REINHOLD ENVIRONMENTAL Ltd.

2011 APC Round Table & Expo Presentation

July 11-12, 2011, in Cleveland, OH / Hosted by FirstEnergy

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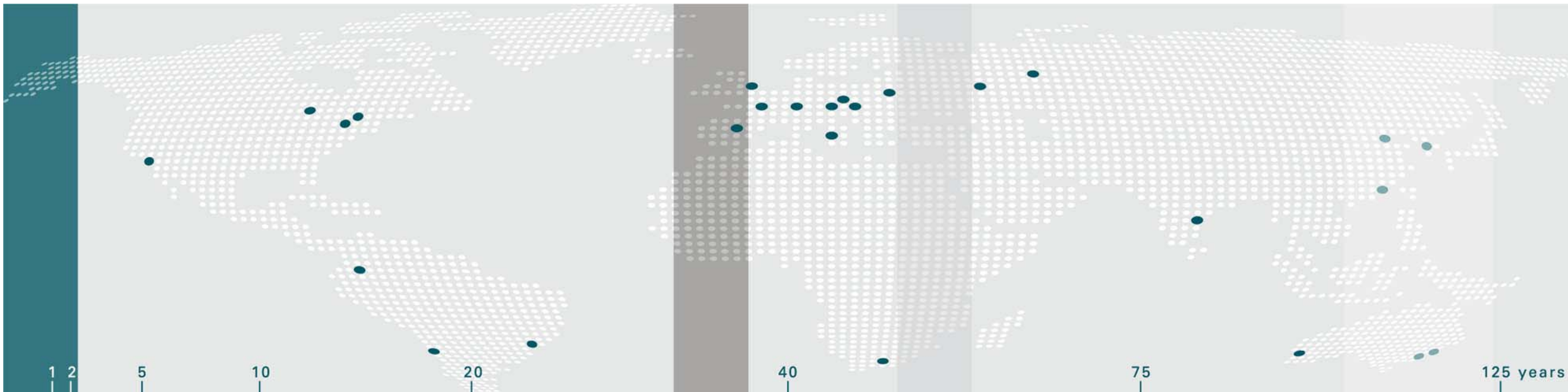
Stock Equipment

weighing feeding screening automation **environmental controls**



ESP Operations 2
July 11, 2011

Jason Horn

we make processes work

Primary Objectives of ESP Operation

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Objective #1: Charge particles in process gas stream

- Current density (mA / ft^2) is typical metric for success

- Process conditions, particulate size & chemistry, and power supply type / operation play largest role in successful charging particulate.

- *"Corona Onset Voltage*" - Electron flow (mA) across the gas path cannot occur without sufficient motive force (kV). Corona Onset Voltage is the minimum kV level at which significant mA will begin to flow and begin charging particulate.

- No charging occurs if mA is high but kV is close to or below corona onset voltage. This is typical of hardware grounds, ash grounds, high spark rates, power supply failures, and other upset conditions.

Primary Objectives of ESP Operation

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Objective #2: Collect particles from the gas stream

- *"Migration Velocity"* – speed at which particulate travel towards the collecting plate. All ESP performance improvements are based around increasing this number. Primarily affected by kV level across the gas path (not necessarily the kV feedback reading).

- Design of ESP internals, power supply type / operation, and process conditions play the primary role in successful collection of particulate.

- Most power supplies operate as current sources where more electron flow (mA) is needed to produce higher kV. Therefore if you fail objective 1, you also fail objective 2.

- Simply getting the particles to the collecting surface not complete the objective. You must hold on to the particles and only release them during cleaning cycles.

Primary Objectives of ESP Operation

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Objective #3: Cleaning and Evacuating Particles

- Thick ash layers on discharge and collecting surfaces can cause decreasing performance as power supplies reach their design limits to compensate for the voltage drop across the ash layers.

- Rappers or other cleaning methods are used to clean these surfaces so that the Charging and Collecting objectives can still be completed efficiently.

- Once the surfaces are clean, the particles still need to be evacuated from the ESP casing. Pressurized or vacuum ash removal systems are used to accomplish this.

- The cleaning / evacuation cycle for inlet fields needs to be completed at a higher frequency than the outlet fields due to the amount of ash collected.

Evaluating ESP Performance

Opacity does not necessarily correlate to efficiency or mass emission rate.

Operating data from the T/R controls or other power supply is the most useful tool to evaluate ESP performance.

Typical parameters used for evaluation:

- Secondary Current (mA)
- Secondary Voltage (kV)
- Primary Current (A)
- Primary Voltage (V)
- Sparks Rate (SPM)
- Optional – Conduction Angle or Firing Angle

For a small ESP, the overall collection efficiency is typically relatable with how the worst lane is performing. The effect is less noticeable with larger ESP's as they can typically tolerate two or three poor performing lanes.

WARNING

Avoiding known maintenance issues of large ESP's during short outages often allows the problem to snowball to a point were either short outages are insufficient to resolve all issues or the list of issues become unmanageable.

Evaluating ESP Performance

Baseline operating data for comparison or additional process data can often shed light on what is causing problems and potentially identify the source as being external to the ESP.

Take data to identify the worst performing bus sections. Look for:

- Excessive sparking
- Lower than average kV for a specific field
- Grounds or resistive (ash) grounds
- Swinging wires
- Significant variations in mA across a field and total mA per lane
- Significant variations in kV across a field

Performance issues typically begin to arise when there is a change from the norm.   This can be anything from a change in fuel to operators making adjustments in the control rooms to their preferred settings. Routine evaluation is key in resolving small issues before they turn into potential violations.

Transient ESP Conditions Startup

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Issues regardless of startup fuel

- Non working insulator heaters or purge air systems lead to damage and inconsistent field strength during startup.

- Temperature differential across the surfaces of the insulators can cause additional stress leading to cracking

- Moisture can lead to tracking on the surface of insulators causing sparking and eventually permanent damage

- Moisture in the air of the penthouse and bus duct can reduce the dielectric strength of the air and lead to sparking

- Insufficient purge air can lead to buildup inside support insulators. Both oil and ash can create paths for surface tracking.

- Cold hoppers can result in clumping ash or rat holed hoppers.

Transient ESP Conditions
Startup

Issues associated with oil fire

- Fouling (oil coating) of the collecting plates and discharge electrodes affects both voltage and in the field
- Can cause increased sparking while oil layer is being removed ash layer is inconsistent in thickness and makeup
- Layers collected during extended oil fire take days to months to completely clean
- Potential ignition of left over combustibles causing ESP damage
  - Fish mouth of ESP Plates
  - Breaking discharge electrode support frames
- Issues are more prominent in inlet fields

Transient ESP Conditions
Startup

Common Startup Practices

- Turn on hopper heaters, purge air systems & heaters, and insulator heaters at least 2 hours prior boiler light off.

- Limit power to ESP inlet fields during oil fire. This can be accomplished automatically through AVC control programs

- Inlet field rapper frequency can be increased during oil fire and initial ash loading to reduce fouling

- ALL power supplies should be turned on with air load to check for proper operation., verify removal of ground, etc.

Transient ESP Conditions
Air Heater Issues

Cold Side ESP performance is greatly effected by air heater performance.

Common issues are:

Air in leakage – affects the temperature of the gas and increases velocity though the ESP. This can also cause erratic operation depending on how continuous the issue is. Generally reduces ESP performance.

Air heater fouling / degrading basket – this reduces heat transfer and increases the air temperature to the ESP. This increases ash resistivity and typically reduces ESP performance.

Air heater rotation failure – this causes rapid increase in temperature to the ESP. This results in both mechanical misalignment and instability in the ESP as well as increasing resistivity. ESP performance degrades rapidly and damage can occur to internal components, and seals.

Proper maintenance and operation of air heater is key to stable ESP performance.

Other Effects of Air Heat on Cold Side ESP

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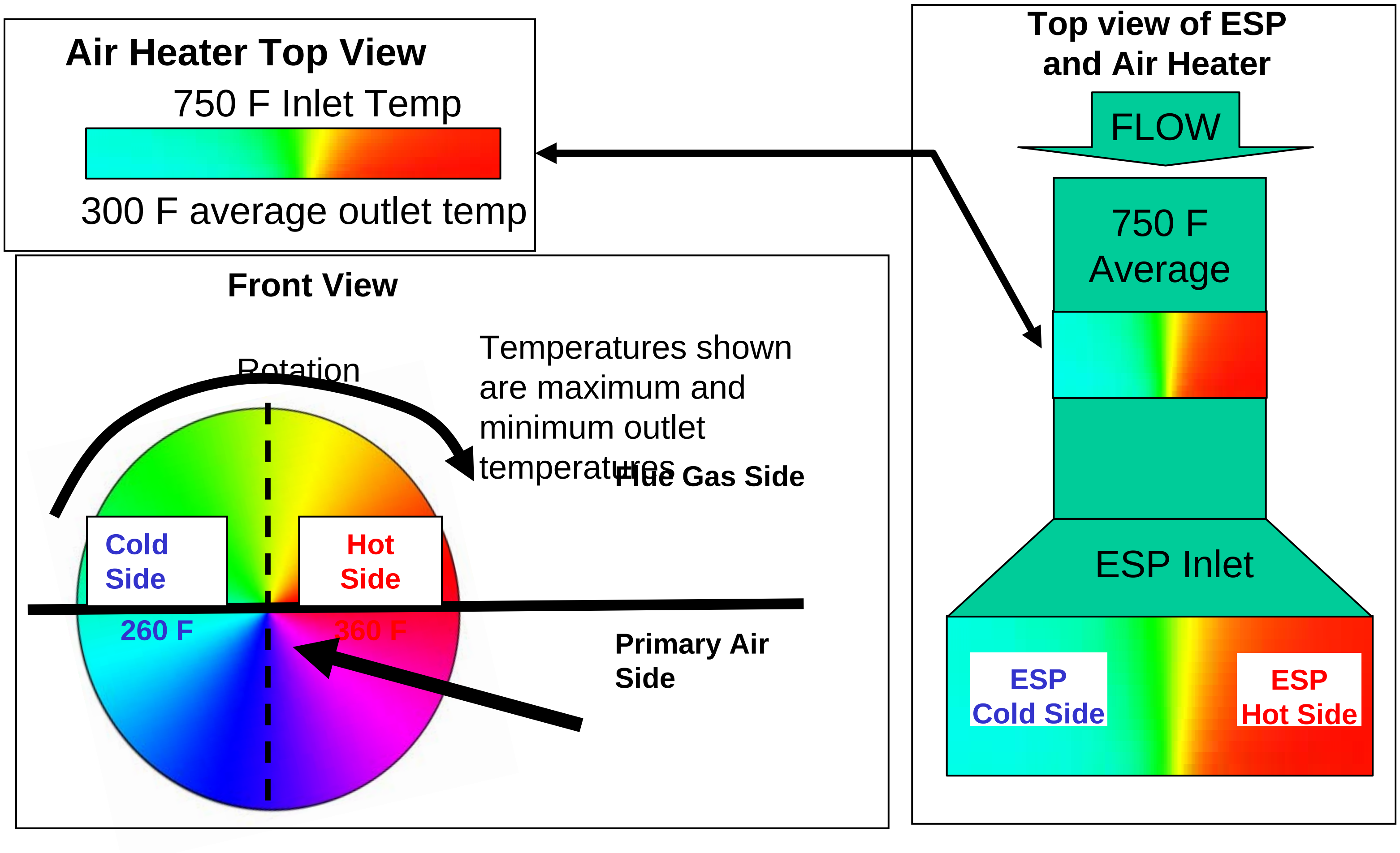
This case shows 100 F difference between hot and cold sides resulting in significant differences in ESP power levels between the two sides of the ESP



Transient ESP Conditions
Improper Flow Distribution

Flow distribution is a major contributor to routinely poor performing lanes in ESP's.

Typical areas of concern:

- Asymmetrical inlet plenum design
- Plugging of SCR catalyst layers SCR
- Clogging or damage to perforated plates
- Warped, deteriorating, or missing anti-sneak baffles
- Creation of eddy currents in ESP casing – especially hoppers
- Buildup on turning vanes
- Sorbent injection fouling
- Significant air in-leakage

The majority of flow distribution issues require hardware modifications inside the gas stream and can only be addressed during outages.

Diagnosis requires detail data analysis, inspection, and / or air flow study by physical model of CFD study.

Transient ESP Conditions
Low Resistivity

Low resistivity causes the following:

- Significant mA increase
- Decrease in kV as mA hits T/R design limit
- Puffing and re-entrainment during rapping

The effects of low resistivity ash will continue until the ash layer on the collecting surface is replaced with a slightly higher resistivity ash.

Causes for low resistivity:

- Changes in fuel
- Changes in flue gas conditioning or sorbent injection rates
- Change in gas temperature

By the time the effects of low resistivity become apparent, it will take many hour, possibly days of operation time to change the ash layer and resolve the issue.

Monitoring process temperatures and ESP data is the best way to identify low resistivity conditions early.

Transient ESP Conditions
High Resistivity

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High resistivity causes the following:

- Increase in sparking in the ESP
- Increase in kV drop across ash layer resulting in increase kV output
- Decrease in mA as kV hits T/R design limit or excessive sparking
- Normal rapping becomes ineffective – thicker ash layer
- Back Corona

The effects of high resistivity ash will continue until the ash layer on the collecting surface is replaced with a slightly lower resistivity ash.

Causes for low resistivity:

- Changes in fuel
- Changes in flue gas conditioning or sorbent injection rates
- Change in gas temperature

By the time the effects of high resistivity become apparent, it will take many hour, possibly days of operation time to change the ash layer and resolve the issue.

Monitoring process temperatures and ESP data is the best way to identify low resistivity conditions early.

Transient ESP Conditions
Shut Down

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All ESP systems should remain in operation until gas flow is stopped or only stack draft is present.

Rappers:

- Turn OFF after fuel flow stops if performing a dirty inspection
- Run at higher frequency to rap down if performing clean inspection
- Discrete rappers can typically be tested at will during shut down

Hopper heaters:

- These should remain on until access to hoppers is required
- Turning off too soon can facilitate rat holing of hoppers

Purge air systems and insulator heaters

- These should remain on for as long as ESP is powered up.

Power supplies

- These typically remain on for some time after startup to capture particulate released during boiler cleaning.

Transient ESP Conditions
Shut Down

Take ESP data prior to or during shut down to identify poor performing lanes.

Air load data taken during shut down can be compared to startup data to determine location of internal EPS issues.

Air load data can also be used to diagnose hardware vs. process issues affecting performance.

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Questions?

Thank You