THERMAL POWER PLANT
PERFORMANCE TESTING

Qualified for 18 PDUs by PEB

Major Equipment Performance Testing, Boilers, Turbines, Condensers, Pumps, Fans, Test Methodology and Code Requirements, Equipment Efficiency, Heat Rate Calculations, Correction Factors

4 – 6 DECEMBER 2017, KUALA LUMPUR, MALAYSIA

Topics Covered

Thermal Plant Performance Testing

Performance Test Methodology and Code Requirements

Performance Test Preparatory Work and Instrumentation

Equipment Efficiency Calculations

Calculating the Heat Rate of CFB and Pulverized Coal Boiler Power Plants

Expert Course Faculty Leader

Philip Kiameh

Has more than 30 years of practical engineering experience with Ontario Power Generation and as a Training Manager, has conduct courses and seminars, to more than 4,000 working engineers and professionals who consistently ranked him as "Excellent" or "Very Good". Philip has also wrote 5 books for working engineers from which three have been published by McGraw-Hill, New York.

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THERMAL POWER PLANT PERFORMANCE TESTING

4 – 6 DECEMBER 2017, KUALA LUMPUR, MALAYSIA

Course Overview

This seminar provides detailed description of the all performance testing methods for all thermal power plant equipment including boilers, turbines, condensers, pumps, fans, deaerators, and feedwater heaters. The methodology, and code requirements for the performance tests for all thermal power plant equipment will be covered thoroughly in this seminar. The preparatory work and instrumentation required for each test will be described in detail in this seminar. The efficiency calculations for all the equipment used in circulating fluidized-bed (CFB) boiler and pulverized coal boiler power plants will be covered in-depth in this seminar. All the processes, operational and maintenance activities, capital projects, technical options, potential initiatives and incentives to implement upgrades/repairs for increasing the power plant equipment efficiency will also be covered in detail. This seminar will also provide a thorough explanation of CFB and pulverized coal boiler technology including hydrodynamics, combustion, emissions, design considerations, gas-solid separators, design of CFB and pulverized coal boiler components, management of solid residues, materials, stoichiometric calculations, and model for sulfur capture. The operation, maintenance, testing, and refurbishment options of all the equipment and systems used in CFB and pulverized coal power plants will be covered in detail including, boilers, superheaters, reheaters, turbines, condensers, feedwater heaters, deaerators, pumps, compressors, fans, electric generators, instrumentation and control systems, and governing systems, etc. All the factors which affect CFB and pulverized coal boiler power plant efficiency and emissions will be explained thoroughly. All the methods used to calculate the heat rate of CFB and pulverized coal power plants will be covered in detail. All the areas in CFB and pulverized coal boiler power plants where efficiency loss can occur will be explained. This seminar will also provide up-dated information in respect to the following methods used to improve CFB boiler and pulverized coal boiler power plant heat rate:

- Optimizing the Combustion Process and Sootblowing
- Controlling the Steam Temperature
- Recovering Moisture from Boiler Flue Gas
- Performing Steam Turbine Maintenance
- Lowering Condenser Back Pressure
- Pre-drying High Moisture Coal and Reducing Stack Temperature

Course Learning Outcomes

- **Thermal Plant Performance Testing**: Gain a thorough understanding of all the performance testing methods for all thermal power plant equipment including boilers, turbines, condensers, pumps, fans, deaerators, and feedwater heaters.
- **Performance Test Methodology and Code Requirements**: Understand the methodology, and code requirements for the performance tests of all thermal power plant equipment
- **Performance Test Preparatory Work and Instrumentation**: Learn about the preparatory work and instrumentation required for each equipment performance test in a thermal power plant
- **Equipment Efficiency Calculations**: Gain a thorough understanding of the efficiency calculations for all the equipment used in circulating fluidized-bed (CFB) boilers and pulverized coal boilers power plants
- **Calculating the Heat Rate of CFB and Pulverized Coal Boiler Power Plants**: Learn all the methods used to calculate the heat rate of CFB and pulverized coal boiler coal power plants
- **Benefits of Lowering the Heat Rate of CFB and Pulverized Coal Boiler Power Plants**: Understand all the benefits of lowering the heat rate of circulating fluidized-bed boiler coal power plants
- **Methods Used to Improve CFB and Pulverized Coal Boiler Power Plants Heat Rate**: Gain a thorough understanding of all the methods used to improve the heat rate of CFB and pulverized boiler coal power plants
- **Processes, Operational and Maintenance Activities in CFB and Pulverized Coal Boiler Power Plants**: Discover all the processes, operational and maintenance activities used to improve the heat rate of CFB and pulverized coal power plants
- **Capital Projects Used to Improve the Heat Rate of CFB and Pulverized Coal Boiler Power Plants**: Learn about all the capital projects used to improve the heat rate of CFB and pulverized coal power plants
- **Technical Options for Improving the Heat Rate of CFB and Pulverized Coal Boiler Power Plants**: Understand all the technical options used to improve the heat rate of CFB and pulverized coal boiler power plants
- **Potential Initiatives and Incentives to Implement Upgrades/Repairs for Improving the Heat Rate of CFB and Pulverized Coal Bed Boiler Power Plants**: Discover all the potential initiatives and incentives to implement upgrades/repairs for improving the heat rate of CFB and pulverized coal power plants
- **Factors Affecting CFB and Pulverized Coal Boiler Power Plants Efficiency and Emissions**: Learn about all the factors which affect CFB and pulverized coal boiler power plants efficiency and emissions
- **Areas in CFB and Pulverized Coal Power Plants where Efficiency Loss Can Occur**: Discover all the areas in CFB and pulverized coal power plants where efficiency loss can occur
- **Optimize the Operation of CFB and Pulverized Coal Power Plant Equipment and Systems to Improve the Plant Heat Rate**: Understand all the techniques and methods used to optimize the operation of CFB and pulverized coal power plant equipment and systems to improve the plant heat rate
- **CFB and Pulverized Coal Power Plant Equipment and Systems: Learn about various types of CFB and pulverized coal power plant equipment and systems including:** boilers, superheaters, reheaters, steam turbines, governing systems, deaerators, feedwater heaters, coal-handling equipment, transformers, generators and auxiliaries

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

Who Should Attend

- Engineers of all disciplines
- Managers
- Technicians
- Maintenance personnel
- Other technical individuals

Your Expert Faculty

Philip Kiameh, M.A.Sc., B.Eng., D.Eng., P.Eng. (Canada) has been a teacher at University of Toronto and Dalhousie University, Canada for more than 23 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 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 30 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.

Prof Kiameh wrote 5 books for working engineers from which three have been published by McGraw-Hill, New York. Below is a list of the books authored by Prof Kiameh:

1 Power Generation Handbook: Gas Turbines, Steam Power Plants, Co-generation, and Combined Cycles, second edition, (800 pages), McGraw-Hill, New York, October 2011.
2 Electrical Equipment Handbook (600 pages), McGraw-Hill, New York, March 2003.
3 Power Plant Equipment Operation and Maintenance Guide (800 pages), McGraw-Hill, New York, January2012.
4 Industrial Instrumentation and Modern Control Systems (400 pages), Custom Publishing, University of Toronto, University of Toronto Custom Publishing (1999).
5 Industrial Equipment (600 pages), Custom Publishing, University of Toronto, University of Toronto, University of Toronto Custom Publishing (1999).

THERMAL POWER PLANT PERFORMANCE TESTING

4 – 6 DECEMBER 2017, KUALA LUMPUR, MALAYSIA

3 Day Course Outline

Day 1 – Steam Power Plants, Steam Generators, Steam Turbines, Steam Turbine Auxiliaries, Boiler Efficiency, Combustion Efficiency, Fuel-to-Steam or Fuel-to-Water Efficiency, ASME Power Test Code PTC 4, Input-Output Method, Heat Loss Method, Standard BTS-2000 Test Conditions

- Review of Thermodynamics Principles
- Steam Power Plants
- Steam Generators
- Steam Turbines
- Reheaters
- Condensers
- Feedwater Heaters
- Efficiency and Heat Rate
- Supercritical Plants
- Superheaters and Reheaters
- Economizers
- Fans
- The Stack
- Steam Generator Control
- Feedwater-Level Control
- Steam-Pressure Control
- Steam-Temperature Control
- Mechanisms of Energy Conversion in a Steam Turbine
- Turbine components
- Rotating and Stationary blades
- Thrust bearings
- Labyrinth seals
- Turbine controls
- Testing of Turbine blades
- Quality Assurance of Turbine Generator Components
- Assembly and testing of turbine components
- Turbine Types
- Compound Turbines
- Turbine Control Systems
- Steam Turbine Maintenance
- Steam Generators, Heat Exchangers, and Condensers
- Power Station Performance Monitoring
- The Turbine Governing Systems
- Steam Chests and Valves
- Turbine Protective Devices
- Turbine Instrumentation
- Lubrication Systems
- Gland Sealing System
- Determine the boiler efficiency
- Combustion efficiency
- Fuel-To-Steam or Fuel-to-Water Efficiency
- ASME Power Test Code, PTC 4
- Gland Sealing System
- Determine the boiler efficiency
- Combustion efficiency
- Fuel-To-Steam or Fuel-to-Water Efficiency
- ASME Power Test Code, PTC 4
- Fuel-to-steam efficiency
- Input-output method
- Heat Loss method
- Standard BTS-2000 test conditions
- Frequently Asked Questions about Turbine-Generator Balancing, Vibration Analysis and Maintenance
- Features Enhancing The Reliability and Maintainability of Steam Turbines

Day 2 – Steam Turbine Performance Testing, ASME PTC 6 Test, ASME PTC 6 Report, ASME PTC 6.1, ASME PTC 6S, DIN-1943, CIE/IEC 953-1, CIE/IEC 953-2, Station Instrument Testing, Condenser Performance Test, Thermal Performance Analysis of Variable Conditions in a Steam Power Plant, Factors Affecting the Condenser Performance, Thermal Balance Equations, Heat Transfer Society (HEI) formula, Condenser Thermal Performance Analyses of Variable Conditions, Boiler Feed Pump (BFP) Performance Assessment, BFP Design Curves, BFP suction and Discharge Head Calculations, Discharge Water Leg Correction, Total Dynamic Head Developed Calculation, BFP Efficiency Calculation, Performance Assessment of Forced Draft and Induced Draft Fans

- Steam Turbine Performance Testing
- ASME PTC 6 Test (steam turbine testing)
- ASME PTC 6 Report
- ASME PTC 6.1 (alternative steam turbine test)
- ASME PTC 6S (Routine Performance Testing)
- DIN-1943 (steam turbine testing with allowances for measurement uncertainty, aging, etc)
- CIE/IEC 953-1 (steam turbine testing code)
- CIE/IEC 953-2 (steam turbine testing code)
- Station Instrument Testing
- Condenser Performance Test
- Thermal Performance Analysis of Variable Conditions in a Steam Power Plant
- Factors Affecting the Condenser Performance
- Cleanliness Factor
- Condenser Corrected Pressure
- Formulas
- Thermal Balance Equation
- Condenser Overall Heat Transfer Coefficient
- Heat Transfer Society (HEI) formula
- Condenser Cleanliness Coefficients
- Condenser Correction Pressure
- Condenser Thermal Performance Analyses of Variable Conditions
- Boiler Feed Pump (BFP) Performance Assessment
- BFP Performance Testing
- Affinity Laws
- BFP Design Curves
- Affinity Laws
- BFP Design Curves
- Pump Suction Head Calculation
- Suction Water Leg Correction
- Pump Discharge Head Calculation

- Water Density at Discharge Conditions, ρd
- Discharge Water Leg Correction, Zd
- Velocity at Pump Discharge, Vd
- Total Dynamic Head Developed Calculation
- BFP Efficiency Calculation
- Performance Assessment of Forced Draft and Induced Draft Fans
- Purpose of the Performance Test
- Performance Tests Terms and Definitions
- Performance Standards
- British Standard, BS848
- Field Testing
- Instruction for Site Testing
- Location of Measurement Planes
- Test Length
- Location of The Flow Measurement Plane within the "Test length"
- Location of Pressure Measurement Plane
- Pitot Tube
- Transverse Readings, Anemometer, Determination of Fan Pressure, Measurment of Static Pressure
- Determination of Power Input
- Power Measurement
- Transmission Systems
- Other Prime Movers
- Example: Performance Test Report of a Fan
- Performance Calculation
- Power Input to Fan Shaft
- Fan Efficiency
- Factors That Could Affect Fan Performance

Day 3 – CFB and Pulverized Coal Fired Power Plants Systems and Equipment, Factors Influencing Coal Fired Power Plant Efficiency and Emissions, Efficiency Standards and Monitoring, International Energy Agency (IEA) Recommendations for Improving the Heat Rate in Coal Fired Coal Power Plants, Calculating Heat Rate of Coal Fired Power Plants, Benefits of Lowering Heat Rate, Heat Rate Improvement – Methodologies, Capital and Maintenance Projects, Steam Turbine Steam Path Modifications; Processes, Operational and Maintenance Activities Used to Increase the efficiency of Coal Fired Power Plants Fired Power Plants

- Major Components of Coal Fired Power Plants
- Coal Fired Power Plant Performance
- Coal Fired Power Plant boiler hydrodynamics, combustion, emissions, design considerations, gas-solid separators
- Design for Boiler Components and Management of Solid Residues in Coal Fired Power Plants
- Materials, Characteristics of Solid Particles, Stoichiometric Calculations and Model for Sulfur Capture in Coal Fired Power Plant Boilers
- Coal Power Plant Performance
- Net Power Generation Capacity
- Steam Cycle Heat Rate
- Design Parameters that Affect the Steam Cycle Heat Rate
- Boiler (Steam Generator) Efficiency
- Coal Composition
- Ultimate Analysis
- Flue Gas Exit Temperature
- Energy Content or Heating Value
- Penalty for Stack Gas Reheat
- Flue Gas Desulfurization (FGD) Systems
- Power Consumption of the Auxiliary Equipment (Allowance for Auxiliaries)
- Power Plant Availability
- Average Load Factor
- Annual Coal Consumption
- Annual Ash and SO2 Generation
- Coal Transportation, Unloading and Storage
- Coal Storage and Reclamation
- Environmental Issues Related with Coal Based Energy Conversion
- Air Pollution
- Sulfur Containing Compounds (SOx)
- Nitrogen Containing Compounds (NOx)
- Carbon Monoxide (CO) and Carbon Dioxide (CO2)
- Particulate Matter
- Environmental Control Systems
- Control Technologies for SOx, NOx, and Particulates
- Electrostatic Precipitators (ESP's)
- Ash and Flue Gas Desulfurization (FGD) Sludge Disposal Systems
- Differences in Reported Efficiency Values
- Energy and Efficiency Losses
- Impact of Condenser-Operating Conditions on Efficiency
- Heat and Power Equivalence
- Efficiency Performance Assessment Periods
- Efficiency Standards and Monitoring
- Reporting Bases for Whole Plant efficiency
- CO2 Emission Reporting
- Generic Reconciliation Methodology
- Efficiency Outlook for Power Generation from Coal
- International Energy Agency (IEA) Recommendations for Improving the Heat
- Rate in Coal Power Plants
- Calculating Heat Rate of Coal Fired Power Plants
- Benefits of Lowering the Heat Rate of Coal Fired Power Plants
- Efficiency and Systems of Coal Fired Power Plants
- Areas of a Coal Plant where Efficiency Loss Can Occur
- Assessing the Range and Applicability of Coal Power Plant Heat Rate Improvements
- Coal Power Plant Heat Rate Improvement – Methodologies, Capital and Maintenance Projects
- Coal Power Plant Heat Rate Improvement – Common Recommendations
- Coal Power Plant Specific Recommendations
- Potential Coal Power Plant Heat Rate Improvements
- Quantified Benefits of Implementation of Recommendations
- Fuel Savings and CO2 Benefits
- Coal Power Plant Heat Rate Improvement – Fleetwide Assessment Case Study
- Coal Power Plant Heat Rate Improvements – Issues and Perspectives
- Flexible Operation, Cycle Alignment, Remote Monitoring Centers
- Steam Turbine Steam Path Modifications
- Coal Power Plant Heat Rate Improvement Program Guidelines
- Realized and Projected Heat Rate Improvements
- Efficiency Improvements to Reduce Greenhouse Gases (GHG)
- Existing Coal Power Plants Efficiency Improvements
- Key Technical Opportunities to Increase Thermal Efficiency
- Processes for Increasing the Plant Efficiency
- Operational and Maintenance Activities Used to Increase the Plant efficiency
- Capital Projects Used to Increase the Plant Efficiency
- Framework for Measuring and Sustaining Improvements
- Technical Options to Increase Plant Efficiency
- Accurate Definition and Standard for Measuring Efficiency in Real Time
- Potential Initiatives for Increasing Plant efficiency
- Incentives for Existing Fleet to Implement Upgrades/Repairs for Increasing Plant Efficiency
- Improve the Heat Rate by Optimizing the Combustion Process and Sootblowing
- Improve the Heat Rate by Controlling the Steam Temperature
- Improve the Heat Rate by Recovering Moisture from Boiler Flue Gas
- Improve the Heat Rate by Performing Steam Turbine Maintenance
- Improve the Heat Rate by Lowering Condenser Back Pressure
- Improve Coal Power Plant Heat Rate by Pre-drying High Moisture Coal and Reducing Stack Temperature

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	PER PARTICIPANT	2 PARTICIPANTS OR MORE	IN-HOUSE TRAINING
3 Day Programme	SGD 2,900 Per Participant	SGD 2,400 Per Participant	Guaranteed Minimum 40% Off Normal Price

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