, Videos and Exercises. The courses include the following training methodologies as a percentage of the total tuition hours:-

- 30% Lectures
- 20% Practical Workshops & Work Presentations
- 30% Hands-on Practical Exercises & Case Studies
- 20% Simulators (Hardware & Software) & Videos

In an unlikely event, the course instructor may modify the above training methodology before or during the course for technical reasons.

Course Program

The following program is planned for this course. However, the course instructor(s) may modify this program before or during the course for technical reasons with no prior notice to participants. Nevertheless, the course objectives will always be met:

Day 1: Monday, 09th of September 2024

0730 – 0800	Registration & Coffee
0800 – 0815	Welcome & Introduction
0815 – 0830	PRE-TEST
0830 – 0930	Basic Principles of Electrical Machines Introduction to Electrical Machines • AC Power Systems • Meters Used in Troubleshooting
0930 - 0945	Break
0945 – 1130	Electrical Devices, Symbols & Circuits Devices & Symbols • Electrical Circuits • Reading and Understanding Electrical Drawings • Reading and Understanding Ladder Logic • Wires & Terminal Numbering
1130 – 1230	Electric Motors Types, Operations and Performance Fundamentals of Motor Technology • Basic Principles of Rotating Electrical Machines • Fundamental Principles of Speed Control • Efficiency, Torque, Inertia, Horsepower / Power Factor • Torque -Speed Curves • Induction /Wound Rotor /Synchronous Motor Types • Basic Construction of a Motor • Principles of Operation & Performance
1230 – 1245	Break
1245 – 1420	3-Phase AC Induction Motors Basic Construction • Principles of Operation • The Equivalent Circuit • Electrical & Mechanical Performance • Motor Acceleration • AC Induction Generator Performance • Efficiency of Electric Motors • Rating of AC Induction Motors • Electric Motor Duty Cycles • Cooling & Ventilation of Electric Motors (IC) • Degree of Protection of Motor Enclosures (IP) • Construction & Mounting of AC Induction Motors • Anti-Condensation Heaters • Methods of Starting AC Induction Motors
1420 - 1430	Recap Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow
1430	Lunch & End of Day One





Day 2: Tuesday, 10th of September 2024

0730 – 0930	Motor Speed Control <i>The Need for Variable Speed Drives • Fundamental Principles • Torque-Speed Curves for Variable Speed Drives • Types of Variable Speed Drives • Mechanical Variable Speed Drive Methods • Hydraulic Variable Speed Drive Methods • Electromagnetic or ‘Eddy Current’ Coupling • Electrical Variable Speed Drive Methods</i>
0930 - 0945	Break
0945 – 1130	Power Electronic Converters <i>Power Diodes • Power Thyristors • Commutation • Power Electronic Rectifiers (AC/DC Converters) • Gate Commutated Inverters (DC/AC Converters) • Gate Controlled Power Electronic Devices • Other Power Converter Circuit Components</i>
1130 – 1230	Protection of AC Converters & Motors <i>AC Frequency Converter Protection Circuits • Operator Information & Fault Diagnostics • Electric Motor Protection • Thermal Overload Protection - Current Sensors • Thermal Overload Protection - Direct Temperature Sensing</i>
1230 – 1245	Break
1245 – 1420	Control Systems for AC Variable Speed Drives <i>The Overall Control System • Power Supply to the Control System • The DC Bus Charging Control System • The PWM Rectifier for AC Converters • Variable Speed Drive Control Loops • Vector Control for AC Drives • Current Feedback in AC Variable Speed Drives • Speed Feedback from the Motor</i>
1420 - 1430	Recap <i>Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow</i>
1430	Lunch & End of Day Two

Day 3: Wednesday, 11th of September 2024

0730 – 0930	Selection of AC Converters <i>The Basic Selection Procedure • The Loadability of Converter Fed Squirrel Cage Motors • Operation in the Constant Power Region • The Nature of the Machine Load • The Requirements for Starting • The Requirements for Stopping • Control of Speed, Torque and Accuracy • Selecting the Correct Size of Motor and Converter</i>
0930 – 0945	Break
0945 – 1130	Installation & Commissioning of AC Variable Speed Drives <i>General Installation & Environmental Requirements • Power Supply Connections & Earthing Requirements • Start/Stop Control of AC Drives • Installing AC Converters into Metal Enclosures • Control Wiring for Variable Speed Drives • Commissioning Variable Speed Drives</i>
1130 – 1230	Electromagnetic Compatibility (EMC) <i>The Sources of Electromagnetic Interference • Harmonics Generated on the Supply Side of AC Converters • Power Factor & Displacement Factor • Voltages & Current on the Motor Side of PWM Inverters</i>
1230 – 1245	Break



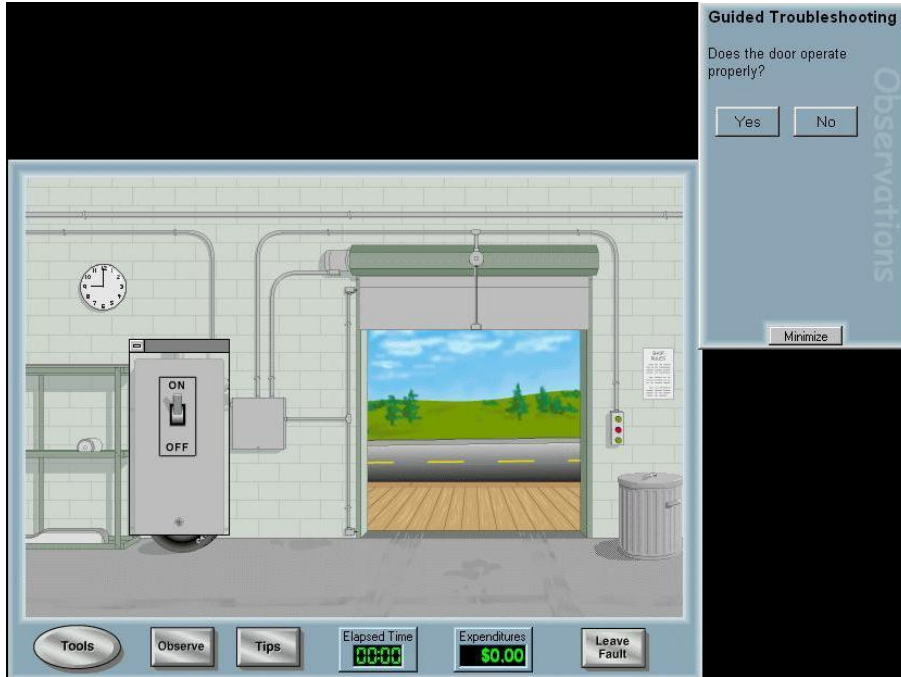
1245 - 1420	Motor Failure Analysis & Testing Types of Motor Failure • Common Causes of Motor Failure • Modern Developments • Insulation Life & Resistance • Polarization Index • DC Hipot • DC Ramp Test • AC Hipot • Capacitance Test • Dissipation Factor • Partial Discharge • Surge Test • Mechanical Testing • Online Testing
1420 - 1430	Recap Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow
1430	Lunch & End of Day Three

Day 4: Thursday, 12th of September 2024

0730 - 0830	Predictive Maintenance Techniques: Basics Maintenance Philosophies • Evolution of Maintenance Philosophies • Plant Machinery Classification & Recommendations • Principles of Predictive Maintenance • Predictive Maintenance Techniques • Vibration Analysis - A key Predictive Maintenance Technique
0830 - 0930	Predictive Maintenance Techniques: Vibration Basics Spring -Mass System: Mass, Stiffness, Damping • System Response • What is Vibration? • The Nature of Vibration • Harmonics • Limits & Standards of Vibration (ISO 2372, API, AGMA, IRD)
0930 - 0945	Break
0945 - 1130	Machinery Faults Diagnosis & Correction Using Vibration Analysis & Corrective Measures Unbalance • Eccentric Rotor • Bent Shaft • Misalignment • Mechanical Looseness • Resonance • Rotor Rubs • Journal Bearings • Rolling Element Bearings • Gearing Defects • Belt Defects • Electrical Problems • Flow Related Vibrations • Rotor Crack
1130 - 1230	Bearing Failure Analysis The Bearing • Failure Analysis • Bearing Failures • Grease & Greasing • The Belt Drive • Balance • Storage Issues • Services Factor Loading
1230 - 1245	Break
1245 - 1345	Lubrication & Oil Analysis Program Oil Fundamentals • Condition-Based Maintenance & Oil Analysis • Setting Up an Oil Analysis Program • Oil Analysis - Sampling Methods • Oil Analysis - Lubricant Properties • Oil Analysis - Contaminants in Lubricants • Particle Analysis Techniques • Alarm Limits for Various Machines (source - National Tribology Services)
1345 - 1400	Course Conclusion Using this Course Overview, the Instructor(s) will Brief Participants about the Course Topics that were Covered During the Course
1400 - 1415	POST-TEST
1415 - 1430	Presentation of Course Certificates
1430	Lunch & End of Course

Simulators (Hands-on Practical Sessions)

Practical sessions will be organized during the course for delegates to practice the theory learnt. Delegates will be provided with an opportunity to carryout various exercises using our state-of-the-art Simutech Troubleshooting Electrical Circuits V4.1” and “Lab Volt Testing Device”.



Simutech Troubleshooting Electrical Circuits V4.1



Lab Volt Testing Device

Course Coordinator

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