ELECTRICAL EQUIPMENT: TRANSFORMERS, GENERATORS, INVERTERS, RECTIFIERS, MOTORS, VARIABLE FREQUENCY DRIVES, UNINTERRUPTABLE POWER SYSTEMS, INDUSTRIAL BATTERIES, CIRCUIT BREAKERS, AND FUSES:

Selection, Applications, Operation, Troubleshooting, and Maintenance

INTRODUCTION

This seminar will provide a comprehensive understanding of the various types of transformers, inverters, rectifiers, motors, variable frequency drives, uninterruptible power systems, generators, circuit breakers, and fuses. This seminar will focus on maximizing the efficiency, reliability, and longevity of this type equipment by providing an understanding of the characteristics, selection criteria, common problems and repair techniques, preventive and predictive maintenance.

This seminar is a MUST for anyone who is involved in the selection, applications, or maintenance of electrical equipment because it covers how this equipment operates, the latest maintenance techniques, and provides guidelines and rules that ensure the successful operation of this equipment. In addition, this seminar will cover in detail the basic design, operating characteristics, specification, selection criteria, advanced fault detection techniques, critical components and all preventive and predictive maintenance methods in order to increase reliability of the equipment and reduce the operation and maintenance cost.

This seminar will provide the following information for all electrical equipment:

- Basic Design
- Specification
- Selection Criteria
- Sizing Calculations
- Enclosures and Sealing Arrangements
- Codes and Standards
- Common Operational Problems
- All Diagnostics, Troubleshooting, Testing, and Maintenance

WHO SHOULD ATTEND

- Engineers of all disciplines
- Managers
- Technicians
- Maintenance personnel
- Other technical individuals (this seminar is suitable for individuals who do not have
SEMINAR OUTCOME

- **Equipment Operation:** Gain a thorough understanding of the operating characteristics of all electrical equipment
- **Equipment Diagnostics and Inspection:** Learn in detail all the diagnostic techniques and inspections required of critical components of electrical equipment.
- **Equipment Testing:** Understand thoroughly all the tests required for the various types of electrical equipment
- **Equipment Maintenance and Troubleshooting:** Determine all the maintenance and troubleshooting activities required to minimize electrical equipment downtime and operating cost
- **Equipment Repair and Refurbishment:** Gain a detailed understanding of the various methods used to repair and refurbish all electrical equipment
- **Efficiency, Reliability, and Longevity:** Learn the various methods used to maximize the efficiency, reliability, and longevity of all types of electrical equipment
- **Equipment Sizing:** Gain a detailed understanding of all the calculations and sizing techniques used for all electrical equipment
- **Design Features:** Understand all the design features that improve the efficiency and reliability of all electrical equipment
- **Equipment Selection:** Learn how to select electrical equipment by using the performance characteristics and selection criteria that you will learn in this seminar
- **Equipment Enclosures and Sealing Methods:** Learn about the various types of enclosures and sealing arrangements used for electrical equipment
- **Equipment Commissioning:** Understand all the commissioning requirements for electrical equipment
- **Equipment Codes and Standards:** Learn all the codes and standards applicable for electrical equipment
- **Equipment Causes and Modes of Failure:** Understand electrical equipment causes and modes of failure
➢ **System Design:** Learn all the requirements for designing different types of electrical systems

**TRAINING METHODOLOGY**

The instructor relies on a highly interactive training method to enhance the learning process. This method ensures that all the delegates gain a complete understanding of all the topics covered. The training environment is highly stimulating, challenging, and effective because the participants will learn by case studies which will allow them to apply the material taught to their own organization.

**SPECIAL FEATURE**

Each delegate will receive a copy of the following materials written by the instructor:

2. Practical manual (300 pages)

**SEMINAR OUTLINE**

Day 1 – Fundamentals of Electrical Systems, and Transformers

➢ Inductors, capacitors, alternating current, Faraday’s law, magnetic field, three-phase system
➢ Machinery principles, magnetic behavior of ferromagnetic materials, energy losses in a ferromagnetic core, core losses, permanent magnets
➢ Transformers, types and construction of transformers, impedance transformation through a transformer, analysis of circuits containing transformers, equivalent circuit in a transformer
➢ Voltage regulation, transformer efficiency, transformer taps and voltage regulators, autotransformers, three-phase transformers, transformer ratings, inrush current, instrument transformers
➢ Transformers’ characteristics, phase relationships, Star/Star connected transformer, basic materials, dielectrics, copper, iron, insulation, leakage reactance, core construction
➢ Transformer windings, transpositions, continuously-transposed strip, impulse strength, thermal considerations, performance under short-circuit
➢ Transformer components and maintenance, classification of transformers, dry transformers, oil-immersed transformers
➢ Components of a power transformer, core, windings, nitrogen demand system, conservative tank with air cell, current transformers, bushings, tap changers, insulation
- Types and features of insulation, reasons for deterioration, forces, cause of transformer failure
- Transformer oil, testing transformer oil, causes of deterioration, neutralization number test, interfacial tension test, Myers index number, transformer oil classification system, methods of dealing with bad oil, gas-in-oil
- Gas relay and collection systems, relief devices, interconnection with the grid

Day 2 – AC Machine Fundamentals, Induction Motors, Speed Control of Induction Motors

- Rotating magnetic field, relationship between electrical frequency and the speed of magnetic field rotation, RMS voltage in a three-phase stator, induced torque in a three-phase machine, winding insulation in ac machines, ac machine power flow and losses
- Induction motor construction, rotor slip, electrical frequency of the rotor, losses and the power flow diagram, induction motor torque-speed characteristics, variation of the torque-speed characteristics, starting induction motors, induction motor starting circuits
- Speed control of induction motors, speed control by changing the line frequency, speed control by changing the line voltage, speed control by changing the rotor resistance, solid-state induction motor drives, motor protection, induction generator, induction generator operating alone, induction motor ratings

Day 3 – Maintenance of Motors, Power Electronics, Rectifiers, and Pulse-Width Modulation Inverters, Variable Speed Drives, Uninterruptible Power Systems, Maintenance of Industrial Batteries

- Characteristics of Motors, enclosures and cooling methods, failures in three-phase stator windings, predictive maintenance, motor troubleshooting, diagnostic testing of motors, repair and refurbishment of ac induction motors
- Power Electronics components, rectifier circuits, filtering rectifier output, pulse circuits, voltage variation by ac phase control, inverters, pulse-width modulation (PWM) inverters
- Variable speed (frequency) drives, principles of ac variable speed drives, inverters, insulated gate bipolar transistors (IGBT’s), pulse-width modulated inverters, input power converter (rectifier), output IGBT inverter, magnetic breaking, regeneration, transients, harmonics, power factor and failures, common failure modes, thyristor failures and testing, IGBT switching transients, cabling details for ac drives, motor bearing currents, selection criteria for variable speed drives, maintenance, common failure modes, motor application guidelines
- Uninterruptible power systems (UPSs), UPS operation, standards, voltage regulation, harmonic distortion, advanced UPS design, efficiency, input power converter, inverter, battery system, remote UPS monitoring, testing of UPS, commissioning of UPS, UPS maintenance, battery maintenance, UPS sizing,
Maintenance of industrial batteries, discharge voltage characteristics, battery life, battery types, lead-acid batteries, installation and operation, placing the battery in service, charging the battery, maintenance, prevention of over-discharging, determination of battery condition, troubleshooting, repairs and maintenance of batteries

Day 4 – Synchronous Machines, Synchronous Generators, Generator Components, Auxiliaries and Excitation, Generator Main Connections, Double-Feed Generators, Performance and Operation of Generators

- Synchronous machines, physical description, synchronous machine windings, field excitation, torque tests, excitation of a synchronous machine, machine losses
- Synchronous generators, construction, synchronous generator operating alone, parallel operation of ac generators, synchronous generator ratings, synchronous generator capability curves
- Generator components, auxiliaries and excitation, the rotor, the stator, cooling systems, shaft seals and seal oil systems, excitation, the voltage regulator, the power system stabilizer, characteristics of generator exciter power systems (GEP), generator operation,
- Generator main connections, isolated phase bus bar circulatory currents, system description
- Double-feed generators, system configuration, equivalent circuit for the brushless double-fed machine, parameter extraction, generator operation, converter rating, machine control
- Generator systems, condition monitoring, operation limitations, fault conditions


- Generator surveillance and testing, generator operational checks (surveillance and monitoring), generator diagnostic testing, insulation resistance and polarization index, dc hipot test, ac tests for stator windings, synchronous machine rotor windings, partial discharge tests, mechanical tests
- Generator inspection and maintenance, on-load maintenance and monitoring, off-load maintenance, generator testing
- Generator operational problems, and refurbishment options, typical generator operational problems
- Generator rotor reliability and life expectancy, generator rotor refurbishment, generator rotor modifications, upgrades, and uprates
➢ Circuit Breakers, circuit breaker rating, plain break type, magnetic blow-out type, oil circuit breakers, recent developments in Circuit Breakers, vacuum circuit breakers, sulphur Hexafluoride (SF₆) Circuit Breakers, maintenance and inspection of circuit breakers

➢ Fuses, Types of fuses, features of current limiting fuses, advantages of fuses over circuit breakers

➢ Bearings and Lubrication, Types of bearings, ball and roller bearings, thrust bearings, lubrication, viscosity of lubricants, greases, VI improved oils

➢ Used oil analysis, test description and significance, visual and sensory inspection, chemical and physical tests

➢ Vibration analysis, resonance, vibration instrumentation, vibration analysis, vibration causes, vibration severity

➢ Power station electrical systems, and design requirements, system requirements, electrical system description, system performance, unit start-up, synchronization, shutdown and power trip, power plant outages and faults, uninterruptible power supply systems, dc systems

➢ Power station protective systems, design criteria, generator protection, dc tripping systems

➢ Frequently asked questions

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**Faculty**

**Philip Kiameh**

*Philip Kiameh, M.A.Sc., B.Eng., D.Eng., P.Eng.* (Canada) has been a teacher at University of Toronto, Canada for 20 years. In addition, Prof Kiameh has taught courses and seminars to more than four thousand working engineers and professionals around the world, specifically Europe and North America. Prof Kiameh has been consistently ranked as "Excellent" or "Very Good" by the delegates who attended his seminars and lectures.

Prof Kiameh wrote 6 books for working engineers from which four have been published by McGraw-Hill, New York. Below is a list of the books authored by Prof Kiameh:


Prof. Kiameh has received the following awards:

1. The first "Excellence in Teaching" award offered by the Professional Development Center at University of Toronto (May, 1996).

2. The "Excellence in Teaching Award" in April 2007 offered by TUV Akademie (TUV Akademie is one of the largest Professional Development centre in world, it is based in Germany and the United Arab Emirates, and provides engineering training to engineers and managers across Europe and the Middle East).

3. Awarded graduation “With Distinction” from Dalhousie University when completed Bachelor of Engineering degree (1983).


Prof. Kiameh performed research on power generation equipment with Atomic Energy of Canada Limited at their Chalk River and Whiteshell Nuclear Research Laboratories. He also has more than 27 years of practical engineering experience with Ontario Power Generation (formerly, Ontario Hydro - the largest electric utility in North America).

While working at Ontario Hydro, Prof. Kiameh acted as a Training Manager, Engineering Supervisor, System Responsible Engineer and Design Engineer. During the period of time that Prof Kiameh worked as a Field Engineer and Design Engineer, he was responsible for the operation, maintenance, diagnostics, and testing of gas turbines, steam turbines, generators, motors, transformers, inverters, valves, pumps, compressors, instrumentation and control systems. Further, his responsibilities included designing, engineering, diagnosing equipment problems and recommending solutions to repair deficiencies and improve system performance, supervising engineers, setting up preventive maintenance programs, writing Operating and Design Manuals, and commissioning new equipment.

Later, Prof Kiameh worked as the manager of a section dedicated to providing training for the staff at the power stations. The training provided by Prof Kiameh covered in detail the various equipment and systems used in power stations.
Professor Philip Kiameh was awarded his Bachelor of Engineering Degree "with distinction" from Dalhousie University, Halifax, Nova Scotia, Canada. He also received a Master of Applied Science in Engineering (M.A.Sc.) from the University of Ottawa, Canada. He is also a member of the Association of Professional Engineers in the province of Ontario, Canada.

Course Fee

The fee for this course is 2,700.00 USD + applicable taxes.

On-site Training

ETC seminars can be delivered on-site at your premises. For more information, please contact Mr. Philip Kiameh at p.kiameh@engineeringtrainingcentre.com or by phone in North America at 416-509-5052.

Group Discounts, Cancellations and Withdrawals

Registration will cover all seminar materials and refreshments which will be offered during breaks and lunch. For companies sending more than one delegate the following discounts will apply:

1- 10% discount to the second delegate,
2- 15% discount to the third delegate,
3- 20% discount to the fourth delegate,
4- 25% discount to the fifth and subsequent delegate registrations.

To withdraw from a course you must send your request, in writing, with a copy of the receipt to our office. The following conditions will apply: All cancellations received fifteen or more business days prior to the commencement of the seminar will receive full refund minus a 200 USD administration charge. All cancellations received less than fifteen business days prior to the commencement of the seminar will not be refunded. However, a credit of equal value will be provided for any future ETC seminar within the period of one year following the cancellation.

Notes

1- In the event of an emergency a delegate who has registered for a seminar may allow a different person to attend in his/her place at no additional cost.

2- ETC reserves the right to cancel or change the date or location of its events. ETC is not responsible for the purchase of non-refundable travel arrangements or accommodation or any associated cancellation. To avoid any fees or charges, please contact ETC to confirm that the course is running before confirming travel arrangements and accommodations.