POWER PLANT AIR QUALITY CONTROL and FLY ASH QUALITY & AVAILABILITY

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David Rylance – Kansas City Fly Ash

AWMA January 18, 2017

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What Major Pollutants are Controlled?

- Particulates (Fly Ash)
- Nitrous Oxides (NO_x)
- Mercury (Hg)
- Sulfur (SO2 and SO3 - Acid Rain)

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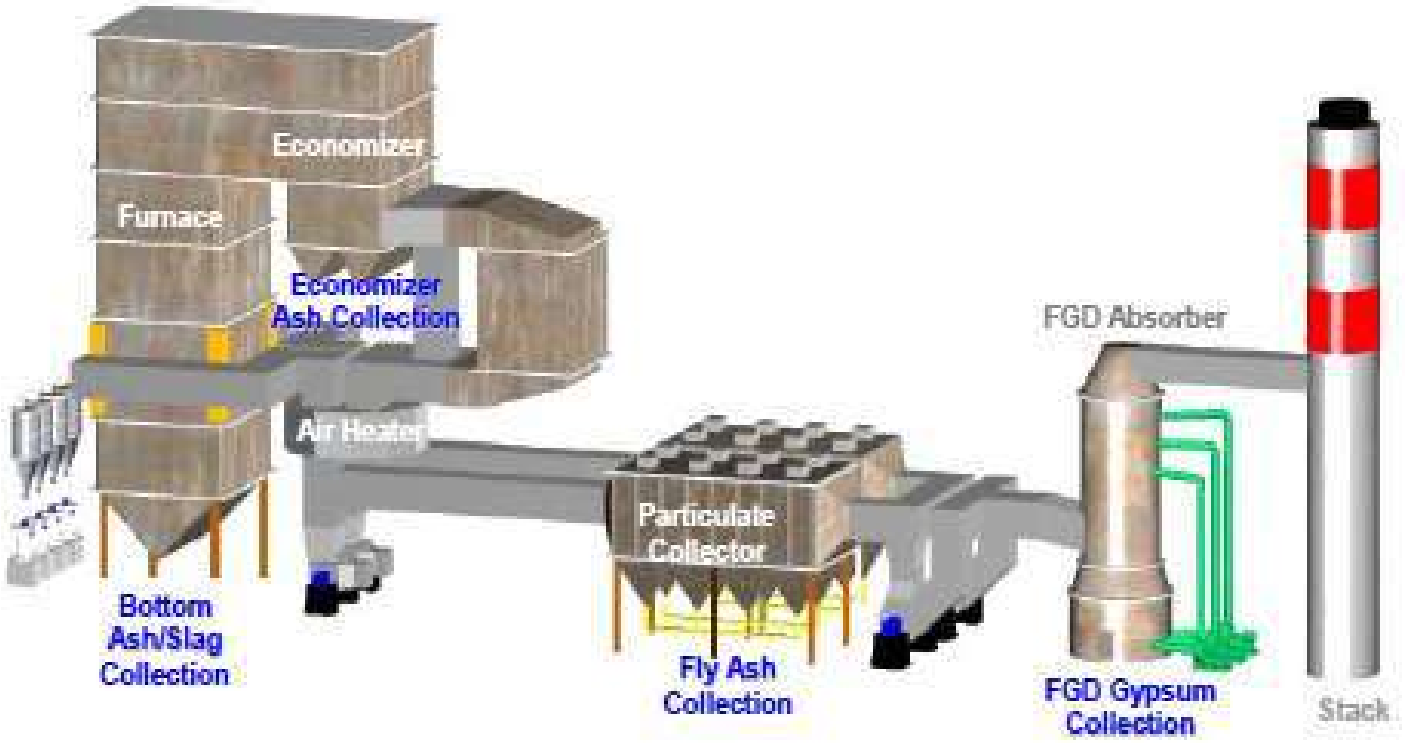
Typical Power Station Layout



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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)

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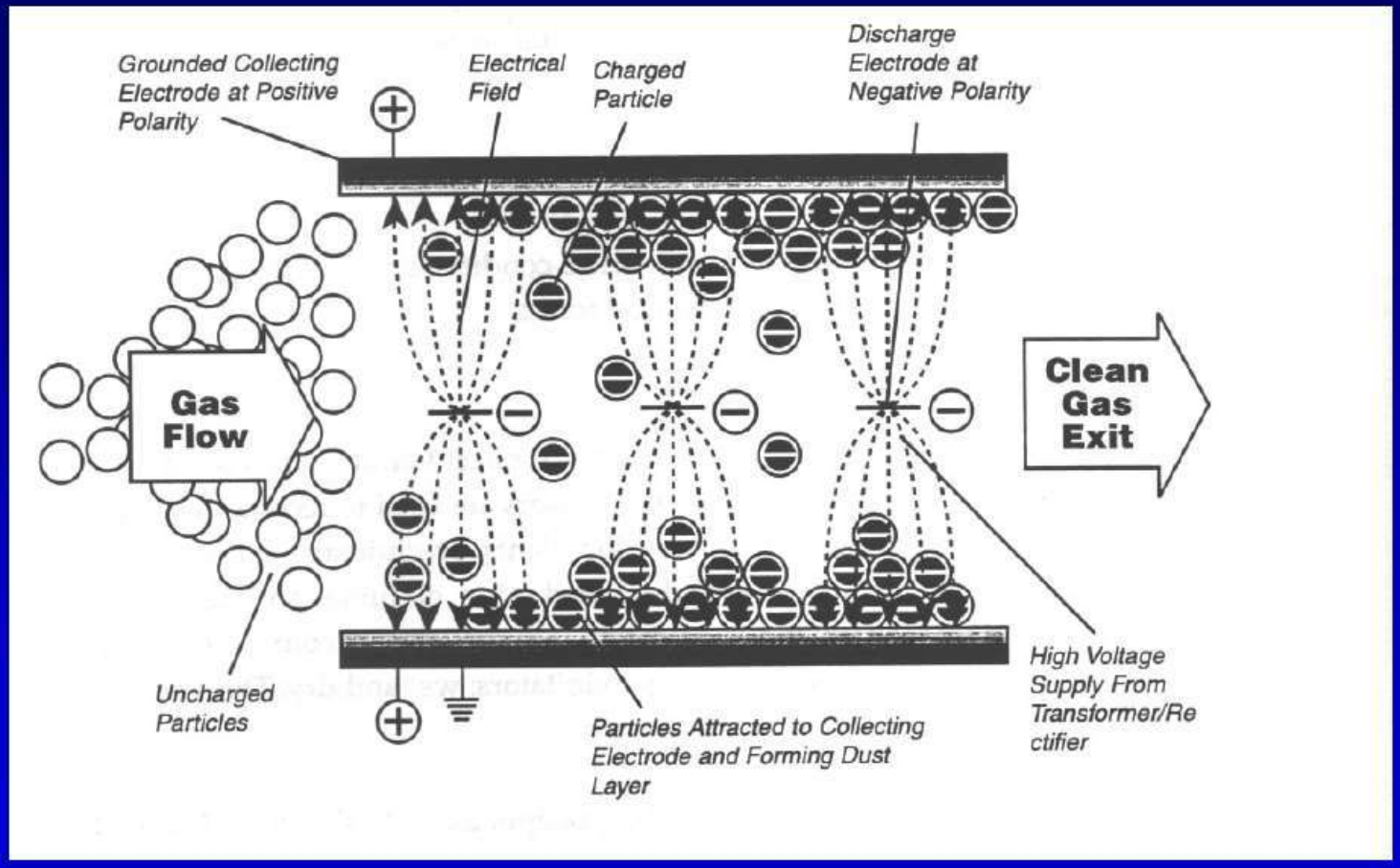
Dust Collection



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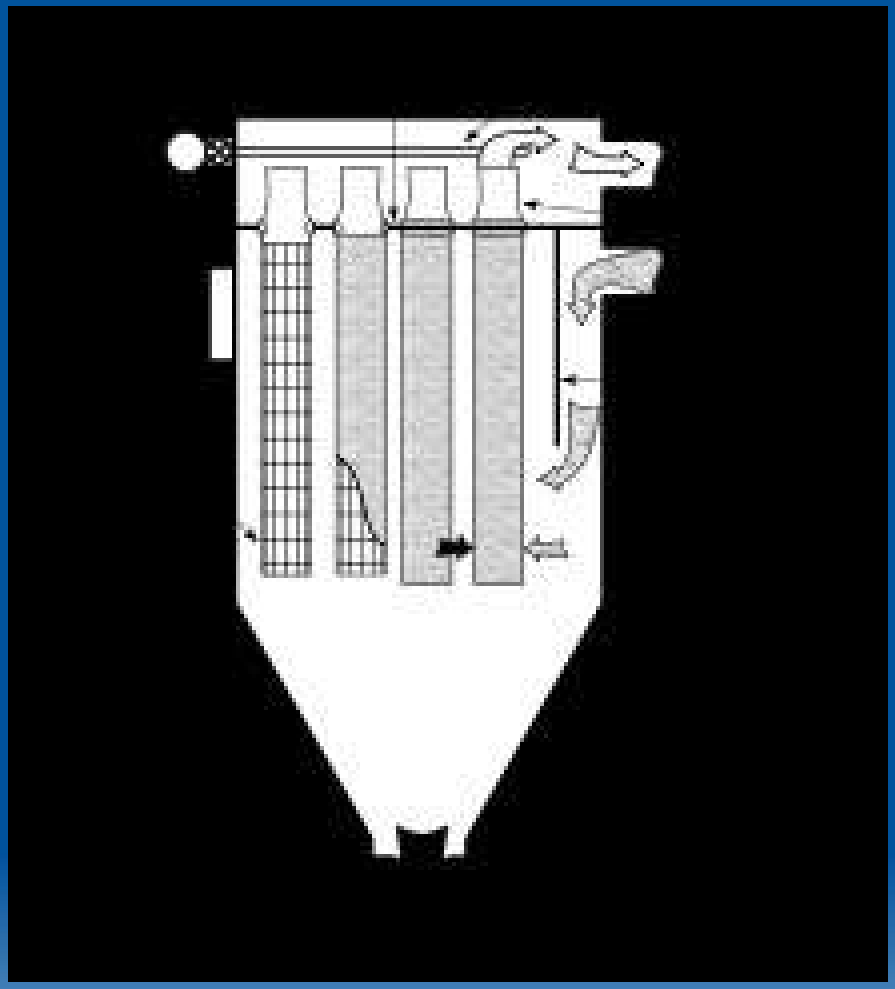

TYPICAL FABRIC FILTER (BAGHOUSE)

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CONTROL OF NITROUS OXIDES (NO_x)

ANHYDROUS AMMONIA

UREA

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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)

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TYPICAL NO_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.

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NO_x REDUCTION

- SCR technology converts flue gas NO_x to nitrogen and water through a catalytically promoted reaction with a reducing agent such as ammonia or urea.

$$\mathbf{NO_x + NH_3 \rightarrow N_2 + H_2O}$$

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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.

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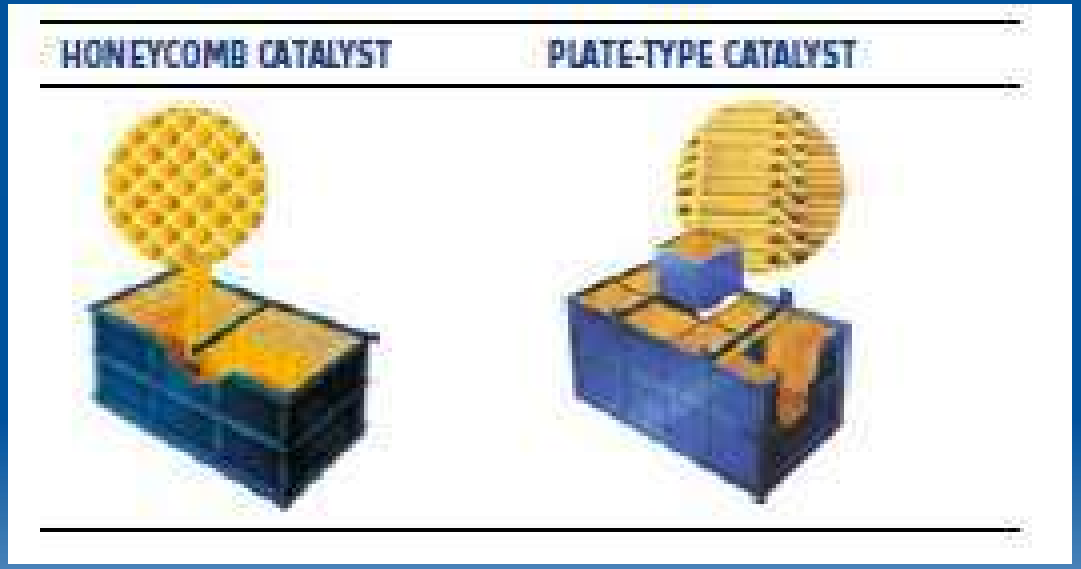
SELECTIVE CATALYTIC REDUCTION



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IATAN SCR

KCP&L plants receive all ammonia and urea shipments by truck

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EMERGENCY
SHOWER

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.

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1005
AMMONIA
MERCURY
90

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

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CONTROL OF MERCURY

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

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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

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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

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PAC SURFACE AREA: 500 m^2/gram

MAGNIFICATION OF ACTIVATED CARBON PORES

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

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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

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CONTROL OF SULFUR DIOXIDE (SO_2)

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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

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CONTROL OF SULFUR TRIOXIDE (SO_3)

- A small % of the coal sulfur may be further oxidized to SO3
- SO3 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

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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

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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

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Fly Ash
Kansas City Fly Ash

1-18-2017

Dave Rylance, P.E.

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