CIRCULATING FLUIDIZED BED BOILERS
Selection, Applications, Operation, Maintenance, Performance Monitoring, Diagnostic Testing, Troubleshooting, Refurbishment, Common Problems and Solutions, Life Extension, and Economics

20 – 22 SEPTEMBER 2017, MANILA, PHILIPPINES

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.
CIRCULATING FLUIDIZED BED BOILERS
20 – 22 SEPTEMBER 2017, MANILA, PHILIPPINES

Course Overview
This seminar will provide a comprehensive understanding of various types of circulating fluidized bed (CFB) boilers. All the components of CFB boilers including furnace, cyclones, economizers, superheaters, reheaters, ammonia injection systems, electrostatic precipitators, polishing dry scrubbers, fuel and sorbent feeding systems, bottom ash handling and extraction systems will be covered in detail. The design, selection considerations, operation, maintenance, diagnostic testing, troubleshooting, refurbishment, pay-back period, and economics as well as, emission limits, reliability, monitoring and control systems of CFB boilers will also be covered thoroughly. This seminar will focus on maximizing the efficiency, common problems and solutions, reliability, and longevity of CFB boilers by providing an understanding of the characteristics, selection criteria, common problems, and repair techniques, preventive and predictive maintenance. All the common problems encountered in CFB Boilers will be discussed in detail. This includes thermally induced failures, anchor system induced failures, water walls tube failures, NMEJ damages, clinker formation, refractory damages, APH tube cho ck-up. Solutions will be presented to each problem.

Several studies have confirmed that CFB boilers are the best method for power generation. This is due to their fuel flexibility, and lowest electricity cost among all types of boilers. This technology is in great demand due to various other advantages such as lower emissions as compared to other types of boilers and has a carbon footprint well below the norms laid down by the World Bank emission requirements. This seminar is a MUST for anyone who is involved in the selection, applications, or maintenance of circulating fluidized bed boilers, because it covers how this equipment operates, the latest maintenance techniques, and provides guidelines and rules that ensure successful operation of CFB boilers. This seminar will also provide up-dated information in respect to all the significant improvements that have been made to this equipment during the last two decades.

Course Learning Outcomes

- **Circulating Fluidized Bed Boiler Advantages**: Gain a thorough understanding of the advantages of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers Components and Systems**: Learn about all components and subsystems of the various types of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boiler Equipment**: Learn about various equipment of circulating fluidized bed boilers including: furnaces, cyclones, economizers, superheaters, reheaters, ammonia injection systems, electrostatic precipitators, polishing dry scrubbers, fuel and sorbent feeding systems, bottom ash handling and extraction systems and materials.
- **Circulating Fluidized Bed Boilers Maintenance**: Learn all the maintenance activities required for circulating fluidized bed boilers, to minimize their operating cost and maximize their efficiency, reliability, and longevity.
- **Circulating Fluidized Bed Boilers Environmental Emissions**: Learn about the monitoring and control of environmental emissions from circulating fluidized boilers.
- **Circulating Fluidized Bed Boilers Instrumentation and Control Systems**: Learn about the latest instrumentation and control systems of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers, Reliability and Testing**: Increase your knowledge of predictive and preventive maintenance, reliability and testing of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers Selection and Applications**: Gain a detailed understanding of the selection considerations and applications of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers Reliability, Refurbishment, and Life Extension Methods**: Learn about the reliability, life cycle cost, profitability, refurbishment, and life extension methods for all types of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers Commissioning**: Understand all the commissioning requirements of circulating fluidized bed boiler.
- **Circulating Fluidized Bed Boilers Codes and Standards**: Learn all the codes and standards applicable for circulating fluidized bed boilers.

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.
WHO SHOULD ATTEND

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

SPECIAL FEATURE

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

2. Practical Circulating Fluidized Bed manual (300 pages)

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:

5. Industrial Equipment (600 pages), Custom Publishing, University of Toronto, University of Toronto, University of Toronto Custom Publishing (1999).
3 Day Course Outline

DAY 1

- Advantages of circulating fluidized bed combustion
- Circulating fluidized bed combustion technology
- Development of circulating fluidized bed boilers
- Components of CFB boilers: wind box and grid nozzle, bottom ash drain, HP blower, cyclone separator, evaporative or superheat wing walls, fuel feeding system, refractory, solid recycle system (loop seal), wall tubes, kick out, limestone and sand system
- Typical arrangements of CFB boilers
- Hydrodynamic in CFB boilers: particle classification, regimes of fluidization, fast fluidization
- Combustion in CFB boilers: coal properties for CFB boiler, stage of combustion, factors affecting combustion efficiency, combustion in CFB, biomass combustion
- Heat transfer in CFB boilers: gas to particle heat transfer, heat transfer in CFB boiler
- Design of CFB boilers: design and required data, combustion calculations, heat and mass balance, furnace design, cyclone separator
- CFB boiler operation: Requirements before starting, grid pressure drop test, cold start procedure, fill boiler procedure, start fan, boiler interlock, purge, start-up burner, drum and DA low level cut off, boiler warm-up, normal operation, normal shutdown, hot shutdown, hot restart,
- Malfunction and emergency: bed pressure, bed temperature, circulation, tube leak, drum level
- Maintenance of CFB boilers: Requirements before maintenance work, overview boiler maintenance, windbox inspection, furnace inspection, kick-out inspection, superheat (wingwalls), superheat (omega tube), roof inspection, inlet separator, steam drum, separator, outlet separator, screen tube, superheat tube, economizer inspection, air heater
- Basic boiler safety: warnings, general safety precaution, equipment entry, operating precautions
- CFB boiler control systems: Basic control, furnace control, main pressure control, main steam pressure control, drum level control, feed tank control, solid fuel control, HP blower control, primary air control, secondary air control, oxygen control, fuel oil control

DAY 2
Components, Operational Performance, Efficiencies, Availability and Reliability, Operational Flexibility, Fuel flexibility, Environmental Performance, Methods Used to Improve the Heat Rate, Supercritical Once-through Internal Recirculation-Circulating Fluidized-Bed (IR-CFB) Boilers for Power Generation, Ultra Supercritical Fluidized Bed (CFB) Boilers

- Circulating fluidized bed combustion boilers
- Circulating fluidized bed combustion boiler and polishing scrubber
- Circulating fluidized bed combustion boiler combustor
- Circulating fluidized bed combustion boiler solid separation system
- Superheaters
- Economizers
- Reheaters
- Convective backpass
- Internal and external heat exchangers
- Fuel and sorbent feeding systems
- Air feeding and distribution system
- Bottom ash handling and extraction system
- Combustors of circulating fluidized bed boilers
- Cyclones of circulating fluidized bed boilers
- Circulating fluidized bed boiler process flow diagrams
- Status of the technology
- Operational performance
- Efficiencies
- Availability and reliability
- Operational flexibility
- Fuel flexibility
- Environmental performance
- Plant Sizes
- Steam conditions
- Design variants
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- Applications
- Developments in circulating fluidized bed combustion
- Furnace design
- Furnace dimensions
- Lower furnace designs
- Solid separation systems
- Cyclones
- Impact separators
- Sidewall membrane panels
- Optimized arrangement of solid separators
- External heat exchangers
- Scale-up
- Advanced circulating fluidized bed steam cycle with once-through boiler technology
- Availability and reliability
- Fluidized bed ash coolers
- Co-combustion
- Conclusions
- Status of circulating fluidized bed technology
- Operational performance
- Applications
- Recent developments in circulating fluidized bed combustion technology
- Scaling-up
- Advanced steam cycle with once-through boiler technology
- Other developments
- Oxy-fuel circulating fluidized bed combustion technology
- Oxy-circulating fluidized bed boiler design challenges
- Developments in oxy-circulating fluidized bed combustion
- Performance and costs
- Oxy-pulverized coal versus oxy-circulating fluidized bed boilers
- Methods used to improve the heat rate of circulating fluidized bed boilers
- Supercritical Once-Through Internal Recirculation-Circulating Fluidized Bed Boilers (IR-CFB) Boilers for Power Generation
- IR-CFB Technology
- Segmented U-beam particle separators
- Proven design features
- High solid collection efficiency
- Controlled furnace temperature
- Low auxiliary power
- Uniform gas flow
- High solid separator reliability
- Minimal refractory use

- Low maintenance
- Dynamic load change
- Wide turndown ratio
- Operating experience
- Reduced diameter zone (RDZ) design for erosion protection at the upper refractory edge
- New commercial projects
- Arrangement of circulating fluidized bed boilers
- New developments in circulating fluidized bed design
- 300 MW IR-CFB boiler
- Supercritical once-through circulating fluidized bed with in-bed heat exchanger (IBHX)
- Internal Bed Heat Exchanger
- Supercritical once-through circulating fluidized bed design study
- Water and steam circuitry
- Flue gas path
- Reheat temperature control
- In-bed heat exchanger development
- In-bed heat exchanger design
- Open-bottom bed drain system
- Conclusions
- Ultra supercritical circulating fluidized bed boilers
- Efficient combustion and fuel flexibility
- Low Inherent NOx emissions at 50 – 200 Mg/NM3
- Low SO2 emissions with 95 – 98% sulfur removal
- Product specifications


- Circulating fluidized bed boiler start-up burner, flame monitors, automation and instrumentation, purge, start-up burner basic logic, control principles
- Fuel oil pressure control, interlocking, troubleshooting, safety, starting problems of the burner, remedy, maintenance instructions, electric ignitor, flame detecting equipment, maintenance during shutdown, safety instructions
• Cold start-up, differential pressure test, bed material filling, burner start-up procedure, burner management system (BMS), furnace purging, natural gas firing, boiler pressurizing, coal firing, steam line charging for first boiler
• Operation Controls, bed temperature control, solid inventory control, furnace inventory control, part-load operation
• Hot start-up, warm start-up, boiler shutdown, emergency shutdown, fuel analysis, bed material specification, limestone, recommended feedwater quality
• Testing and commissioning of CFB boiler and auxiliaries, commissioning stages of the boiler and auxiliaries, pre-commissioning checks, trial run of equipment, pre-commissioning tests, alkali boil out, thermal flow tests, chemical cleaning of the boiler, steam boiling, safety valve setting
• Commissioning of the boiler, reliability run of the boiler, typical boiler commissioning schedule
• Hydraulic test and wet preservation, purpose of the boiler hydrostatic pressure test, regulatory requirements for the boiler hydrostatic pressure test, state of the plant
• Air testing of pressure parts, boiler hydrostatic pressure test procedure, stage 1, hydrostatic pressure test of pressure parts, completion criterion for the boiler hydrostatic pressure test, Dry or wet preservation of the boiler
• Air and gas tightness test, test procedure, zones tested by the air and gas tightness test, furnace zone, second pass of boiler zone, electrostatic precipitator zone, forced draft fan ducts zone, hot air duct, cold air duct, primary air fan ducts zone, cold air ducts, hot air ducts, protocol on smoke generator test
• Trial run of equipment, fans, tests, constructional tests, commissioning checklist of induced draft fan, pre-commissioning tests, commissioning tests, fuel and limestone feed system, superheating system
• Electrostatic precipitators (ESP): components and operation, main components of ESP, basic diagram of ESP, rapping system of ESP, control cabinet, transformer, rectifier, hopper
• Main processes of an ESP, operation of an ESP, dust collection efficiency and electrical resistivity of dust, rectifier transformer, spark reaction, tripping, discharge electrodes

• ESP collecting electrodes, gas distribution system, rapping system, collecting rapping system, emitting rapping system, rapping system for distribution screen
• Rapper (electrostatic precipitation), rappers and precipitators, types of rappers, mechanical rappers, pneumatic rappers, tumbling hammers, design considerations
• ESP rectifier transformer, principle of operation, back corona, field short, voltage-current characteristics, parameters affecting the performance of ESP: gas temperature, moisture content, dust particle size, dust resistivity, rapping frequency, components of rectifier transformers
• SCR controller, transformer unit, current limiting reactor, rectifier diode assembly, high frequency choke
• Resistance board assembly – feedback signal for control and monitoring, mA feedback, kV feedback signal
• Insulating oil, characteristics of silicon oil, principle of operation, unipulse/semi-pulse mode, charge ratio, spark control rate, field current setting, specification – stage II transformers, transformer connections, open circuit test – BHEL transformer, short circuit test – BHEL transformer, acceptance test, fault detection
• Measures to be taken for avoiding frequent transformer failures
• Commissioning and testing of ESP, commissioning procedure of the electrical equipment inside the ESP, commissioning of the control system
• ESP no-load field charging test, transformer tests, open circuit test on transformer, short circuit test on transformer, insulation resistance of cables
• Commissioning procedure of the mechanical equipment inside the ESP, mechanical, gas distribution wall – bottom gaps and provision of inspection doors
• Before first light up of the boiler, gas distribution test, air load test of ESP
OTHER AVAILABLE COURSES

4 Pillars of Transformer Condition
Advanced Project Finance for Power
Advanced Technical Report Writing & Presentation Skills
Advanced Turnaround Shutdown & Outage Management
Ancillary Services in Competitive Electricity
Asset Management for the Power Industry
Best Practice Renewable Energy Capital & Project Management
Biomass Power Generation
CFB Combustion for Boiler Operations
Clean Development Mechanism and Carbon Markets
Coal Contracts
Combined Cycle Power Plants Operation
Combined Heat & Power (CHP) and Co-Generation Plant Operations
Competency Management System for the Power Industry
Design & Operations of Circulating Fluidized Bed Boiler
Developing & Structuring Public-Private Partnership (PPP) for Infrastructure
Effective Tender Process Management for Power & Utilities
Electrical Hazop (eHazop) Studies for the Power Industry
Electricity Demand-Side Management
Electricity Industry Design
Electricity Network Planning
Electricity Retail Contracts
Electricity Theft
Electricity Trading Essentials
Energy Efficiency
EPC Contract Management for Power & Utilities
Essentials of Coal Markets and Trading Essentials
of Power Trading
Excitation Systems
Feed-In Tariffs for PV Systems
Finance for Non-Finance Professionals in Power & Utilities
Financial Modelling for Project Finance in Power & Utilities
Fitness-For-Service AP1 579 & High Energy Piping Life Management
Fundamentals of Geothermal Energy
Fundamentals of Power Generation
Gas & LNG Contract Negotiation
Gas Turbine Generator Selection, Operation & Maintenance
Gas Turbine Hot Gas Paths, Rotors & Failure Analysis
Gas Turbine Major Inspection & Overhaul
GE Gas Turbine Operations Simulation Based
HRSG Design, Operations & Understanding, Controlling of HRSG Damage
HV Substation Design & Construction
IEC for Utilities
Integration of Distributed Generation
Introduction to Carbon Capture & Storage
Introduction to Clean Coal Technology
Introduction to Power Systems
Keeping Electrical Switchgear Safe
Leadership & Team Dynamics for Power & Utilities
LNG Fundamentals
LNG Markets & SPOT Trading
Maintenance Planning & Scheduling
Making IPP & Renewable Energy Projects Contract Frameworks
Bankable
Managing Complex Projects for Power and Utilities Professionals
Medium Voltage & High Voltage Switchgear
Metallurgy for Engineers
Mechanical Engineering for Non-Mechanical Engineers
Mini Hydro Project Analysis
MKV Speedtronic Control System
MK VI Speedtronic Control System
Nuclear Energy Project Planning & Economics
Nuclear Power
Offshore Platforms Electrical Systems Design & Illustrations
Operations of Coal Fired Power Plants
Power Generation Commissioning, Operations & Maintenance
Power Generation Operation, Protection & Excitation Control
Power Plant Chemistry for Chemist & Chemical Engineers
Power Purchase Agreements
Process Control Methods
Programmatic CDM
Project Management for Power and Utilities
Relay Protection in Power Systems
Reliability Centered Maintenance Masterclass
Reliability Engineering
Renewable Energy Development & Investment
Renewable Energy Integration
Risk Based Inspection
Risk Management in Power Markets
Root Cause Analysis
Rotating Equipment Maintenance & Reliability Excellence
SCADA & Power Systems
Smart Grid
Solar Energy & Photovoltaic Power
Spare Parts Optimisation
Supercritical and Ultra-Supercritical Coal-Fired Power Plant
Technical Report Writing & Presentation Skills for Power & Utilities Professionals
Ultra Low NOx Gas Turbine Combustion
Uninterruptible Power Supply
Vibration Analysis & Condition Monitoring
Waste to Energy Plant Operations
Water Treatment and Corrosion Control for Steam Generation and Power Production
Writing Effective Standard Operating Procedures (SOP) for Power & Utilities Professionals & Engineers

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1. Does PowerEdge have other programmes than those listed? We have more than 200 programmes that we are capable of running. All we need is for you to contact us and request for the preferred programme and we will able to develop it.

2. Where is PowerEdge based? PowerEDGE is headquartered in Singapore but we run our training programmes in different venues around Asia.

3. What does PowerEdge do? We are a Power & Utilities Training Specialist.

4. Can this course be done in our city? It absolutely can. Get in touch with us to request for a training programme to be carried out in your city.

5. Can you reduce the price of our preferred course? While our price has been reduced before it is even launched, we are always happy to help you with further discounts.

6. Can you change the dates of the course? If you have a special requested date, let us know and we will arrange another session for you.

7. Who are the companies that will be participating? This varies from a diversity of Power Operators, Regulators, Financiers, to Vendors in the Power & Utilities industry.

8. Where is the venue for the course? We usually engage a 4 to 5 star hotel meeting room to ensure the comfort of our participants.

9. How many delegates should we expect for each course? This varies from 15 to 20 participants. Class sizes are kept small to allow trainers to focus better on each participant.

10. What are the different payment modes? We accept Visa/MasterCard, cheques, bank transfers and cash on site.

11. Is accommodation included when I sign up for a course? Accommodation is not included in the course fee but we are always happy to advise on available accommodations.

12. Can I get a cheaper accommodation through PowerEdge? We will be pleased to help you negotiate a better rate with hotels.

13. Is lunch provided during the course? We provide lunch and 2 tea breaks every day during our training programmes.

14. Are the training materials included once I have signed up for a course? Yes, training and course materials are included in the course fee.

15. Will there be a certificate for the course? Yes, there will be a certificate of participation upon completion of a course.

16. Who are PowerEdge trainers? They are expert consultants and practitioners with many years of experience in the subject matter that they deliver on.

17. Are PowerEdge trainers competent? We have received numerous favourable feedbacks on our trainers from past participants.

18. Can PowerEdge assist with Visa travel applications? We can assist in advising you on the relevant procedure(s) and embassies/consulates that provide Visa for travel purposes.

19. Can we purchase training materials without attending a course? Unfortunately this option is not available as training materials are specially developed for courses.

20. Can course content be tweaked to cater to our needs? Of course! Just let us know your request and we will get the trainer to assist in carrying it out.
# CIRCULATING FLUIDIZED BED BOILERS
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## ATTENDEE DETAILS

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## PAYMENT METHODS

- Cheque/Bank Draft: Make payable to PowerEdge Pte Ltd.
- Telegraphic Transfer: Please quote AE1 with the remittance advise

Bank Details:
- Bank Address: 65 Ulica Street OCBC Centre, Singapore 049513

All bank charges and payment in Singapore dollars (SGD) to be borne by payer. Please ensure that PowerEdge Pte Ltd receive the full invoiced amount.

### TERMS & CONDITIONS

- Payment is due in full at the time of registration. Full payment is mandatory for event attendance. I agree to PowerEdge Pte Ltd. payment terms
- * GST: Exclusive price is only applicable for overseas corporate customers subject to qualifying conditions.

You may substitute delegates at any time. POWEREDGE PTE LTD does not provide refunds for cancellations. For cancellations received in writing more than seven (7) days prior to the training course you will receive a 100% credit to be used at another POWEREDGE PTE LTD training course for up to one year from the date of issuance. For cancellations received seven (7) days or less prior to an event (including day 7), no credits will be issued. In the event that POWEREDGE PTE LTD cancels an event, delegate payments at the date of cancellation will be credited to a future POWEREDGE PTE LTD event. This credit will be available for up to one year from the date of issuance. In the event that POWEREDGE PTE LTD postpones an event, delegate payments at the postponement date will be credited towards the rescheduled date. If the delegate is unable to attend the rescheduled event, the delegate will receive a 100% credit

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