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ESPs - Problems & Solutions!

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Outline

- ESP Problem and Solution
- How to define ESP improvement?
- **w** as a CI tool

Shared Knowledge?

- Plant heat rates
- Plant thermal efficiency
- ESP precipitation rate
- Precipitator migration velocity (w)
- **Migration velocity** is to precipitators as **heat rate** is to power plants.

Importance of **w**

- ESP manufacturers use **w** to size ESP.
- Generally treated as proprietary info.
- ESP guarantee curves are generated using their **w** and a safety factor.
- Research institutions and universities validate innovations by demonstrating increase in **w**.

- Maybe Utilities can validate their ESP innovations or improvements in the same way.

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 needed for flow and particulate efficiency to calculate **w**

What is w

- **w** is the Effective Migration Velocity (EMV) of an average particle toward the collecting plate.
- **w** is calculated using the Deutsch Equation

Deutsch Equation

w is a variable in the Deutsch Equation. Some people have made slight modification to this equation, but the classical version from 1922 works just fine for most applications.

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

E = Efficiency/100

w = Effective Migration Velocity

A = Effective collection area

V = Actual gas volume

Solving for w

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

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 emission and estimate the inlet particulate loading using a calibrated computer model.

Determining A and V

- Plate area (A) in service seldom changes except for corrosion. Deduct for the % of electrical fields out of service to get 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 with a 3D pitot traverse of the ESP outlet duct.

Baseline and % Improvement

- A previous efficiency test can be used to establish a baseline only if all runs give a constant **w**.
- Focus on % improvement in **w** before entering a global competition for best **w**.

Yes, **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 improve the ESP without negatively impacting other critical functions. These include SO2 to SO3 conversion, air heater outlet temperature gradient and temperature mixing. These are fair game for precipitator adoption.
2. Things that negatively impact the precipitator performance while slightly benefiting something else. These are negotiable benefits.
3. Everything else. These include LOI, carbon injection, rapid fuel switching that substantially changes fine particle concentration or particle resistivity. These need special factors.

Handling Potential Problems

- Each coal **may** need a separate **w** or a correction factor to adjust **w** for particle size distribution and chemistry.
- Blended coal **may** also need correction factors.
- Changes in the SO2 to SO3 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 changes in LOI will need a correction factor.

Summary

- Measuring the improvement in **w** is a good way to quantify improvements to an ESP.
- Opacity alone can be misleading when there is a change in gas flow volume or ESP fields in service.

Reference Wish List

- H. J. WHITE, Industrial Electrostatic Precipitation, Addison Wesley (1962)
- Reference wish list
- EPS-Hints.com
- ESP-Expert-Exchange.com
- ESP-Wiki.com