POWER PLANT AIR QUALITY CONTROL and FLY ASH QUALITY & AVAILABILITY

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What Major Pollutants are Controlled?

- Particulates (Fly Ash)
- Nitrous Oxides (NO\textsubscript{x})
- Mercury (Hg)
- Sulfur (SO\textsubscript{2} and SO\textsubscript{3} - Acid Rain)
Typical Power Station Layout
Particulate Matter

- National Ambient Air Quality Standard requires control down to PM 2.5
- Typical methods for control are
  - Electrostatic Precipitator (ESP)
  - Fabric Filter (Baghouse)
Dust Collection

- Grounded Collecting Electrode at Positive Polarity
- Electrical Field
- Charged Particle
- Discharge Electrode at Negative Polarity
- Gas Flow
- Uncharged Particles
- Particles Attracted to Collecting Electrode and Forming Dust Layer
- High Voltage Supply From Transformer/Rectifier
- Clean Gas Exit
TYPICAL FABRIC FILTER (BAGHOUSE)
CONTROL OF NITROUS OXIDES (NO$_x$)

ANHYDROUS AMMONIA

UREA
METHODS FOR CONTROL OF NO$_x$

- Combustion modifications/Low-NO$_x$ Burners
- Rich Reagent Injection (RRI)
- Selective Catalytic Reduction (SCR)
- Selective NON-Catalytic Reduction (SNCR)
TYPICAL NO\textsubscript{X} CONTROL LAYOUT
SELECTIVE CATALYTIC REDUCTION

• The NO$_x$ reduction process takes place as the gases pass through a catalyst chamber.

• Before entering the catalyst chamber, the ammonia is injected and mixed with the gases.
NO\textsubscript{x} REDUCTION

- SCR technology converts flue gas NO\textsubscript{x} to nitrogen and water through a catalytically promoted reaction with a reducing agent such as ammonia or urea.

\[
\text{NO}_x + \text{NH}_3 \rightarrow \text{N}_2 + \text{H}_2\text{O}
\]
CATALYSTS

- The catalyst provides active surface area on which the reactions can take place.
- Catalysts typically are made of a ceramic that includes titanium oxide as a carrier and vanadium oxide as the active species.
- Catalysts are generally installed in a honeycomb or plate configuration in order to maximize surface area.
SELECTIVE CATALYTIC REDUCTION
KCP&L plants receive all ammonia and urea shipments by truck.
SAFETY CONSIDERATIONS

• Anhydrous ammonia is a deadly gas.
• A Risk Management Plan must be prepared for each plant and approved by US EPA.
• Ammonia awareness training required for all personnel working at or visiting Iatan, LaCygne and Hawthorn.
• Showers and eyewash stations at storage locations.
• Driver training certification.
EFFECT OF NH$_3$ ON FLY ASH QUALITY

- Control of NH$_3$ usage is better with SCR than SNCR due to the catalyst
- High ammonia “slip” will result in fly ash odor
- High ammonia on fly ash particles may result in NH$_3$ off-gassing due to alkalinity of concrete, and adequate ventilation is needed
CONTROL OF MERCURY

- Activated Carbon Injection (PAC)
- “Native” mercury capture through
  - Hg oxidation in SCR
  - Fabric filter cake
  - FGD wet limestone scrubber
ACTIVATED CARBON (PAC) INJECTION

• All coal plants are required to control Hg to comply with the US EPA’s Mercury and Air Toxics Standards Rule (MATS Rule)
• ACI is the technology chosen by KCP&L for compliance with MATS
• ACI is pneumatic injection of a fine powder (-325 mesh) of activated carbon into the flue gas duct upstream of the Baghouse or ESP
ACTIVATED CARBON (PAC) INJECTION

- Activated carbon is made from coal or lignite that is processed with heat and steam to produce a highly porous powder that has great capacity for adsorption.
- Mercury in the flue gas adsorbs onto the carbon particles, and is collected along with the carbon and fly ash in the unit’s baghouse or ESP.
- Some activated carbons are treated with bromine to improve their performance with low-chlorine-content coal.
- Other non-carbon-based materials (silicates, mineral-based sorbents) are available.
PAC SURFACE AREA: 500 m$^2$/gram
Side Benefit of SCR and NH$_3$

- SCR catalysts have been observed to oxidize mercury (Hg)
- Oxidized mercury is easier to capture than elemental mercury
- This allows for less activated carbon to be used for mercury control
EFFECT OF CARBON INJECTION ON FLY ASH QUALITY

- Increased carbon content will affect air entrainment of concrete
- May also affect color of concrete
- PAC injection rates may be minimized if compliance is maintained
- Day-to-day consistency is key to marketability of fly ash
CONTROL OF SULFUR DIOXIDE (SO$_2$)
CONTROL OF SULFUR DIOXIDE ($SO_2$)

- **Wet FGD Systems**
  - Iatan and La Cygne use wet limestone scrubbers downstream of fly ash collection
  - Major byproduct is gypsum
  - No effect on fly ash quality

- **Dry FGD Systems**
  - Hawthorn 5 uses a spray dryer and pebble lime
  - Major byproduct is calcium sulfite
  - Fly ash is used to supplement lime and is no longer usable in concrete
CONTROL OF SULFUR TRIOXIDE (SO$_3$)

- A small % of the coal sulfur may be further oxidized to SO$_3$
- SO$_3$ combines with moisture to form sulfuric acid
- The mist exiting the scrubber causes opacity or “blue plume”
- Can be treated with Sodium-Based Sorbents, Hydrated Lime, or Trona
FLY ASH SUPPLY
UTILITY CONSIDERATIONS

• New utility industry operating paradigm
  – KCP&L is a member of a regional power pool with day-ahead auctions and economic dispatch of generating units
  – Natural gas and wind have replaced coal to some extent

• Yes, some coal units are shutting down
  – Environmental compliance is expensive
  – Older, smaller, less-efficient units are being retired
  – Remaining coal plants are well-equipped to meet environmental regulations
FLY ASH SUPPLY
MARKET CONSIDERATIONS

• Regulatory certainty re: EPA hazardous designation
• Investments in beneficiation technologies
• Recovery of unused ash from landfills and ponds
• Fly ash marketers are addressing logistical issues with transportation and storage
EAGLE MATERIALS

- Purchased Lafarge Assets in December 2012
  - Talon and Quicksilver
  - Kansas City Fly Ash
  - Central Plains Cement
  - Kansas City Performance Center
- Marketing rights for KCP&L fly ash included in purchase
- Lafarge personnel came over in the acquisition
- Dallas-based company
FLY ASH

- The inert, inorganic matter present in coal that has been fused together during combustion, solidified while suspended in the exhaust gases, and collected from the exhaust gases by electrostatic precipitators.
  - Type C
  - Type F
FACTORS INFLUENCING THE PROPERTIES OF FLY ASH

• Design and Operation of Boiler
  • Dictates the mineralogy or degree of crystallinity of the ash

• Coal Source
  • Dictates the inorganic matter present in the fly ash
  • Uniformity of coal dictates uniformity of constituents in ash
COAL COMBUSTION PRODUCT USES

- Traditional – One to one replacement of cement in Portland Cement Concrete ~ half of sales
- Non-Traditional – Soil Drying, Soil Stabilization, Slurry Backfill, and Full Depth Reclamation ~ half of sales
- Raw Feed for Cement Manufacturing – Bottom Ash
FLY ASH IN PORTLAND CEMENT CONCRETE

- Higher Late Strengths
- Lower permeability
- Typically more durable
- Mitigates ASR (Concrete Cancer) in PCC
- Lower Price Point than Portland Cement
- Increases Set Time – Ideal in Hot Windy Conditions
- Over half the concrete poured in US contains fly ash
- Lower price point than Portland Cement
SOIL STABILIZATION WITH CLASS C FLY ASH

- Increased bearing capacity
- Reduction of shrink/swell properties
- Longer lasting versus cement or lime
- Quicker acting – speeds up construction
FLY ASH AVAILABILITY FORECAST

• National – Estimates Provided by American Coal Ash Association (ACAA)
  • Coal usage expected to increase 3.4% annually for the next 2 decades (ACAA)
  • Fly Ash production expected to increase 2.6 percent through 2033
  • Beneficiation technologies will increase volume of fly ash available
  • Reclamation of fly ash currently in land fills will increase supply

• Local – Kansas and Missouri
  • Little impact on local fly ash supply
  • Nearman Creek Station installed a dry scrubber – Sept 2016
  • Montrose Unit #1 has been decommissioned
  • Montrose Units #2 and #3 will be decommissioned over next 5-7 years
  • Oklahoma and Nebraska will be more dramatically impacted
    • Gas Conversions or wind
Questions?

Thank You