COURSE OVERVIEW EE0234

Electrical E-Learning Module

LV/MV/HV Circuit Breakers & Switchgears: Specification, Design, Operation, Inspection, Testing, Maintenance, Repair & Troubleshooting

Course Title

Electrical E-Learning Module: *LV/MV/HV Circuit Breakers & Switchgears: Specification, Design, Operation, Inspection, Testing, Maintenance, Repair & Troubleshooting*

Course Reference

EE0234

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 LV/MV/HV circuit breakers and switchgears specification, design, operation, inspection, testing, maintenance, repair and troubleshooting. It covers the voltage convention, voltage classification, circuit breakers, selection considerations, types of breakers, construction and low voltage circuit breakers; the thermal magnetic circuit breakers and molded case; and the electronic trip molded case circuit breakers standards, circuit breaker mounting, terminal pad usage, circuit breaker connections, thermal trip elements, magnetic trip and solid-state trip circuit breaker construction.

Further, the course will also discuss the LV breaker accessories, remote controls, circuit breaker utilization, circuit breaker ratings, ambient temperature rating, interrupting rating and catalog numbering system; the medium voltage switchgear, circuit breakers characteristics, relay-circuit breaker combination, MV and HV circuit breaker and the forms of medium voltage switchgear; the basic circuit breaker design and deterioration of oil circuit breaker; and the plain double break oil circuit breaker, contact grip due to electromagnetic effect and electromagnetic forces in oil circuit breaker.

Moreover, this course will also discuss the oil dashpots to cushion the mechanism, side vent arc control device and small oil volume circuit breakers; the air blast circuit breakers and basic air blast circuit breaker; the performance of oil and air blast circuit; the schematic of axial air blast circuit breaker; the SF_6 and vacuum circuit breakers and puffer type SF_6 circuit breakers; the sequence of operation of puffer type circuit breaker; the vacuum interrupter in SF_6 enclosure switchgear with rated three position disconnector; the SF6 gas monitoring and Teledyne 3010TAC oxygen in gas analyzer, SDDLG moisture in gas analyzer and acidity in gas analyzer; the operating mechanisms and automatic reclosing; the switchgear service conditions; the voltage ratings, continuous current ratings, interrupting capacity rating and ambient temperature rating; the switchgear asset management, asset registers and condition-based maintenance (CBM); the relationship of asset condition to time; the failure modes effects analysis (FMEA) and failure modes effects critical analysis (FMECA); and the risk matrix and comparative circuit breaker lifetime costs.

During this interactive course, participants will learn the trip coil monitoring, switchgear diagnostic techniques, short term pd monitoring, semi-permanent monitoring and continuous monitoring; the substation battery condition and monitoring, substation maintenance, station structure and MV switchgear testing; the fuse testing, power factor and capacitance test, high potential insulation tests and switchgear maintenance procedures; the various tests on circuit breaker, cabling, routine and high voltage; the control and protection circuits, routine high voltage testing of vacuum switches and high voltage test levels and durations; the control and protection circuit operation, PM plant maintenance work orders management, processing maintenance tasks, maintenance order integration and switchgear maintenance procedures; the equipment tools, spares and test instruments; the test on completion of maintenance, defect management and action diagram for type-specific switchgear defect; the electrical safety and minimum approach distances for non-qualified electrical workers; the safety ground sets, short-circuit currents and sizing of safety grounding cables; and the typical key interlock scheme for a double-ended substation, application schemes, effect of crushed stone and typical shock situations.

Course Objectives

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

- Specify, design, operate, inspect, test, maintain, repair and troubleshoot LV/MV/HV circuit breakers and switchgears in a professional manner
- Discuss voltage convention, voltage classification, circuit breakers, selection considerations, types of breakers, construction and low voltage circuit breakers
- Identify thermal magnetic circuit breakers and molded case circuit breaker construction
- Recognize electronic trip molded case circuit breakers standards, circuit breaker mounting, terminal pad usage, circuit breaker connections, thermal trip elements, magnetic trip and solid-state trip
- Explain LV breaker accessories, remote controls, circuit breaker utilization, circuit breaker ratings, ambient temperature rating, interrupting rating and catalog numbering system

- Recognize medium voltage switchgear, circuit breakers characteristics, relay-circuit breaker combination, MV and HV circuit breaker and the forms of medium voltage switchgear
- Illustrate the basic circuit breaker design and deterioration of oil circuit breaker
- Identify the plain and plain double break oil circuit breaker, contact grip due to electromagnetic effect and electromagnetic forces in oil circuit breaker
- Discuss oil dashpots to cushion the mechanism, side vent arc control device and small oil volume circuit breakers
- Recognize air blast circuit breakers and basic air blast circuit breaker
- Compare performance of oil and air blast circuit and describe the schematic of axial air blast circuit breaker
- Identify SF_6 and vacuum circuit breakers and puffer type SF_6 circuit breakers
- Discuss the sequence of operation of puffer type circuit breaker
- Apply vacuum interrupter in SF_6 enclosure switchgear with rated three position disconnector
- Employ SF6 gas monitoring and discuss Teledyne 3010TAC oxygen in gas analyzer, SDDLG moisture in gas analyzer and acidity in gas analyzer
- Describe operating mechanisms and automatic reclosing
- Determine switchgear service conditions covering indoor switchgear and special service conditions
- Review voltage ratings, continuous current ratings, interrupting capacity rating and ambient temperature rating
- Discuss rated voltage U, rated insulation level, rated short time withstand current (I_k) and rated peak withstand current (I_p)
- Explain symmetrical and asymmetrical rating and review rated supply voltage of closing or opening devices (U_a)
- Employ switchgear asset management, asset registers and condition-based maintenance (CBM)
- Discuss the relationship of asset condition to time and carryout failure modes effects analysis (FMEA) and failure modes effects critical analysis (FMECA)
- Review risk matrix and determine comparative circuit breaker lifetime costs
- Employ trip coil monitoring, switchgear diagnostic techniques, short term pd monitoring, semi-permanent monitoring and continuous monitoring
- Apply substation battery condition and monitoring, substation maintenance, station structure and MV switchgear testing
- Carryout fuse testing, power factor and capacitance test, high potential insulation tests and switchgear maintenance procedures
- Maintain items specific to distribution switchgear and apply various tests on circuit breaker, cabling, routine and high voltage

- Identify the control and protection circuits, routine high voltage testing of vacuum switches and high voltage test levels and durations
- Employ control and protection circuit operation, PM plant maintenance work orders management, processing maintenance tasks, maintenance order integration and switchgear maintenance procedures
- Clean down oil filled switchgear, avoid the ingress of moisture and maintain items specific to distribution switchgear
- Recognize equipment tools, spares and test instruments as well as apply test on completion of maintenance, defect management and action diagram for type-specific switchgear defect
- Carryout electrical safety and minimum approach distances for non-qualified electrical workers
- Install safety ground sets, disconnect safety ground sets and estimate short-circuit currents and sizing of safety grounding cables
- Identify the typical key interlock scheme for a double-ended substation, application schemes, effect of crushed stone and typical shock situations

Who Should Attend

This course provides an overview of all significant aspects and considerations of LV/MV/HV circuit breakers and switchgears for those who are involved in the design testing, commissioning, maintenance, repair and troubleshooting of such equipment. Electrical engineers and other technical staff who need a sound understanding of low, medium and high voltage switchgear and circuit breaker will find this course beneficial.

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 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 Contents

- Introduction
- Voltage Convention
- Voltage Classification
- Circuit Breakers
- Selection Considerations
- Types of Breakers, Construction
- Low Voltage Circuit Breakers
- Thermal Magnetic Circuit Breakers
- Molded Case Circuit Breaker Construction
- Electronic Trip Molded Case Circuit Breakers, Standards
- Circuit Breaker Mounting
- Terminal Pad Usage
- Circuit Breaker Connections
- Thermal Trip Elements
- Magnetic Trip
- Solid State Trip
- LV Breaker Accessories
- Remote Controls
- Circuit Breaker Utilization
- Circuit Breaker Ratings
- Ambient Temperature Rating
- Interrupting Rating
- Catalog Numbering System
- Quiz
- Medium Voltage Switchgear
- Introduction
- Circuit Breakers Characteristics
- Relay-circuit Breaker Combination
- MV & HV Circuit Breaker
- Forms of Medium Voltage Switchgear
- Basic Circuit Breaker Design

- Oil Circuit Breakers
- Oil Circuit Breaker Deterioration
- Plain Oil Circuit Breakers
- Plain Double Break Oil Circuit Breaker
- Contact Grip Due to Electromagnetic Effect
- Electromagnetic Forces in Oil Circuit Breaker
- Oil Dashpots to Cushion the Mechanism
- Side Vent Arc Control Device
- Small Oil Volume Circuit Breakers
- Small Oil Volume Circuit Breaker (One Phase Shown)
- Quiz
- Air Blast Circuit Breakers
- Basic Air Blast Circuit Breaker
- Comparative performance of oil and air blast circuit
- Schematic of Axial Air Blast Circuit Breaker
- SF6 and Vacuum Circuit Breakers
- Puffer Type SF6 Circuit Breakers
- Sequence of Operation, Puffer Type Circuit Breaker
- Vacuum Interrupter in SF6 Enclosure Switchgear, with Rated Three Position Disconnector
- SF6 Gas Monitoring
- Oxygen
- Teledyne 3010TAC Oxygen in Gas Analyzer
- Moisture
- SDDLG Moisture in Gas Analyzer
- Acidity
- Anachem HF-1000 Acidity in Gas Analyzer
- Operating Mechanisms
- Automatic Reclosing
- Quiz
- Switchgear Service Conditions
- Indoor Switchgear
- Outdoor Switchgear
- Special Service Conditions

- Voltage Ratings
- Continuous Current Ratings
- Interrupting Capacity Rating
- Ambient Temperature Rating
- Rated Voltage Ur
- Rated Insulation Level
- Rated Short Time Withstand Current (Ik)
- Rated Peak Withstand Current (Ip)
- Symmetrical and Asymmetrical Rating
- Symmetrical and Asymmetrical Fault Conditions
- Rated Supply Voltage of Closing or Opening Devices (Ua)
- Switchgear Asset Management
- Asset Registers
- Condition Based Maintenance (CBM)
- Reliability Centered Maintenance (RCM)
- Failure Modes Effects Analysis (FMEA)
- Failure Modes Effects Critical Analysis (FMECA)
- Risk Matrix
- Comparative Circuit Breaker Lifetime Costs
- Quiz
- Earth Fault Alarms
- Trip Coil Monitoring
- Trip Coil Current and Main Contact Opening
- Trip Coil Tester (TCT)
- Trip Coil Tester (TCT) by Relay Engineering Services (RES)
- Switchgear Diagnostic Techniques
- Partial Discharge
- Short term PD monitoring (1 - 2 hours).
- Semi-permanent monitoring (1 -3 days).
- Continuous monitoring
- Quiz
- Substation Battery Condition and Monitoring
- Substation Maintenance
- Detail View of Outside Substation

- Substation Sections
- Substation Structures
- Lightning (Surge) Arresters
- High Voltage Fuses
- Disconnecting Switch
- Substation Compound - Substation Fence and Grounding
- MV Switchgear
- Substation Maintenance Techniques
- Metal-Clad Switchgear
- Circuit Breaker Compartment
- Breaker Compartment
- Contacts
- Primary Contacts
- Arc Interrupters
- Operating Mechanisms
- Auxiliary Devices
- Main Busbar Compartment
- Quiz
- Cable Connection Compartment
- Cable Compartment
- Low Voltage Compartment
- Metal Enclosed Switchgear
- Loadbreak Switch Compartment
- Power Fuse and Cable Compartment
- Station Structure and MV Switchgear Testing
- Insulation Resistance Test - (Megohmmeter or Megger Test)
- Fuse Testing
- Fuse Testing by Low Resistance Non-destructive (Ductor) Test
- Power Factor and Capacitance Test
- High Potential Insulation Tests
- Switchgear Maintenance Procedures
- Maintenance Items Specific to Distribution Switchgear
- Points to consider During Switchgear Maintenance
- Circuit Breaker Test

- Procedures
- Cabling Tests
- Routine Tests
- High Voltage Tests
- Detail task list
- Control and Protection Circuits
- Routine High Voltage Testing of Vacuum Switches
- High Voltage Test Levels and Durations
- Control and Protection Circuit Operation
- Cubicle Heaters
- Quiz
- PM Plant Maintenance Work Orders Management
- PM Components
- PM Highlights
- PM Developments
- PM Components
- Plant Maintenance Related Functions
- Processing Maintenance Tasks
- Maintenance Order Integration
- Switchgear Maintenance Procedures
- Lighting
- Safe Exit from Substation
- Tools and Equipment
- Safe Working - Power Closing
- Environmental Protection
- Protection from Live LV Equipment
- Cleaning Materials
- Unit Identification
- Cleanliness
- Oil Filled Switchgear
- Cleaning Down Oil Filled Switchgear
- Avoiding the Ingress of Moisture
- Solvents
- Maintenance Items Specific to Distribution Switchgear

- Position Indicators and Oil Level Indicator Windows
- Arc Gaps
- Earth Bonding Continuity
- Shutters and Locking Devices
- Interlocks
- Knowledge of Interlocking Requirements
- Maintenance of Interlock Systems
- Mechanical Aspects
- Electrical Aspects
- Ventilation
- Functional Test
- Equipment Heating and Lighting
- Lifting Devices
- Quiz
- Maintenance Items Specific to Distribution Switchgear Cont'd
- Equipment Tools, Spares and Test Instruments
- Tripping and Closing Supplies
- Cable Boxes & Compound Filled Busbar Chambers
- Test Access Covers
- Insulation, Bushings, Barriers and Tank Linings
- Porcelain
- SRBP
- Permali
- Epoxy Resin & DMC
- Insulating Oil
- Fuses and Fuseholders
- Fastenings
- Test on Completion of Maintenance
- Defect Management
- Action Diagram for Type-Specific Switchgear Defect
- Quiz
- Electrical Safety
- Minimum Approach Distances for Non-Qualified Electrical Workers
- Limited Approach Boundary

- Prohibited Approach Boundary
- Restricted Approach Boundary
- Use and Care of Safety Ground Sets
- Installing Safety Ground Sets
- Disconnecting Safety Ground Sets
- Estimating Short-Circuit Currents and Sizing Safety Grounding Cables
- Equipment Safety Interlocks
- Typical Key Interlock Scheme for a Double-Ended Substation
- Application Schemes
- Understanding Step – Touch Potential Hazards
- Step Potential
- Effect of Crushed Stone
- Touch Potential
- Typical Shock Situations