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# COAL QUALITY & COMBUSTION

**COURSE DURATION: 3 DAYS**

## COURSE OBJECTIVES

The Coal Quality and Combustion is designed specifically to answer the questions about **coal quality, plant performance and pollution control issues.**

This class will introduce the attendee to **laboratory coal analysis** and how to utilize the results to predict power plant performance.

It will also covers how coal quality affects boiler performance, cost, efficiency, and pollution.

# COURSE OUTLINE

### Boiler Basics

- Major components of PC - fired boiler

### Coal Formation

- What is Coal
- Coal Rank
- Where are the different coals located?

### Coal Quality Introduction

- Coal
- Moisture, Ash, Volatiles, Sulfur, Btu/lb
- Sizing, Slagging

Now we follow coal though the plant and examine how coal quality interacts with equipment performance, maintenance, and cost.

### Wet Coal

- Causes
- Measurements
- Solutions

### Coal Mining

- Surface
- Deep
- Out of seam dilution
- Coal Washing
- Drying coal
- Transportation Impacts
  - ∗ Time and Climate
  - ∗ Barge Coal tends to gain moisture

### Sampling coal and coal analyses

- Sampling methods
  - ∗ The Good, The Bad and the Ugly
  - ∗ Good sampling is hard work

- ISO, ASTM Sampling:
  Guidelines
  - ∗ Hand samples
    - Feeder and belt
    - Car top
  - ∗ Mechanical Sampling
    - Sampling systems
    - Augers
    - Core holes

- Terms
  - ∗ Proximate – Moisture, ash, volatile, fixed carbon (by difference)
  - ∗ Short Prox – Moisture, ash, sulfur, Btu/lb
  - ∗ Ultimate – Moisture, ash, sulfur, + carbon, hydrogen, nitrogen, oxygen (by difference)

## WHO SHOULD ATTEND?

- Power and Cement plants operation, production and maintenance engineers
- Fuel Procurement Managers
- Plant Chemists
- Plant Performance Engineers
- Power Plant Project Engineers
- Coal Mining Engineers and Coal Marketers

- Coal Cost
  - Sold by the ton - $/ton
  - Boilers want Calorific Value not tons
  - Evaluated by the Kcal or millions of Kcal (MMcal)

**Coal Handling**

- Moisture plays a dominant role
- Fines
  - What sizes are important?
- Clays and mineral matter
- Chemical additives

**Spontaneous Combustion**

**Combustion**

- The three T's in practice
- Size the coal and add air!
- Coal Reactivity

**Dusty and Spontaneous Combustion**

- Minimizing and controlling dust
- Clean up procedures
- Spon Comb potential
- Fire fighting and precautions

**Combustion Process**

- Coal Rank
- Air to fuel ratios
- Balancing furnaces
- Balancing burners
- NOx formation
- CO analysis

**The Story of NOX**

- To minimize the formation of NOx
- Post Combustion Control

**Combustion Tune-up Procedures**

- Air Flow and Balancing
  - Air Heater Leakage
  - Other Leakage
  - Balancing
    - $O_2$ levels
    - Temperature
    - Flows

**Pulverizers**

- Basic operation
- Adjustments
- Coal Quality Impacts
  - Low Btu
  - High Ash
  - Reject material
  - High Moisture
  - Concern for fires
  - Impact of high air flow
  - Impacts on flame, NOx and SLAG

## COURSE DURATION

- 3 Days Training

## DAILY SCHEDULE

- 8:30am - 5:30pm

- Pulverizer Performance
  * Coal Sizing
  * Air and Fuel Flow
  * Clean and Dirty Coal Pipe Measurements
  * Pyrite Rejects
  * Primary Air Flow
  * Adjustments include: Roller and journal pressure, alignment, air flow, Classifiers, temperature, ball charge, ball size

- LOI Testing and Combustion Verification
  * LOI Test
  * Carbon in Ash
  * Sampling Location
  * Sampling Methods
  * Operator Feedback
  * CO Analyses
  * NOx Analyses

**Results Engineering**

- Boiler Efficiency and Heat Rate Variables
  * Boiler Efficiency vs. Excess Oxygen
  * Moisture and Hydrogen Impacts
  * Higher vs. Lower Heating Value
  * Exit Gas Temperatures
  * Steam Temperature Impacts on Heat Rate
  * Carbon and CO Losses

- Boiler Efficiency Testing
  * Output/Input
  * Heat Loss Method
  * **Problem areas**

- Improving Boiler Efficiency
  * Improving Combustion
  * Optimizing Combustion
  * Optimizing NO

**Unit Heat Rate**

- Input/Output
- Performance Diagrams
- Causes of Ash Deposits
  * Fuel Related
  * Equipment Related
  * Design Related
- Analytical Procedures

**Coal Testing**

- Slagging and Fouling Indices.
  * Elemental loading
    - Pounds of iron per million Btu
    - Pounds calcium, sodium, and other elements

- The ASTM Fusion Temperature Test
  * Ash levels used as slagging and fouling indices.
    - Elemental loading
      ~ Pounds of iron per million Btu
      ~ Pounds calcium, sodium, and other elements

- Slagging with Bituminous Type Ash - High Iron
  * Ash fusion temperatures
  * Advanced ash fusion techniques.
  * Ash Chemistry
    - Basic Slagging factors
      ~ B/A – Base to acid ratio, sum of total bases divided by sum of all acid elements
      ~ Slagging Factor – Ash and Elemental Loading

    - Slagging index
      ~ Dry sulfur x B/A
      ~ Iron squared term

    - Silica% Raask Quartz, Clay type

  * Computer Controlled Scanning Electron Microscopy provide some of the best mineralogical information but has not come into common use.

- Cyclone and Wet Bottom Furnaces
  * Ash Viscosity
    - Calculating T-250
    - Measuring T-250
    - Temperature verses Ash Viscosity Curves

**Fouling Deposits**

- Sulfate salts – $CaSO_4$, (K, Fe) $SO_4$, $H_2SO_4$, $(NH_4)HSO_4$, $(NH_4)_2SO_4$

  * Chemical Fractionation
    - Active alkali
      ~ Water soluble
      ~ Ammonium Acetate soluble
      ~ Weak acid soluble
      ~ Micro crystals

    - Major and Minor Ash Elements
      ~ Acid Oxides or Glass Formers
      ~ Basic Oxides or Fluxing agents or Gluing Elements

**TABLE I - MAJOR CAUSES OF ASH DEPOSITS**

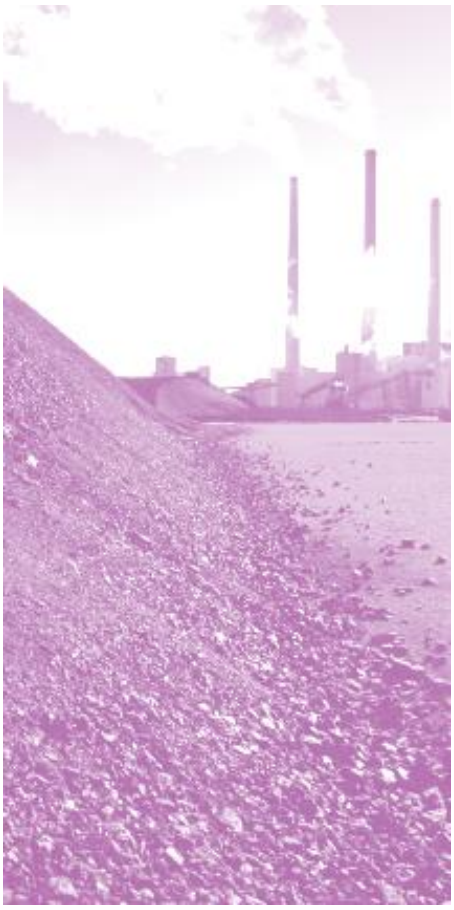
| | |
|---|---|
| **Fuel Related** | • Large pyrite particles that impact the furnace wall before they completely combust<br>• Clay minerals that contain significant amounts of iron, calcium, sodium or potassium causing them to have low melting temperatures<br>• Interaction of pyrite, clays and alkalis with alumino silicates to form low viscosity melts<br>• Extremely fine or organically bound alkalis |
| **Equipment Related** | • Soot blowers not in operation or used improperly<br>• Poor pulverization of fuel<br>• Improper air to fuel ratio<br>• Burners damaged or improperly adjusted<br>• Changes in operation of boiler or other equipment |
| **Design Related** | • Furnace size too small for fuel<br>• Tube material and/or spacing inadequate<br>• Soot blowing coverage inadequate<br>• No means provided to observe slag build up |

Most Slag begins on the Furnace walls and the proceeds up the furnace.

**Advanced Methods for Slag**

- Mineral and Elemental Analyses of Coal
  - * Computer Controlled Scanning Electron Microscopy (CCSEM)
    - Uses Energy Dispersive X-ray Analyses (EDAX) to size and quantify elemental composition
  - * Low Temperature Ashing
    - Microscopically identify minerals present
  - * Chemical Fractionation
    - Provides information on Organically Bound Elements
  - * Elemental Analyses of float sink and/or size fractions
    - Can be performed by ASTM coal laboratories
    - Pounds of iron per million Btu
    - Pounds calcium, sodium, and other elements

- Ash Deposit Analyses
  - * Sampling Procedure for Ash Deposits
  - * Polarized Light and Scanning Electron Microscopy
  - * Forms of Iron by chemical fractionation
  - * Mossbauer spectroscopy
- Fouling Deposit Formation



**Electrostatic Precipitators**

- Basic Operation Principles
  - High Voltage DC – Transformer Rectifier Sets
  - Voltage Control – Controlling the wave from and sparking rate
  - Sizing ESP – Plate area (fixed) and Flue gas volume (operational variable?)
  - Migration Velocity or why the particle goes to the plate
  - Ash Resistivity concerns
  - Gas Velocity – impacts ESP size and treatment time
  - Rapping – important equipment that can be high maintenance
  - Hopper Evacuation – useful for determining ash partitioning
  - Dust Collection and Storage

- Advanced ESP Methods and Tune-up
  - Combustion Influences
  - Calculating and Measuring Fly Ash Resistivity
  - Correlating and making sense of resistivity data
  - Rappers
  - High Voltage controls
  - Measuring gas flows and particular loadings
  - ESP Inspections
  - Tune-up Procedures
  - Ash Handling
  - Scrubber
  - Out of stack pollutants
  - Trace Elements

**Summary**

- Coal Specifications
- Computerized Evaluations
- Test Burns
- Conclusion

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TRAINER'S PROFILE

# ROD HATT

**Rod Hatt from U.S. has experience in most aspects of how coal quality impacts the operation and performance of industrial and utility coal-fired steam plants. He works regularly with fuel purchasing, plant operation and engineering departments at utilities and with coal sales and mining companies. His services include training classes, expert services and computer software sales and development.**

Rod has over 37 years of experience, 26 as an independent coal quality specialist, 7 years in technical coal sales and marketing and 6 years as a utility combustion and results engineer.

Rod's marketing and engineering experience, along with a unique blend of creative analytical and communication skills, have allowed him to understand, communicate and solve countless complex coal quality problems. He organizes and participates in a number of classes and workshops and conferences. The "Coal Quality & Combustion Workshop" has been attended by hundreds of attendees representing dozens of companies.

Rod specializes in **ash deposits** and provides **advanced analytical services** including **electron microscopy of deposits**. Rod founded and works as President and CTO at Coal Combustion Inc, and is available for select projects.

## EDUCATIONAL QUALIFICATION

- BS degree in Chemistry, Michigan Technical University.

## MEMBER OF

- American Chemical Society (ACS)
- Society of Mining Engineers (SME)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Materials (ASTM)

## CLIENTS SERVICED

### UTILITIES

- AES
- Ameren
- CLP - Hong Kong Electric
- DRAX
- Duke
- Exelon
- GLOW Power-Thailand
- Longview
- Louisville Gas & Electric
- Luminant
- NIPSCo
- NRG Energy
- Orlanco Municipal Utilities
- Pennsylvania P&L
- PPL Montana
- TransAlta
- Xcel

### MINING COMPANIES

- Alliance
- Arch
- Ammerican
- Cloud Peak
- Goldman Sachs
- Koch Carbon
- P&M
- Peabody
- Westmoreland
- Xinergy

### OTHERS

- AIMCOR
- Alcoa
- CSX
- Eastman Chemical
- IDC Training House
- Jupiter Oxygen
- SHAW

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TRAINER'S PROFILE

# ROD HATT

## EXPERIENCES & ACHIEVEMENTS

### 1994 - 2002

- Mr. Hatt operated the Fuel Utilization Services section of Commercial Testing & Engineering Co. located in Lexington, KY. Fuel Utilization specializes in providing customers with the understanding of the impacts of coal quality on power plant performance and cost. Rod teaches a one-day Coal Quality and Combustion class that have been attended by hundreds of industry personnel over the last nine years.

### 1999

- Mr. Hatt took on the additional responsibility of Director of Marketing for CT&E. This position designs, develops and produces company literature, website and manages exhibits at conferences nationwide.

### 1986 - 1994

- Director of Technical Services for Island Creek Coal Corporation.
- Developed and implemented marketing plan for sales of low volatile coal to utilities, $450,000,000 of new sales resulted from these efforts.
- Created over 8,000,000 tons per year of new sales opportunities by persuading customers to modify their specifications. This increased price realization by creating a larger customer base.
- Provided leadership and direction to steam sales which resulted in over 25 test programs, which led to two major long term contracts and several short term sales.
- Developed and implemented the use of coal quality impact models, that created improved markets for high quality coals.

### 1980 - 1986

- Combustion Engineer with Northern Indiana Public Service Co.
- Evaluated potential fuels to predict operational effects and costs. Conducted test burns and evaluated results to confirm predictions. Solved opacity problems at six units and determined cause of deposit formation on ten occasions. Developed and taught combustion training programs to all levels.
- Improved coal handling by developing wet coal monitoring procedures. Improved coal and ash sampling procedures.
- Responsible for evaluation of coal and coal ash chemistry, coal sampling procedures and coal blending. Implemented microscopic techniques for determining asbestos at plant, saving over $250,000 annually by eliminating disposal of non -asbestos material as hazardous.
- Responsible for boiler and precipitator performance testing, fly ash sampling and resistivity measurements.
- Present and/or past member of:
  - American Chemical Society **(ACS),**
  - Society of Mining Engineers **(SME),**
  - American Socienty of Mechanical Engineers **(ASME),**
  - American Society for Testing and Materials **(ASTM).**