REINHOLD ENVIRONMENTAL Ltd.

2018 APC & Wastewater Round Table & Expo Presentation

July 23 & 24, 2018 in Lexington, KY / Hosted by East Kentucky Power Coop

Southern Company

Indirect Troubleshooting Techniques

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7/24/18

Troubleshooting Types

<u>Direct</u>
Indications that are real-time or unequivocal

<u>Indirect</u>
Indications that are abstract or conditional

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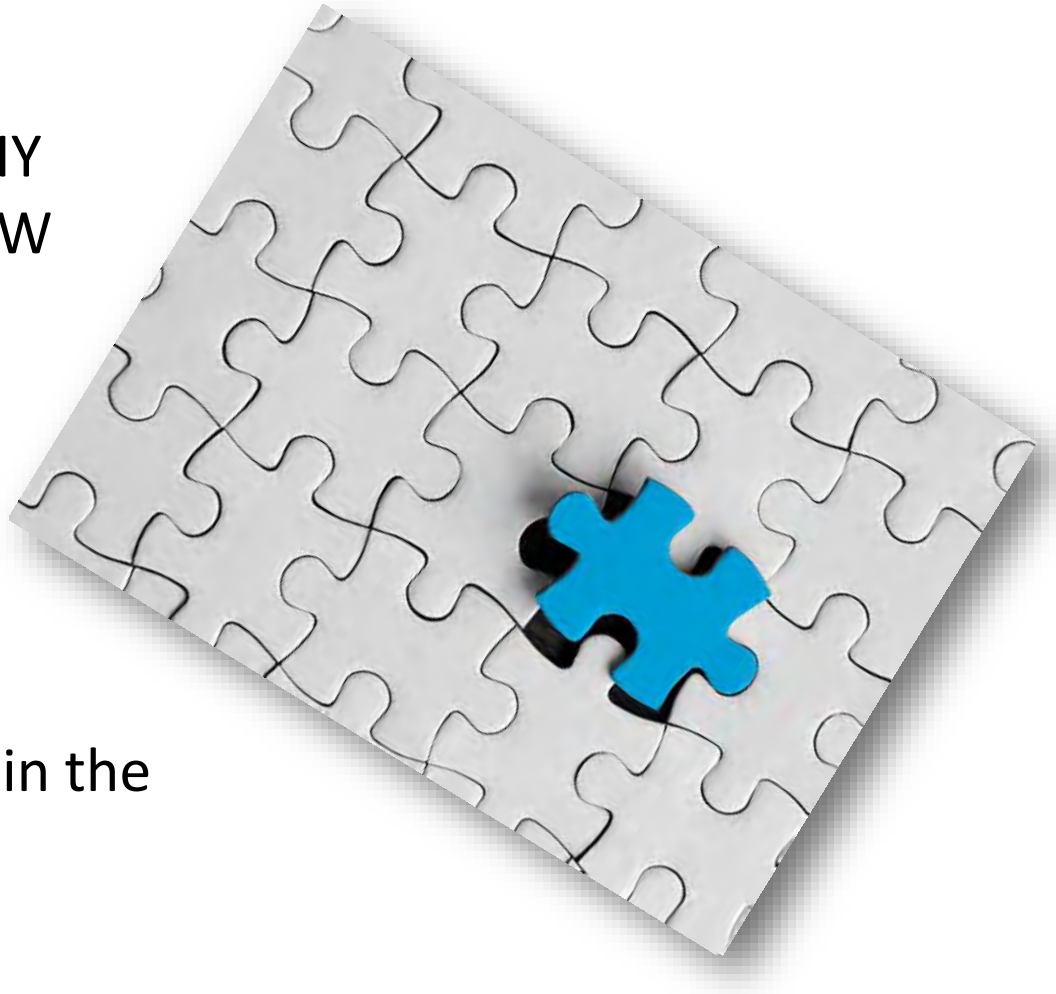
Importance of Knowing Both

Direct Indications

- Don’t always tell you WHY
- Don’t always tell you HOW
- Aren't always AVAILABLE

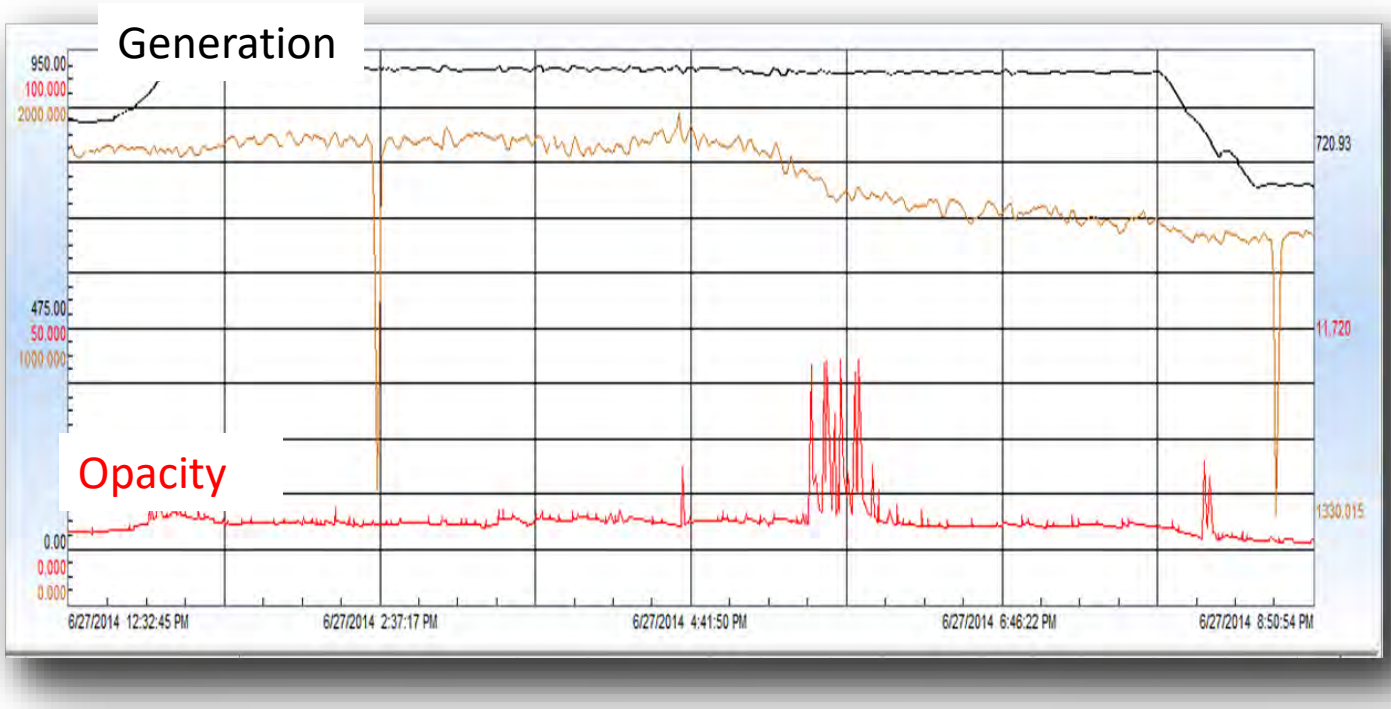


To solve a puzzle, more information may be needed in the form of Indirect Indications

Troubleshooting Types

Direct

- Opacity Measurements



Important as a general indication of the outlet emissions

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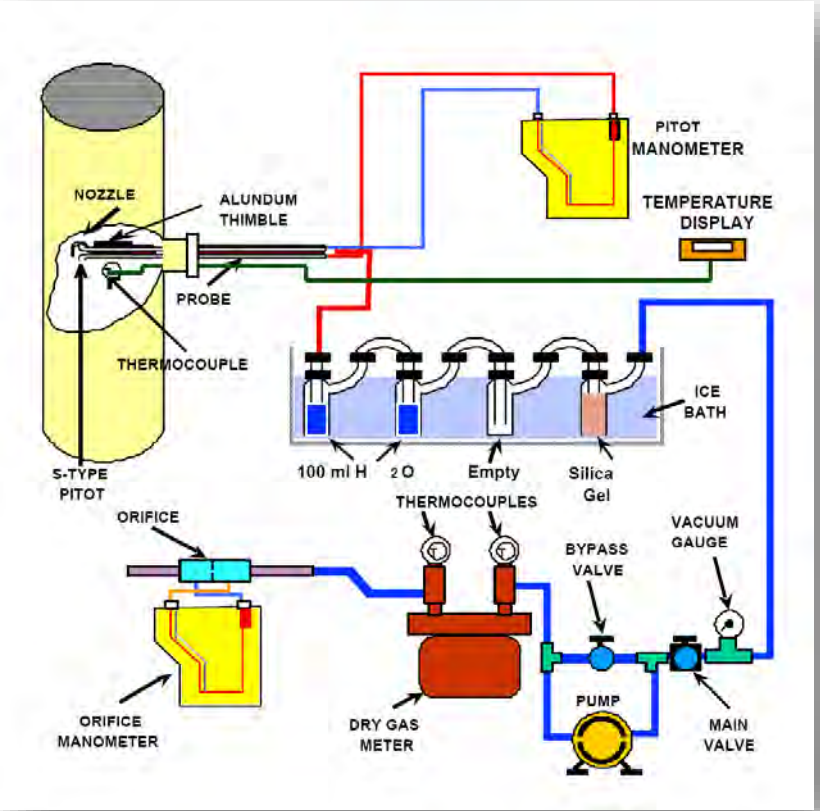
Troubleshooting Types

Direct

- Opacity Measurements
- Source Testing



Important as a snapshot of outlet mass emissions

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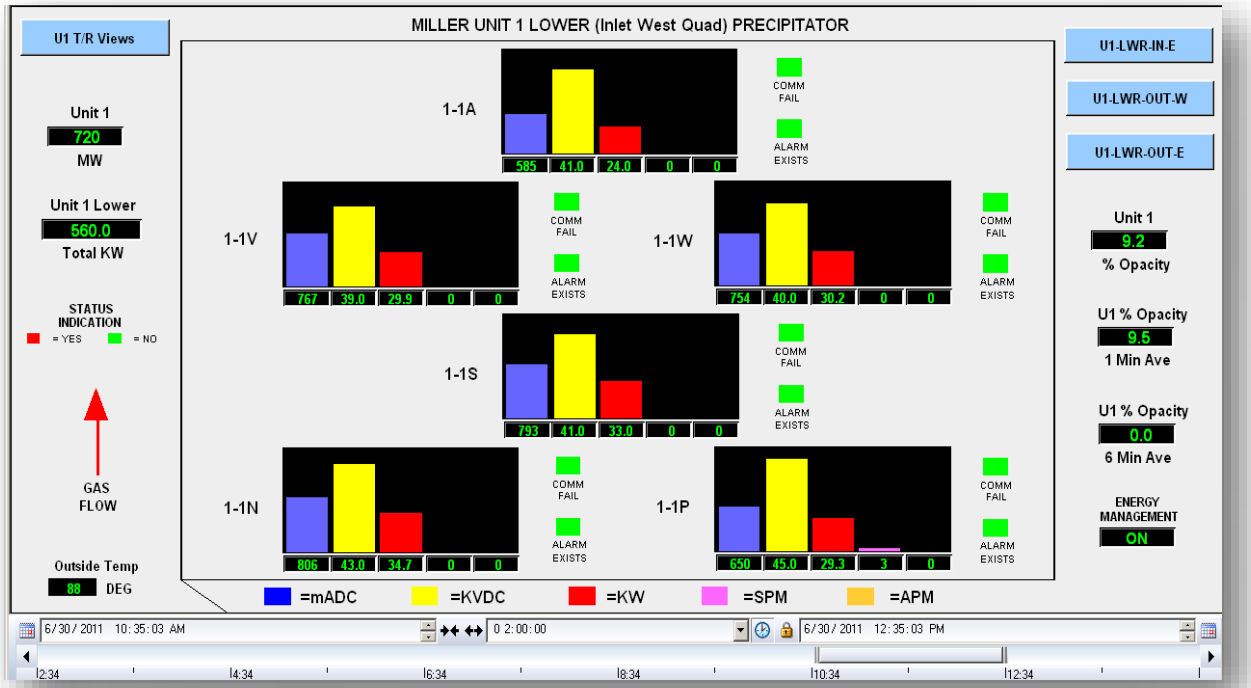
Troubleshooting Types

Direct

- Opacity Measurements
- Source Testing
- Electrical Readings



Important as an indication of the distribution of ESP power

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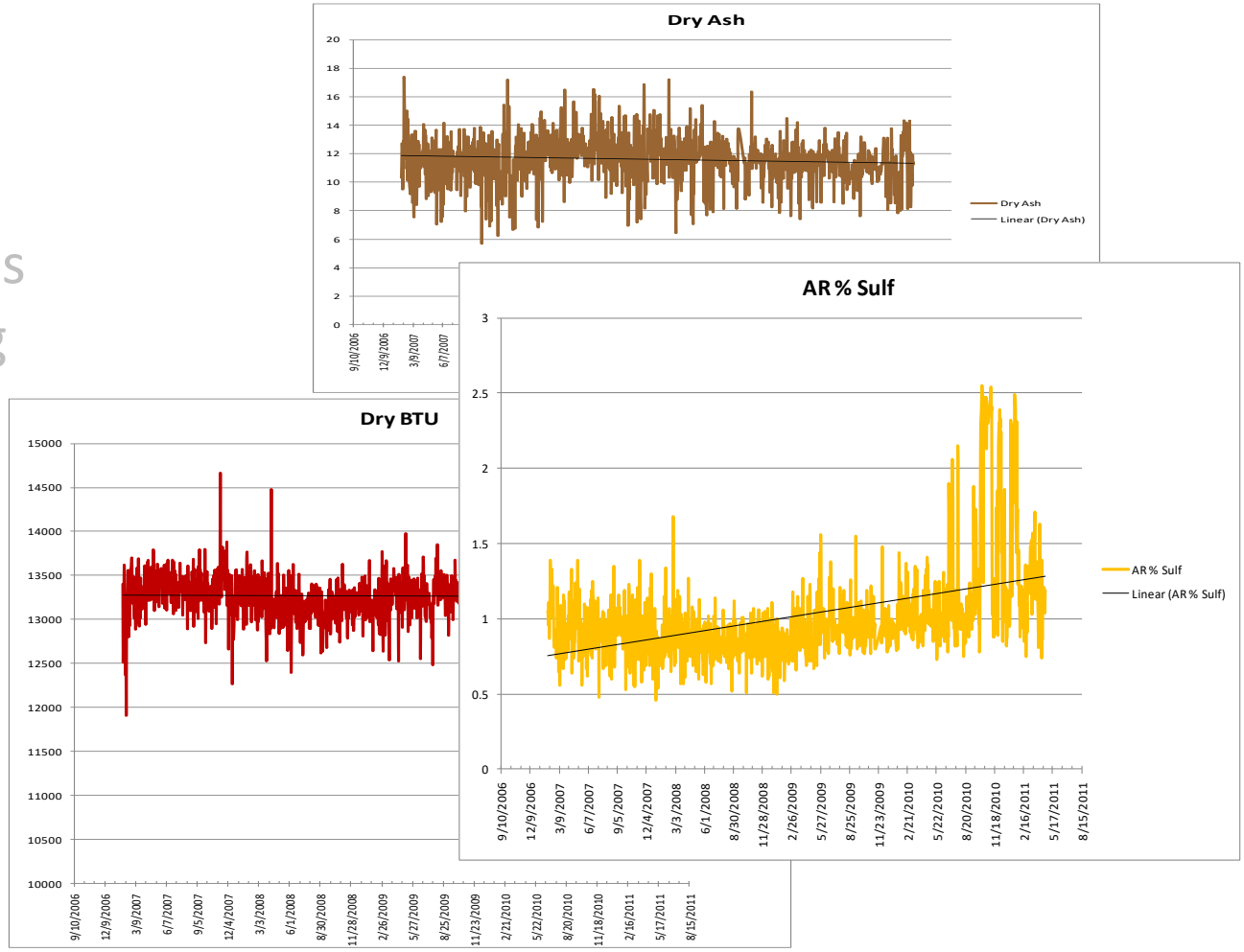
Troubleshooting Types

Direct

- Opacity Measurements
- Source Testing
- Electrical Readings
- Fuel Analysis



Important as a qualifier to opacity and power

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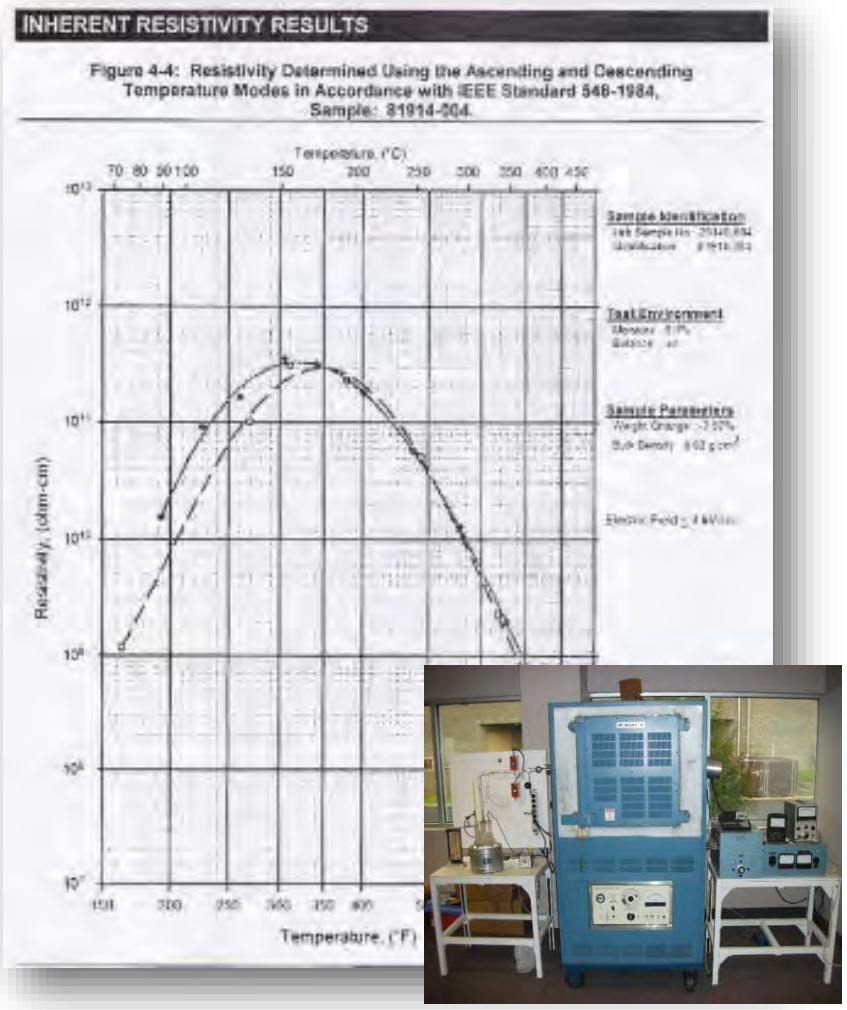
Troubleshooting Types

Direct

- Opacity Measurements
- Source Testing
- Electrical Readings
- Fuel Analysis
- Resistivity Analysis
  - Bulk or In-situ



Important as another qualifier to opacity and power

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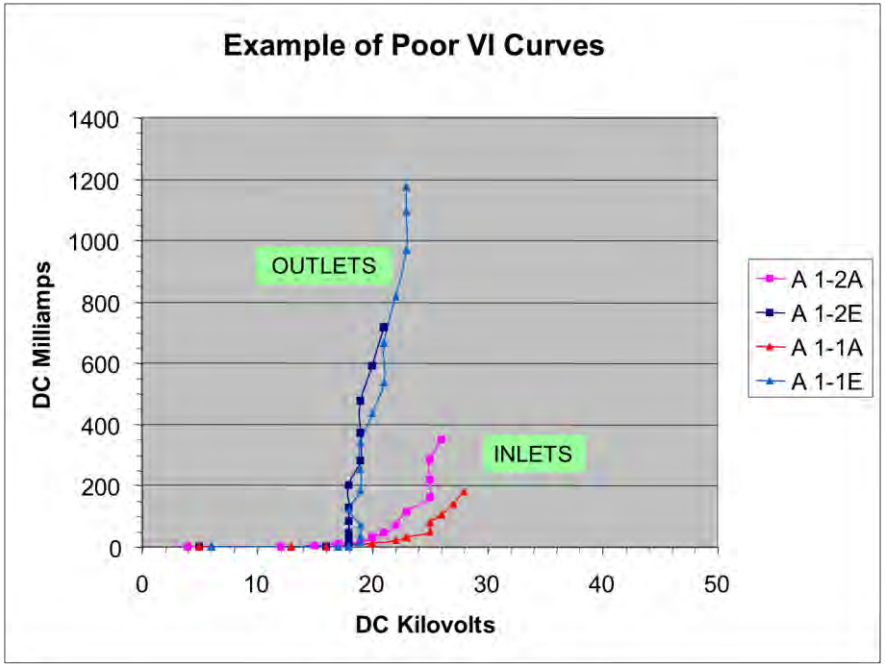
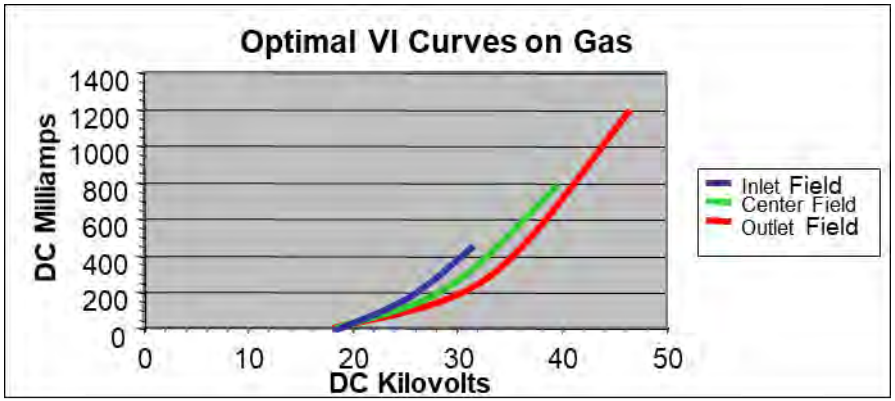
Troubleshooting Types

Indirect

- V/I Relationships





Important as an indication of corona onset, inlet vs. outlet, curve slope, and function

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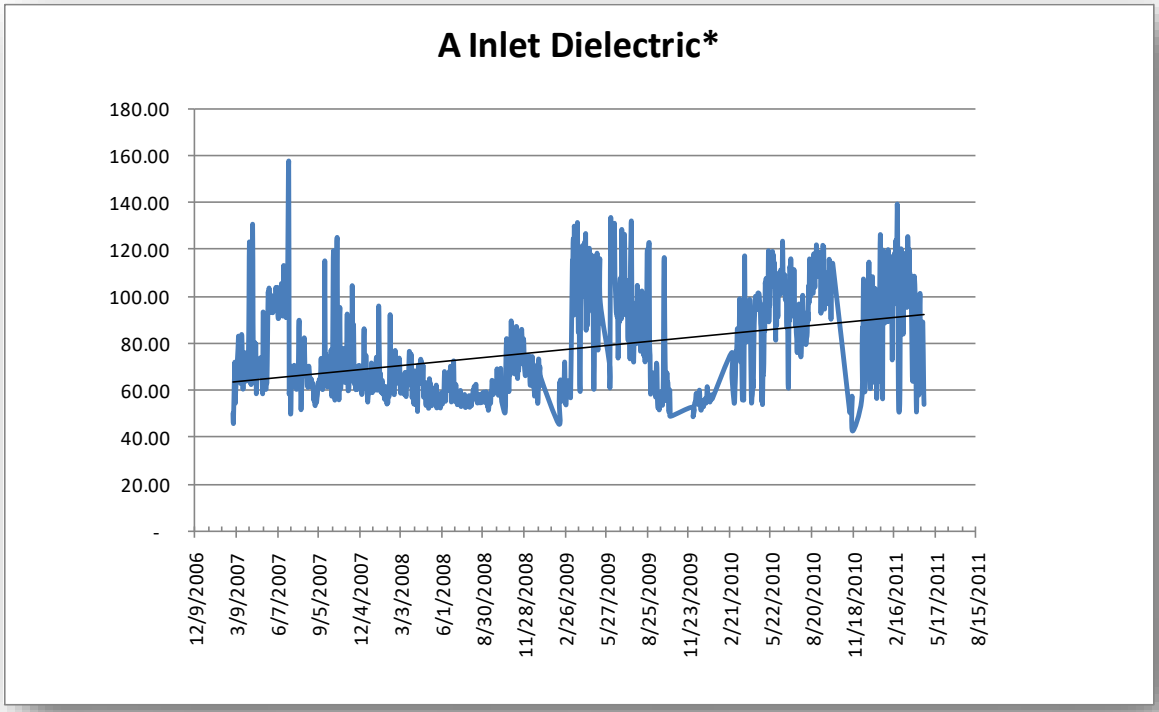
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending



*Dielectric (K ohm = (Kv/mA)x10^6)

Important as an indication of changes in bulk resistivity

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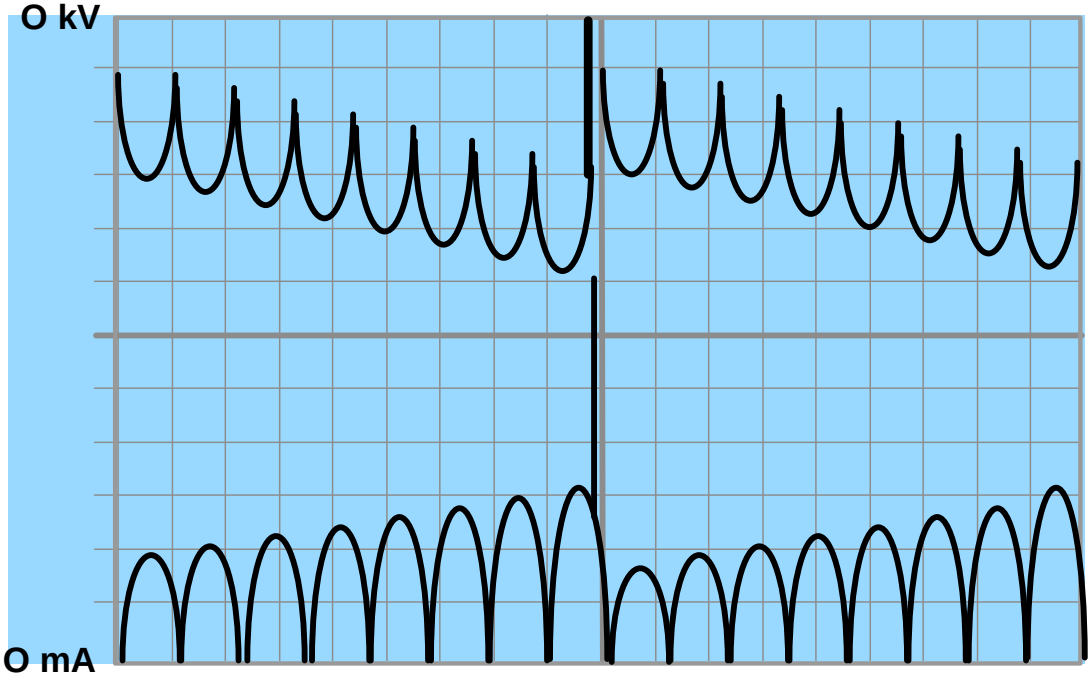
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis



Important as an indication of spark/arc response as well as power supply performance

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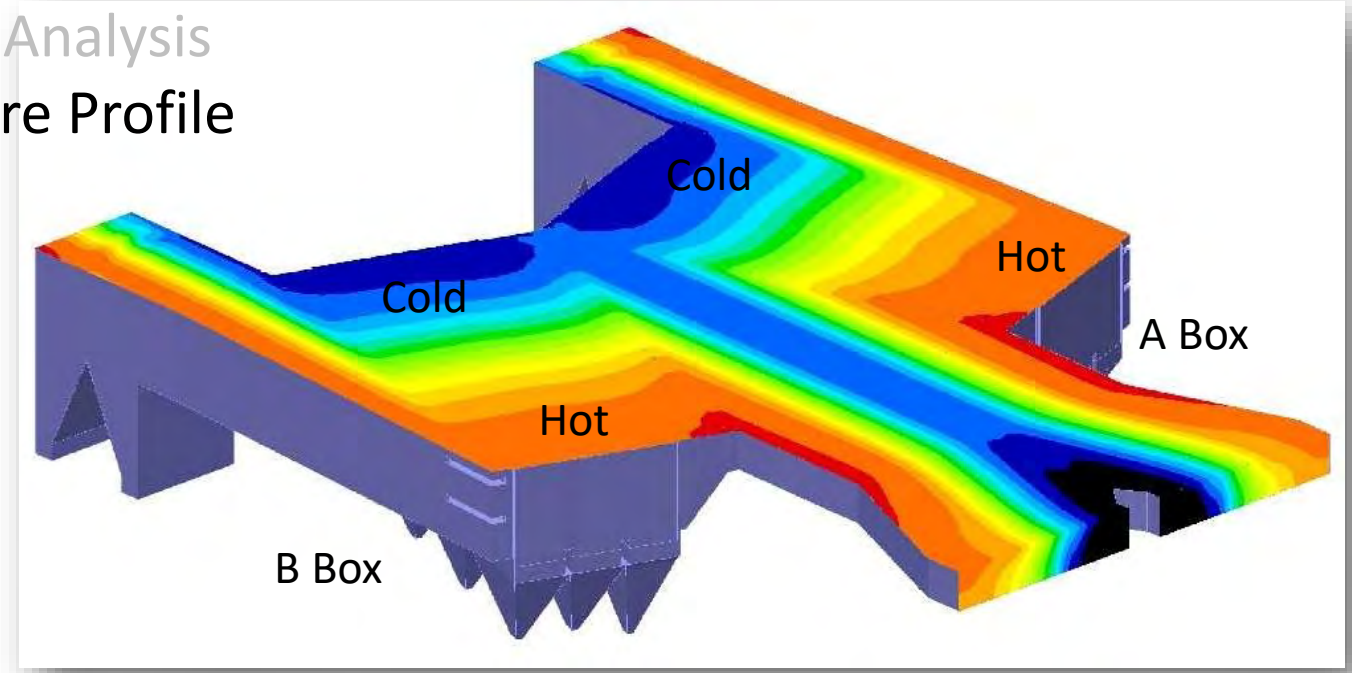
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile



Important to explain differences in power distribution

Courtesy: Airflow Sciences Corporation

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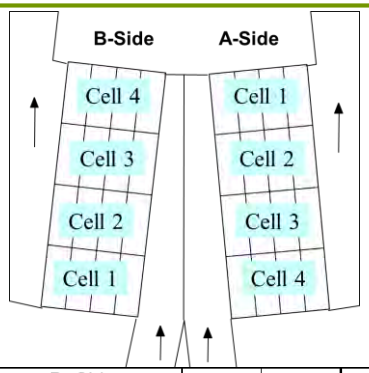
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile

Important to explain differences in power distribution impacted by resistivity and dewpoint



		B- Side				A- Side		
	Rows	Outlet Trail	Inlet Trailing		Rows	Inlet Trailin	Outlet Trailing	
	55	0.0301	0.0203		5	0.0256	0.0276	
	45	0.0309	0.0203		15	0.0208	0.0257	
	35	0.0303	0.0218		25	0.0212	0.0275	
	25	0.0309	0.0211		35	0.0184	0.0276	
	15	0.0302	0.0219		45	0.0256	0.0266	
Cell 4	5	0.0317	0.0218		55	0.0212	0.0287	Cell 1
	55	0.0287	0.0221		5	0.0241	0.0282	
	45	0.0294	0.0219		15	0.021	0.0288	
	35	0.0322	0.0234		25	0.023	0.0293	
	25	0.0323	0.0263		35	0.0222	0.029	
	15	0.0322	0.0223		45	0.0265	0.0296	
Cell 3	5	0.0335	0.026		55	0.0258	0.0303	Cell 2
	55	0.0343	0.0254		5	0.0244	0.0311	
	45	0.0331	0.0266		15	0.0229	0.0311	
	35	0.0331	0.0273		25	0.0243	0.0313	
	25	0.033	0.0293		35	0.0247	0.0322	
	15	0.032	0.0314		45	0.0253	0.031	
Cell 2	5	0.0327	0.0298		55	0.0265	0.032	Cell 3
	55	0.0332	0.0292		5	0.0277	0.0333	
	45	0.0322	0.0302		15	0.0277	0.0313	
	35	0.0334	0.0303		25	0.0298	0.0326	
	25	0.0319	0.03		35	0.0286	0.0319	
	15	0.0325	0.0318		45	0.0293	0.0318	
Cell 1	5	0.0325	0.033		55	0.0257	0.0331	Cell 4
	Average	0.0319	0.0260			0.0247	0.0301	
	Average			0.0282				

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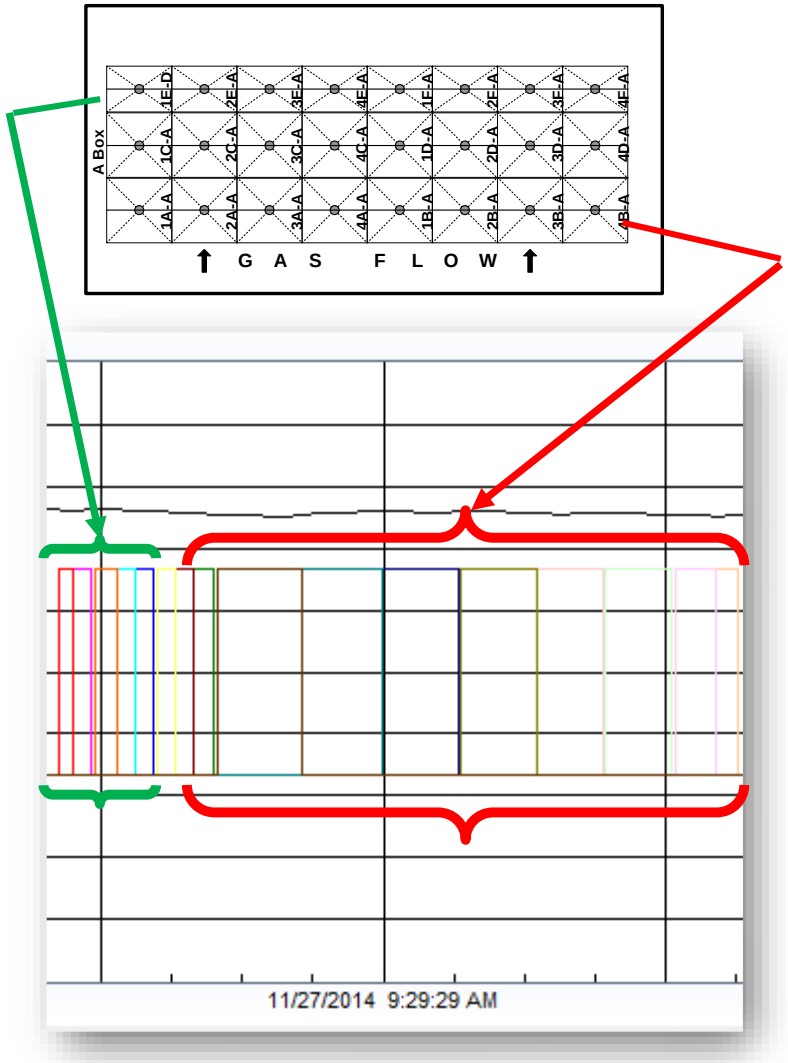
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile

Important to indicate relative ash capture across gas flow



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Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
  - Laboratory

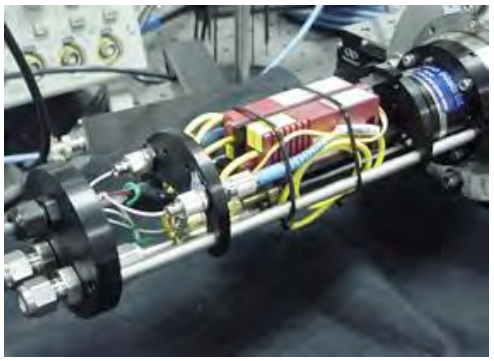
Used on hopper grab samples or high volume Inlet sample catches

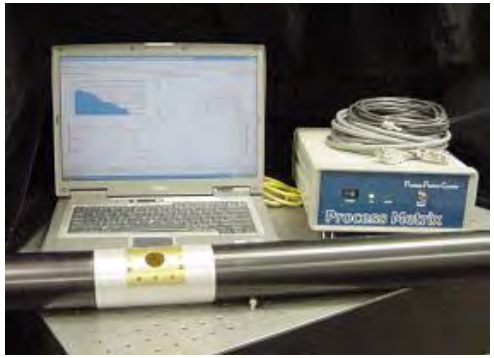
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
  - In-situ
    - Anderson
    - Holve

Cascading Impactor





Laser Probe

Impactor best used on inlet, the Holve on the outlet

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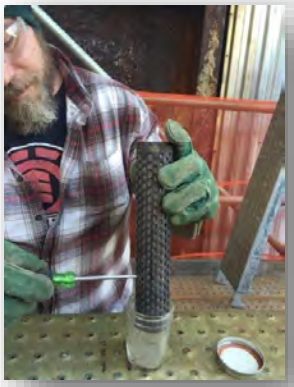
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
  - High Vol Sampling (Storm Probe)



Adaptation of mill fineness procedure

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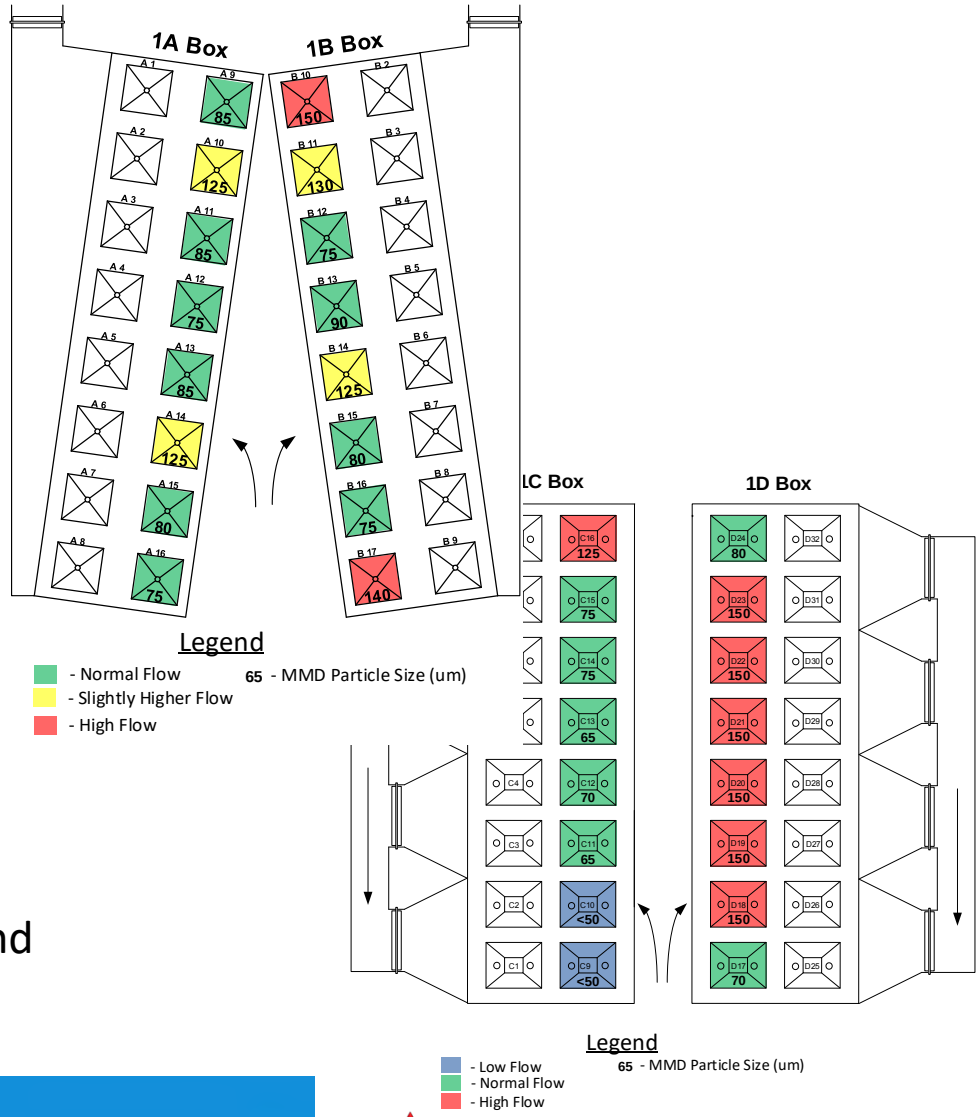
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
  - Hopper Sieving



Useful to locate areas of high gas flow and re-entrainment

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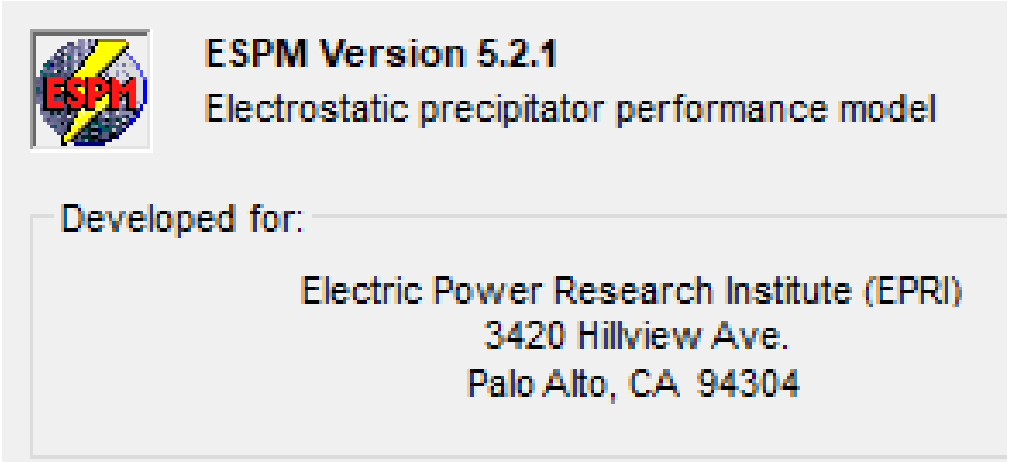
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model



Used for theoretical conditions that can't be tested physically

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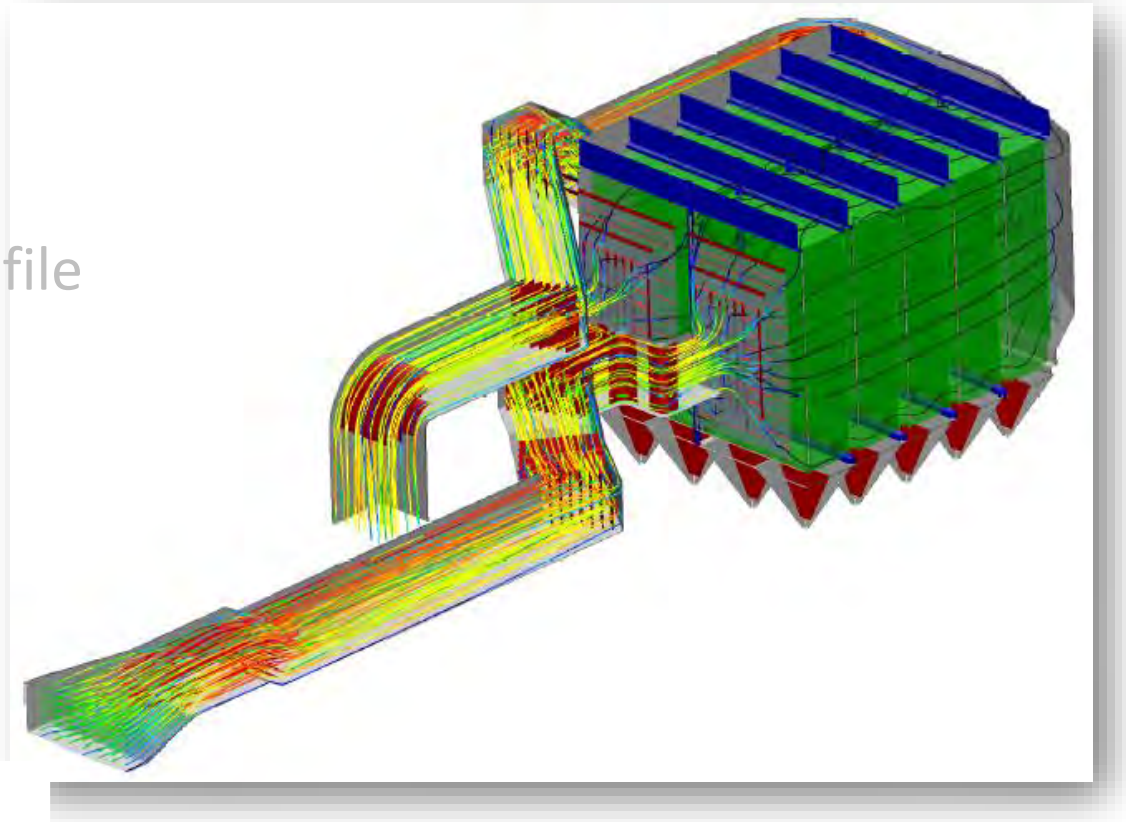
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
  - CFD - Flow

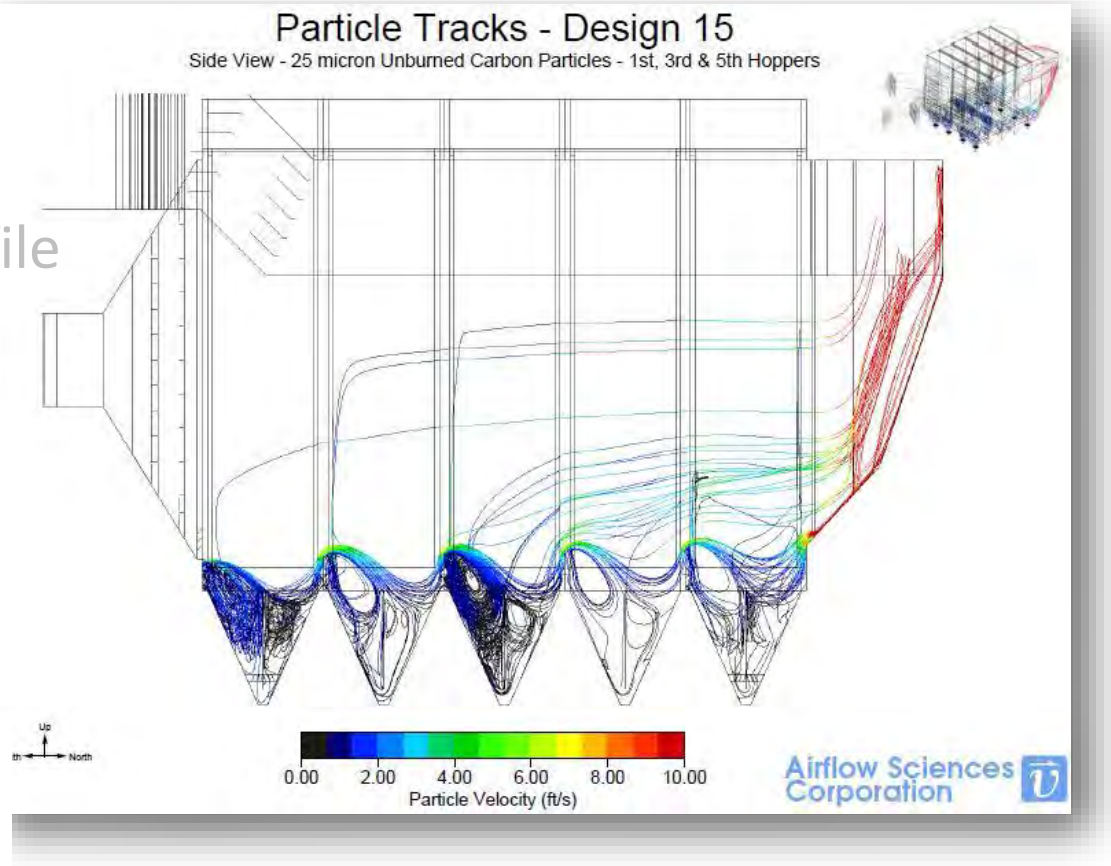


Used for theoretical conditions that can't be tested physically or as a confirmation of design

Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
  - CFD - Particulate



Used when flow/solids separation is suspected

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Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
  - Physical (Mid-scale)

Used to validate CFD flow results

1:12th Scale Model

Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
  - Physical (Large-scale)

1:4.5 Scale Model

Used to validate CFD Particulate results

Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
  - Physical (Large-scale)

Used to validate CFD Particulate results

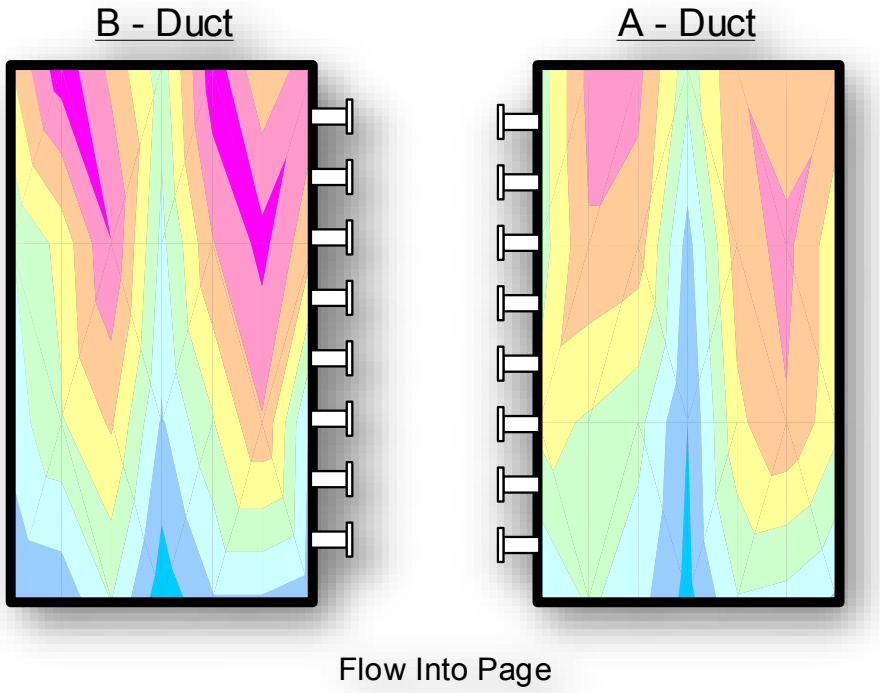
Injecting Dust

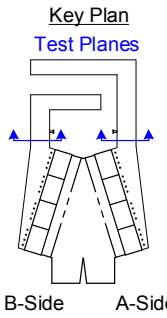
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
- Flow Testing
  - Pitot Tube

Used in high velocity regions such as inlet or outlet ducts





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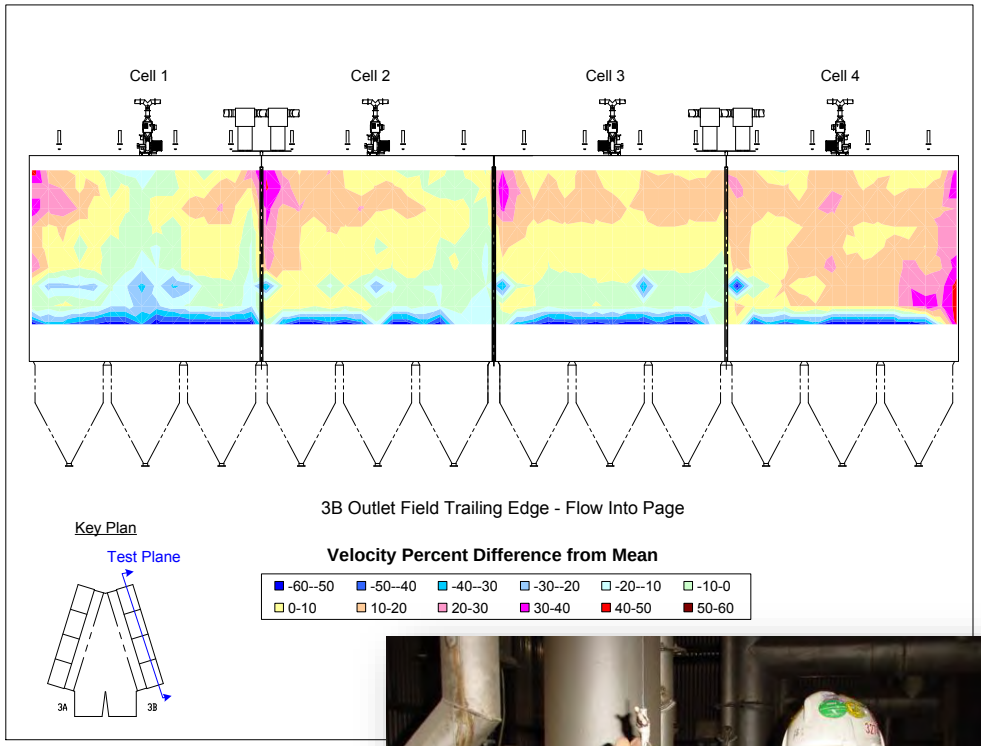
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
- Flow Testing
  - Anemometer



Used in low velocity regions such as in the ESP under cold air conditions

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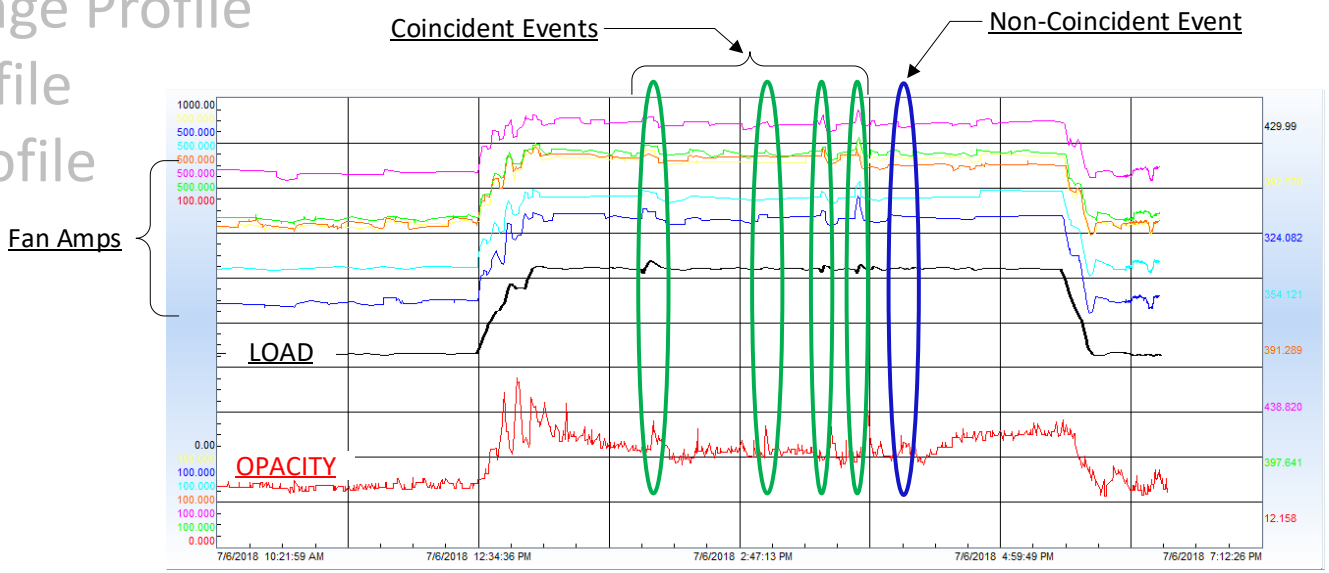
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
- Flow Testing
- ID Fan Amps



Used as an adjunct to opacity readings

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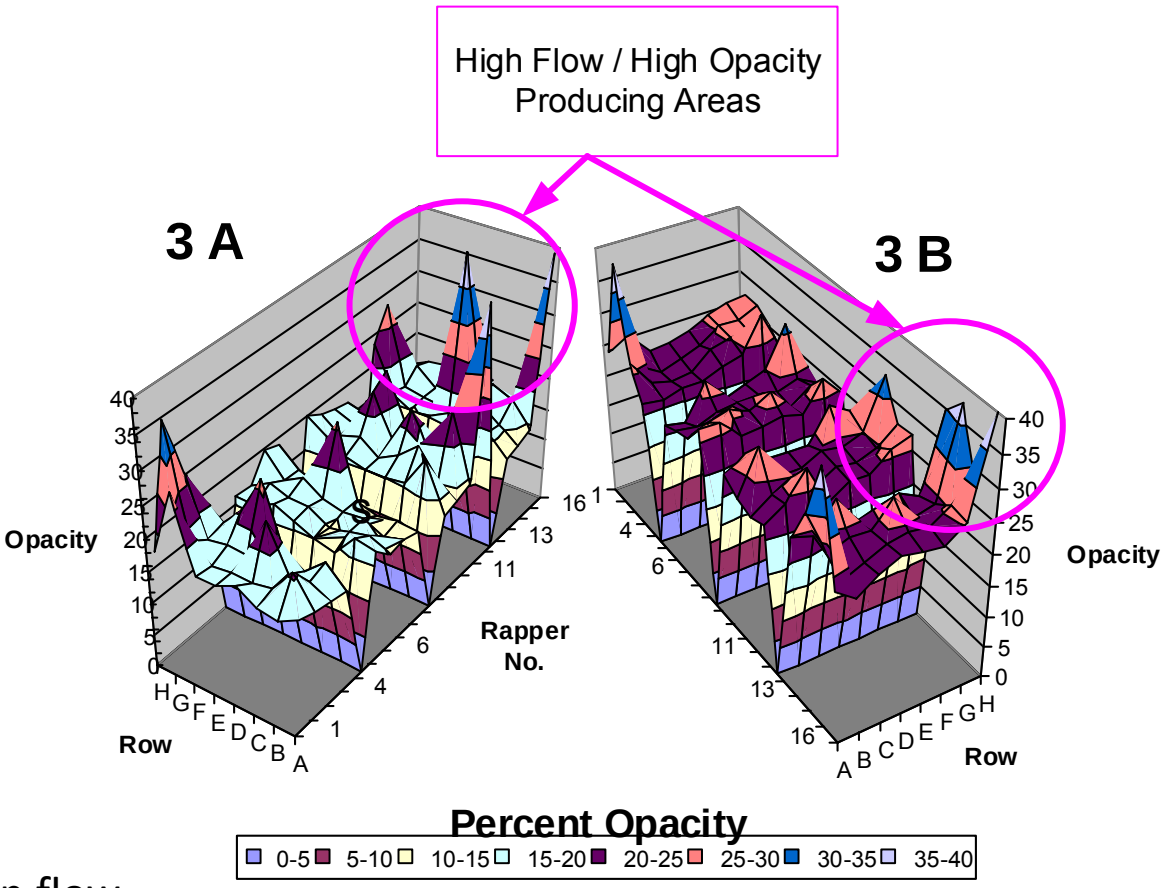
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
- Flow Testing
- ID Fan Amps
- Rapper Profiles



Used as a screening method when flow abnormalities are suspected

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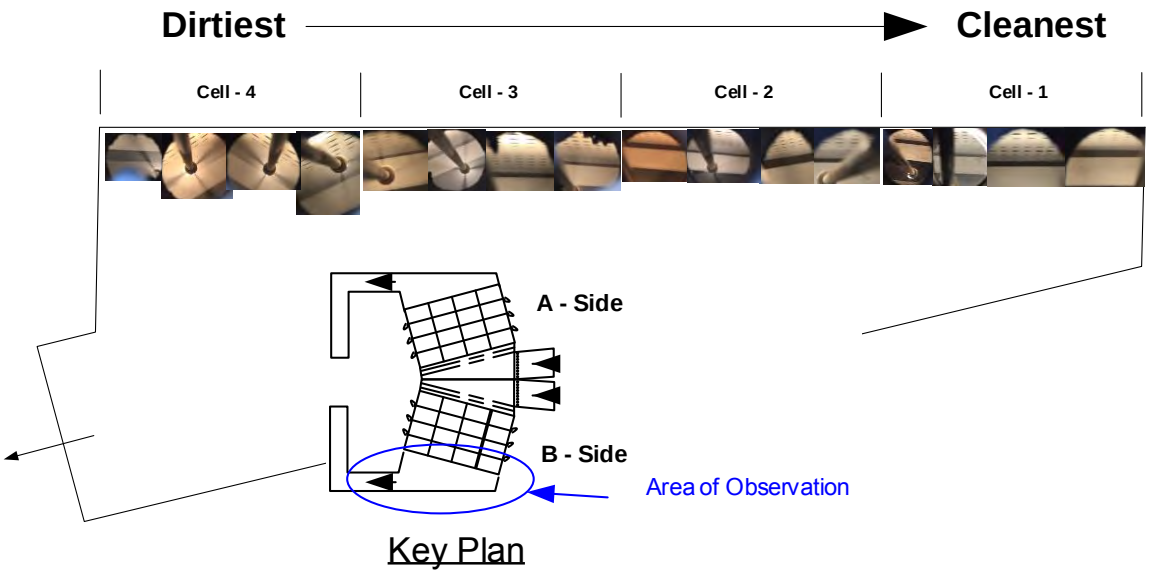
Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
- Flow Testing
- ID Fan Amps
- Rapper Profiles
- Video Observations



Used as an effective visualization method when re-entrainment is present

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Troubleshooting Types

Indirect

- V/I Relationships
- Dielectric Trending
- Waveform Analysis
- Temperature Profile
- Internals Wastage Profile
- Ash Pulling Profile
- Particle Size Profile
- ESPM Model
- Flow Model
- Flow Testing
- ID Fan Amps
- Rapper Profiles
- Video Observations

Used as an effective visualization method when re-entrainment is present

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Questions?