Worldwide Pollution Control Association

Duke Energy Seminar

September 3 – 5, 2008

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ESPs - Problems & Solutions!

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ESP Problem and Solution

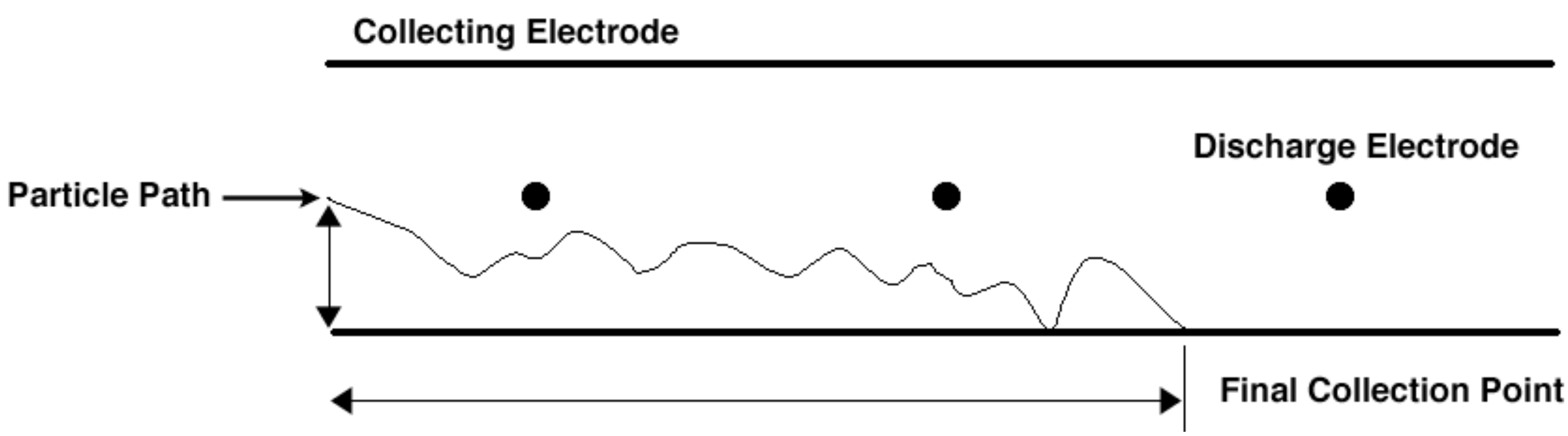
- How to define long term ESP improvements in spite of boiler and ESP operational variations
- Use **w** as a tool for continuous improvement

Shared Knowledge Opportunities

- Plant heat rates
- Plant thermal efficiency
- ESP precipitation rate
- Precipitator migration velocity (w)
- **Migration velocity** or **W** is to a precipitator as **heat rate** is to a power plant.

What is **w**

- **w** is the Effective Migration Velocity or velocity vector of an average particle toward the collecting plate



Importance of **w**

- ESP manufacturers use **w** to size precipitators but generally treated **w** as proprietary info
- ESP guarantee curves are generated using these well guarded **w** databases

- Research institutions and universities validate their innovations by demonstrating an increase in **w**

- Stack testers use **w** to validate ESP efficiency tests

Why don't utilities use **w**?

- ESP manufacturers use slightly different or confidential **w** equations
- EPA doesn't care about **w**
- Stack testers don't put **w** in the reports
- There is no direct reading **w** meter
- Good test data is required for both flow and particulate efficiency to calculate **w**

How is **w** determined

- **w** is generally calculated using the Deutsch Equation or some variation of it.

Deutsch Equation

Some people have made slight modifications to this equation, but the original version from 1922 works just fine for most precipitator improvement purposes.

$$E = 1 - e^{-(A/V)\mathbf{w}}$$

where

E = Efficiency/100

w = Effective migration velocity

A = Effective collection area

V = Actual gas volume

solving for **w**

$$\mathbf{w} = -(V/A) \cdot \ln(1 - E)$$

Determining E

- Best is to do **ESP Efficiency Tests** (this may not be practical unless there is a guarantee or an efficiency problem that needs to be diagnosed)
- Next best is to use **EPA PS11** to calibrate opacity monitors to predict mass. Combine this with real time boiler and precipitator computer models to estimate **w** (calibration may be needed for each coal or blend)
- Lastly, if ESP is the last PC device, use the **Stack Test** for the outlet loading and estimate the inlet particulate loading using a calibrated computer model

Determining A and V

- Plate area in service seldom changes except due to corrosion. Deduct for the % discharge electrodes out of service to get Effective Collection Area (A).

- Gas Flow Volume (V), can be from an outlet pitot traverse or a stack flow monitor corrected to ESP outlet conditions. May need to calibrate these data with a 3D pitot traverse of the ESP outlet duct.

Baseline and % Improvement

- A previous efficiency test can be used to establish a baseline, but only if all runs give a constant **w**

- Concentrating on the % improvement in **w** can get a focus on improving precipitators

w will accurately account for all ESP improvements such as:

- Rapping
- Resistivity
- Conditioning
- Hopper Sweeping
- Flow Distribution, etc
- Gas Sneaking Around Baffles
- And a lot more

What Non-ESP Parameters Impact **w**

These are in three categories:

1. Things that can be modified or controlled to **effect the ESP** without significantly impacting other critical functions. These include SO_2 to SO_3 conversion, air heater outlet temperature gradient and temperature mixing. These are fair game for **precipitator operator adoption**.

2. Things that impact the precipitator performance while slightly benefiting something else. These will need **special analysis** to determine the best approach.

3. Everything else. These include LOI, carbon injection, fuel blending or switching that substantially changes fine particle concentration or particle resistivity. These will need **w correction factors**.

Handling Potential Problems

- Each coal **may** need a separate **w** or a correction factor to adjust **w** for changes in particle size distribution and fly ash resistivity.
- Blended coal **may** also need correction factors.
- Changes in the SO_2 to SO_3 conversion factor ahead of a cold precipitator can change **w** so consider this to be free precipitator conditioning that impacts **w** even though it occurs in the boiler or SCR.
- Carbon injection and big changes in LOI will need correction factors.

Summary

- Measuring the improvement in **w** is a good way to quantify improvements to an ESP
- Opacity alone can be misleading when trying to judge precipitator improvements because of the short term operational ups and downs of the boiler and the ESP
- **w** can be the long term trend line to demonstrate continuous improvement

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- Conversation with Dr. Harry J. White, September 8, 1982

Online Deutsch Equation Calculator

www.ajdesigner.com/phpprecipitator/electrostatic_precipitator_collection_electrodes_area.php

Reference wish list

- www.ESP-Hints.com
- www.ESP-Expert-Exchange.com
- www.ESP-Wiki.com