REINHOLD ENVIRONMENTAL ®

2026 Reinhold/PCUG Round Table Presentation

Hosted by TVA, Southern Company and Vistra

in the Sonesta Nashville Airport Hotel, Nashville, TN

on June 22-23, 2026

nwl

to the next power

Electrostatic Precipitator Performance in Aging Systems:
Recovering Performance Under Modern Constraints

Reinhold Roundtable 2026

Paul Leanza – Director of ESP Field Services

What Changed?

THEN (1980s–1990s)

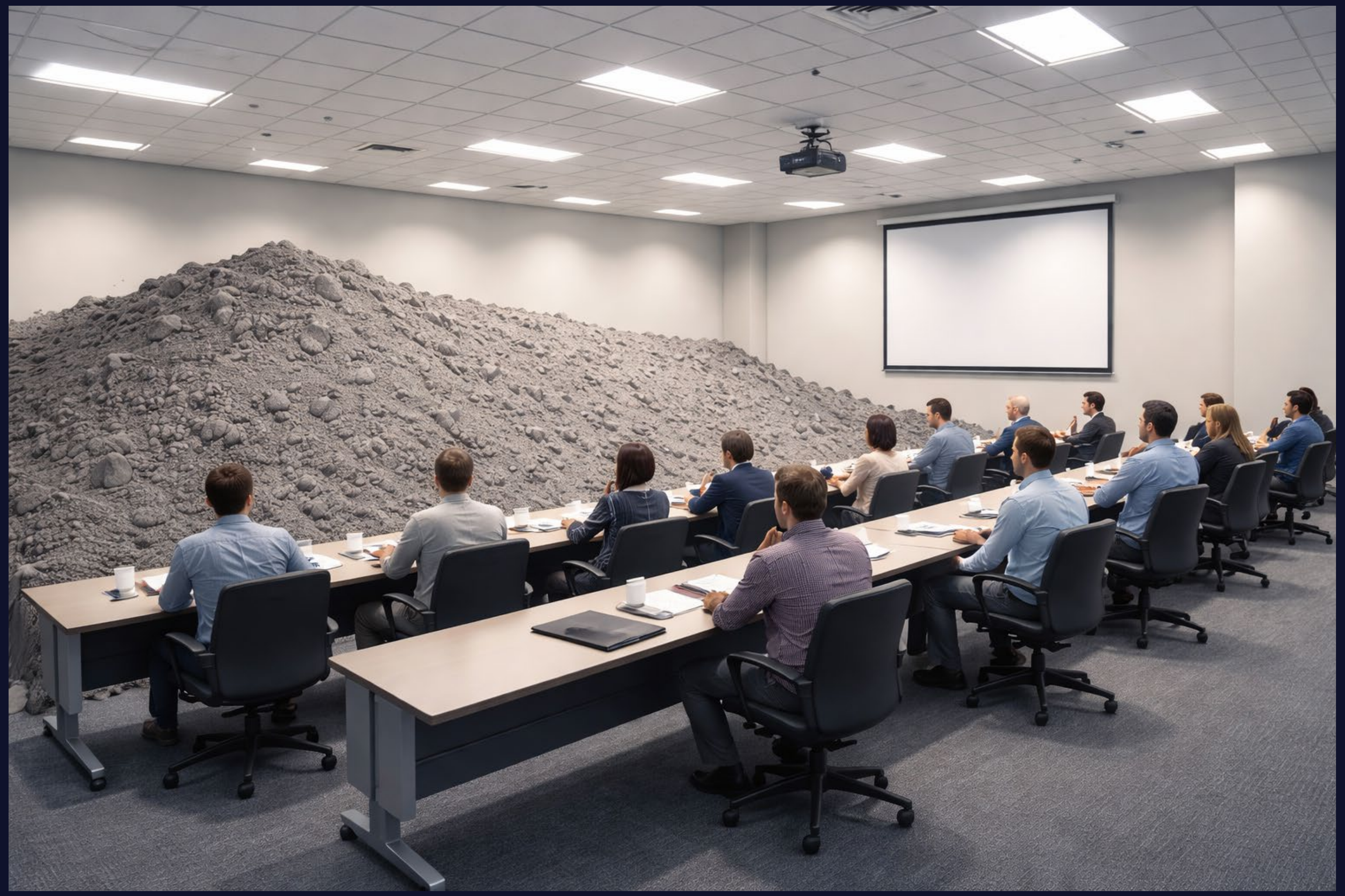
- Dedicated ESP specialists
- Stable fuel and base load operation
- Large operating margin
- Multi-week outages
- Deep institutional knowledge

TODAY

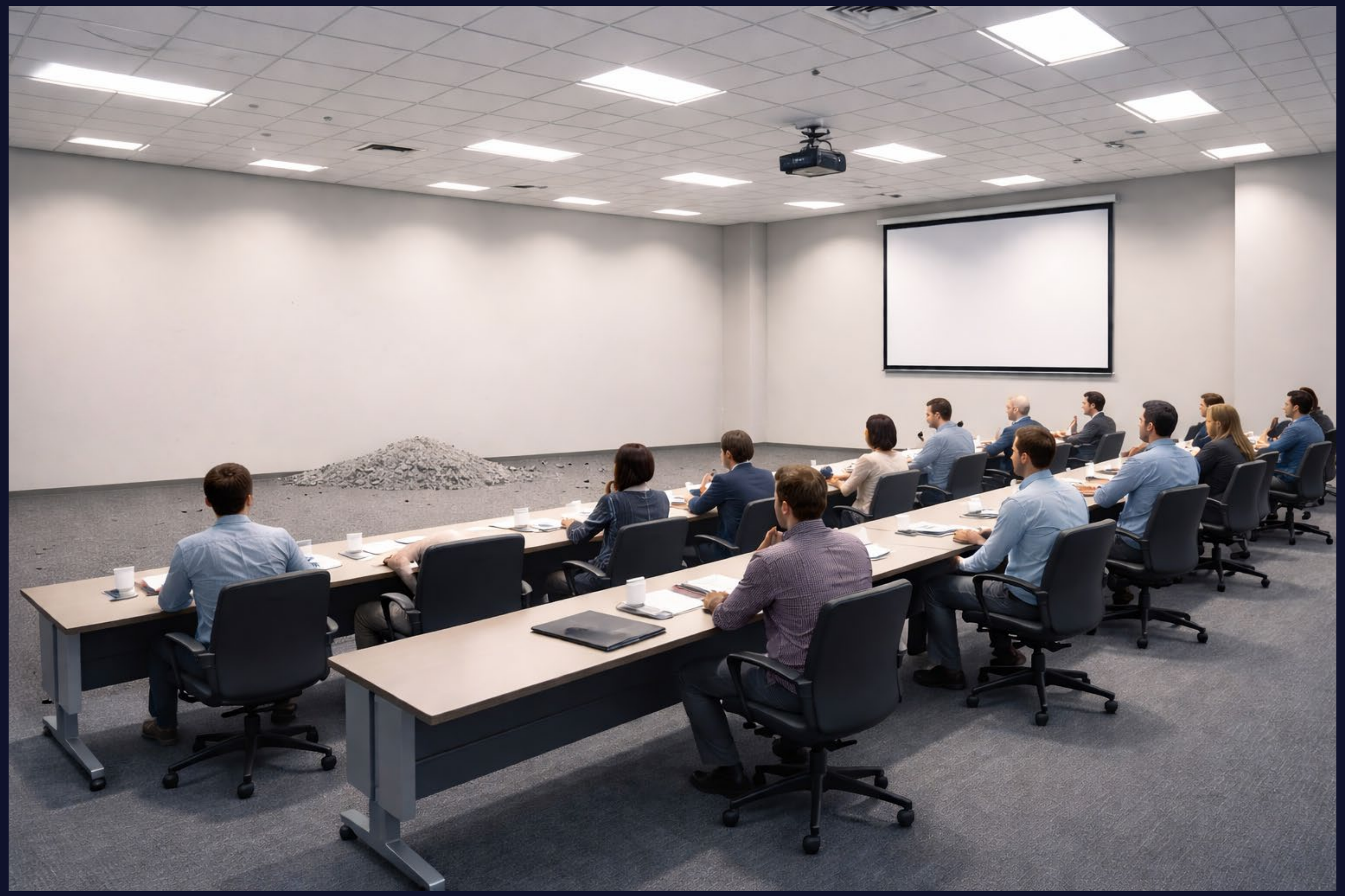
- Lean staffing
- Fewer ESP specialists
- Fuel variability and cycling
- Short outages
- Deferred maintenance
- Single-digit opacity expectations

The ESP did not fundamentally change. The operating environment did

Small Changes Create Big Consequences



ESP



50,000 lb/hr
Fly Ash to ESP

100 lb/hr
Leaving Stack
(10% Opacity)

When You're Already Removing 99.9%, There Is Little Room For Error

Deutsch-Anderson Equation

$$\eta = 1 - e^{\left\{-\left(\frac{Aw}{Q}\right)\right\}}$$

η = Collection Efficiency
w = Particle Migration Velocity
A = Collecting Plate Area
Q = Gas Flow Rate

Why Voltage (KV) Matters

Particle-Migration Velocity

$$w = \frac{\left(d_p E_o E_p\right)}{4\pi\mu}$$

$d_p =$ *diameter of the particle*, μm
$E_o =$ *strength of field in which particles are charged (represented by peak voltage)*, V/ft
$E_p =$ *strength of field in which particles are collected (normally the field close to the collecting plates)*, V/ft
$\mu =$ *gas viscosity*, $Pa \bullet s$ (cp)
$\pi = 3.14$

Voltage (KV) is King

Why Voltage Drives ESP Efficiency

Not In Your Control

- Collecting Area
- Gas Flow
- Particle Size
- Particle Resistivity
- Gas Viscosity

Voltage ↑

Migration Velocity ↑↑

Migration velocity increases approximately with the square of voltage.

Collection Efficiency ↑↑

In Your Control

VOLTAGE

Small Voltage Gains Create Large Efficiency Gains

Common Causes of Lost Voltage

Why We Lose Voltage

Electrical

- Failed field
- Excessive sparking
- Controller limits
- TR set limitations

Mechanical

- Misalignment
- Broken electrodes
- Dust buildup
- Insulator contamination

Process

- High resistivity ash
- Fuel changes
- Air inleakage
- Gas distribution problems

Low Effective Voltage
Reduced ESP Performance

Low Effective Voltage Is Often a Symptom, Not the Root Cause

What Really Drives ESP Performance?

ESP Performance

~50% Effective Voltage

~50% Reentrainment

Gas Distribution Influences Both

Voltage and Reentrainment Drive ESP Performance

to the next power

Why ESPs Must Be Viewed as a System

Don't Ask "Which Field Is Bad?" Ask "What Is The ESP Doing?"

Gas Flow

5-A4 315 VAC 43 AAC 42 KVDC 280 mADC 30 SPM 80 Deg Spark Limit	**5-B4** 312 VAC 64 AAC 43 KVDC 420 mADC 30 SPM 110 Deg Spark Limit	**5-C4** 361 VAC 101 AAC 48 KVDC 650 mADC 10 SPM 124 Deg Seconday Amp/Spark Lin	**5-D4** 270 VAC 42 AAC 32 KVDC 275 mADC 30 SPM 67 Deg Spark Limit	**5-E4** 361 VAC 107 AAC 48 KVDC 700 mADC 0 SPM 106 Deg Seconday Amp Limit
5-A3 196 VAC 12 AAC 26 KVDC 90 mADC 60 SPM 34 Deg Spark Limt	**5-B3** 270 VAC 44 AAC 32 KVDC 308 mADC 30 SPM 67 Deg Spark Limit	**5-C3** 324 VAC 64 AAC 44 KVDC 420 mADC 30 SPM 110 Deg Spark Limit	**5-D3** 142 VAC 13 AAC 19 KVDC 96 mADC 30 SPM 101 Deg Spark Limit	**5-E3** 324 VAC 1 AAC 44 KVDC 505 mADC 30 SPM 110 Deg Spark Limit
5-A2 315 VAC 43 AAC 42 KVDC 280 mADC 30 SPM 80 Deg Spark Limit	**5-B2** 315 VAC 43 AAC 42 KVDC 280 mADC 30 SPM 76 Deg Spark Limit	**5-C2** 331 VAC 79 AAC 44 KVDC 520 mADC 30 SPM 106 Deg Spark Limit	**5-D2** 156 VAC 14 AAC 21 KVDC 98 mADC 30 SPM 106 Deg Spark Limit	**5-E2** 361 VAC 107 AAC 48 KVDC 700 mADC 0 SPM 106 Deg Seconday Amp Limit
5-A1 263 VAC 26 AAC 35 KVDC 170 mADC 60 SPM 56 Deg Spark Limt	**5-B1** 312 VAC 64 AAC 43 KVDC 420 mADC 30 SPM 110 Deg Spark Limit	**5-C1** 361 VAC 104 AAC 48 KVDC 680 mADC 5 SPM 124 Deg Seconday Amp/Spark Lin	**5-D1** 361 VAC 107 AAC 48 KVDC 700 mADC 0 SPM 106 Deg Seconday Amp Limit	**5-E1** 361 VAC 107 AAC 48 KVDC 700 mADC 0 SPM 106 Deg Seconday Amp Limit

1. Identify the Weakest Gas Path
- Multiple weak fields
- Performance bottleneck

2. Find the Critical Constraints
5-A3 and 5-D3

3. Verify the Strongest Gas Path
- Performing as expected

Stop Looking at Fields. Start Looking at Gas Paths.

Where ESP Performance Is Lost

⚡ Electrical Performance

Common Indicators

- Low operating voltage
- Excessive sparking
- Out-of-service fields
- Controller limitations

What Happens

- Reduced charging
- Lower migration velocity

🌬 Gas Distribution

Common Indicators

- High velocity lanes
- Maldistribution
- Air inleakage
- Uneven residence time

What Happens

- Some gas receives insufficient treatment

🔄 Reentrainment

Common Indicators

- Aggressive rapping
- Hopper buildup
- Poor dust evacuation
- Dust becoming airborne again

What Happens

- Previously collected material re-enters gas stream

Gas Distribution Can Influence Both Electrical Performance and Reentrainment

Most ESP Performance Problems Can Be Traced to One of These Three Areas

A Structured Approach to ESP Performance Recovery

Many Findings

Evaluate Impact

Identify Constraint

Select Recovery Strategy

Tier 1
Assessment & Understanding

Tier 2
Optimization & Repairs

Tier 3
Rehabilitation & Modernization

Understand First. Invest Second.

Tier 1: Assessment & Understanding

Inputs

- ⚡ Electrical Data
- 🔧 Mechanical Inspections
- 📈 Operating History

Tier 1 Assessment

Deliverables

- Identify Constraints
- Prioritize Actions
- Develop Recovery Strategy

Tier 1 Identifies the Constraints Limiting Performance

Tier 2: Optimization & Targeted Repairs

⚡ Electrical

Examples

- Return out-of-service fields
- Optimize controller settings
- Calibrate controllers
- Repair TR set and AVC issues
- Restore operating voltage

🌬 Gas Distribution

Examples

- Seal air inleakage
- Restore perforated plates and turning vanes
- Correct flow imbalances
- Perform gas flow modeling

🔧 Mechanical

Examples

- Repair rapper train
- Correct hopper evacuation issues
- Replace broken components
- Restore alignment

Tier 1
Assessment

→

Tier 2
Optimization & Recovery

Most ESP Performance Can Be Recovered Without Major Capital Investment

Tier 3: Rehabilitation & Modernization

Applied when aging infrastructure limits long-term performance and reliability

Structural

Examples
- Replace collecting plates
- Replace discharge electrodes
- Rebuild rapper systems
- Full Rebuild

Electrical

Examples
- Replace TR sets
- Upgrade controllers
- Upgrade to SMPS
- Improve electrical reliability

Modernization

Examples
- Flow distribution upgrades
- Sectionalization improvements
- Capacity enhancements
- Life extension projects

Tier 1
Assessment

Tier 2
Optimization & Recovery

Tier 3 Rehabilitation &
Modernization

Tier 3 Restores Reliability and Extends Asset Life

Start with Tier 1

Tier 1
Assessment & Understanding

Use When:
- Performance issues are not fully understood
- Root cause is unclear
- Multiple potential constraints exist
- Baseline condition is unknown

Tier 2
Optimization & Recovery

Use When:
- Constraints have been identified
- Equipment is fundamentally sound
- Performance can be restored through repairs and optimization
- Major capital investment is not justified

Tier 3
Rehabilitation & Modernization

Use When:
- Equipment is approaching end of life
- Repeated failures occur
- Maintenance costs continue to increase
- Optimization alone is no longer sufficient

Unknown Problem = Tier 1 → Known Constraint = Tier 2 → End-of-Life = Tier 3

Understand, Prioritize and Invest

Key Takeaways

- Voltage is the most powerful performance lever we control
- Evaluate gas paths, not individual fields
- Most performance losses originate from electrical, gas distribution, or reentrainment constraints
- Apply the right Tier to the actual constraint

Understand First. Invest Second.

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