Reinhold Environmental Ltd.

2010 NOx-Combustion Round Table & Expo Presentation

February 8 & 9, 2010 Chattanooga, TN

LPA Analysis, Formation and Control?
Design inference for SCR Screen Systems

Iain Hall – NoNOx Components LLC
Midlothian, VA

Presented : Michael Edwards

Scope of Study

- LPA and fly ash were retrieved from several different utilities with a view to the determination if possible of formation mechanisms and an understanding of the impact of LPA and fly ash on the region between the economizer outlet and the SCR catalyst bed.
- Preliminary result from five plants are presented in this ongoing study.

Contributing Utilities

- AES – Greenidge (AES)
- Hoosier Energy – Merom (HEM)
- Consumers Energy – JH Campbell (JHC)
- KCP&L – Hawthorn (KCPL)
- Southern Company/AL Power – Barry (PB)

(Other contributing utilities pending)

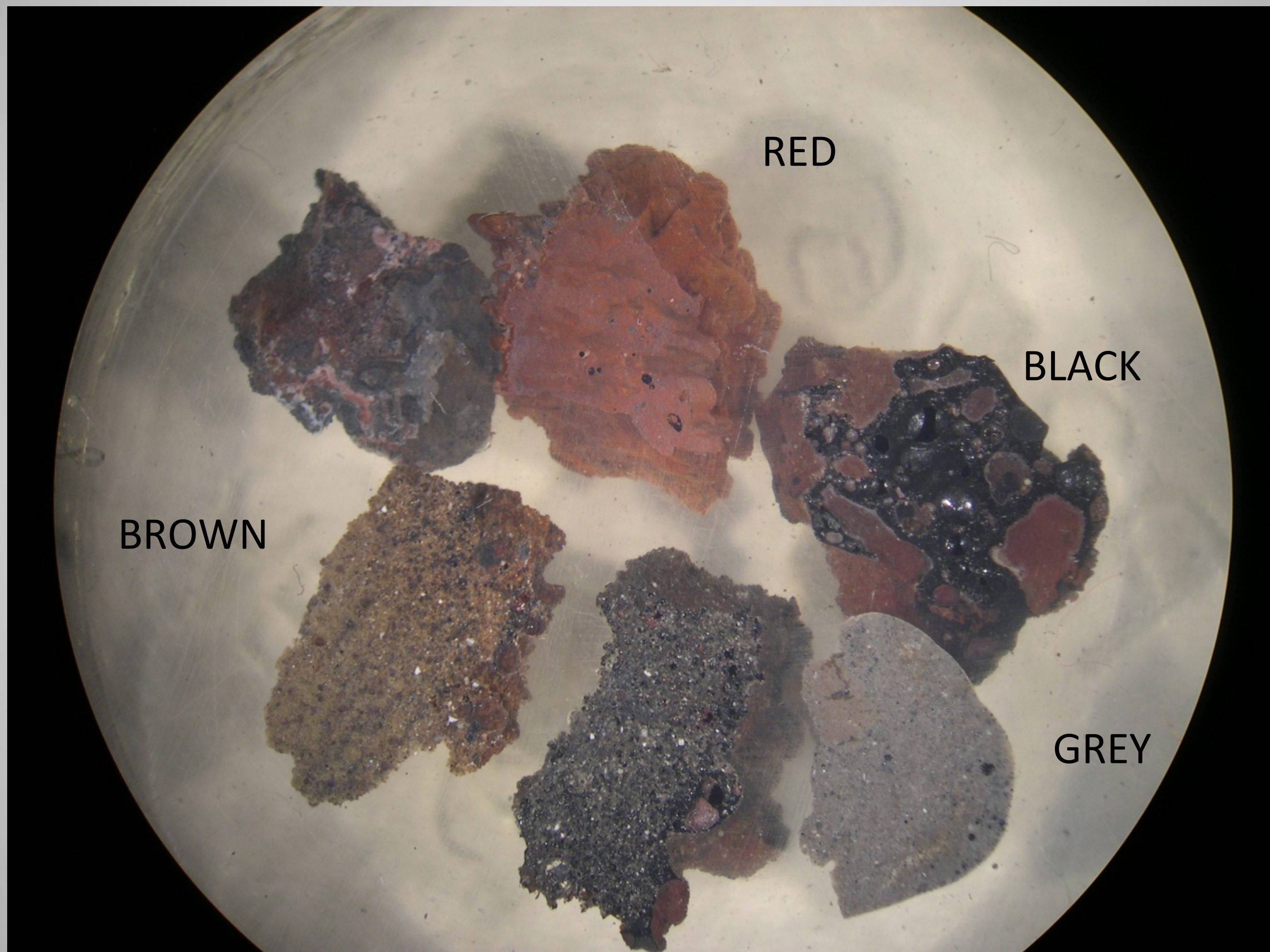
LPA Analysis

- Close examination of LPA provides the data with which to determine what, if any, controls can be applied to unit operation to mitigate formation.
- Alternatively an understanding of the physical structure and distribution of LPA provides a means to design an effective filtration system.

Potential Correlations

- Fuel type and processing
- Burner type and boiler configuration
- In furnace and backpass slag/ash control
- Furnace and backpass gas velocities

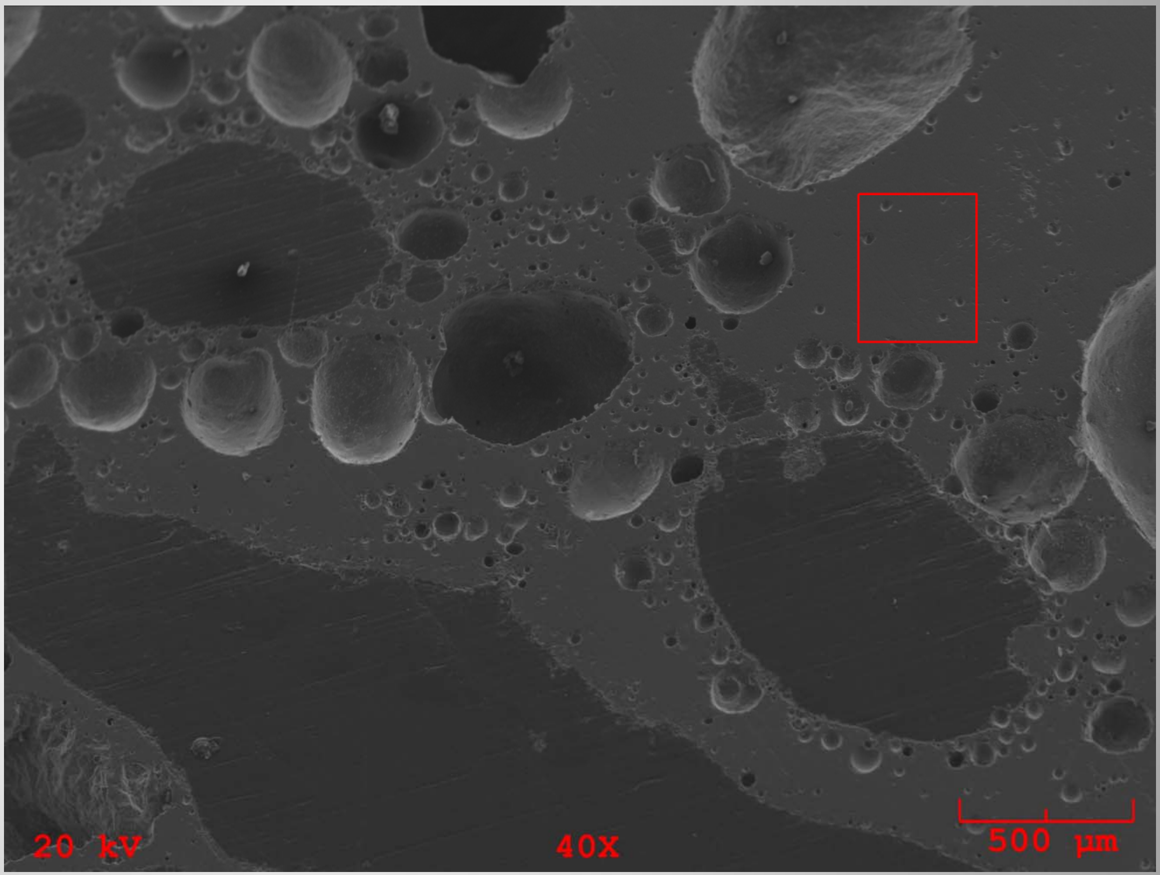
LPA Structure and Composition



AES

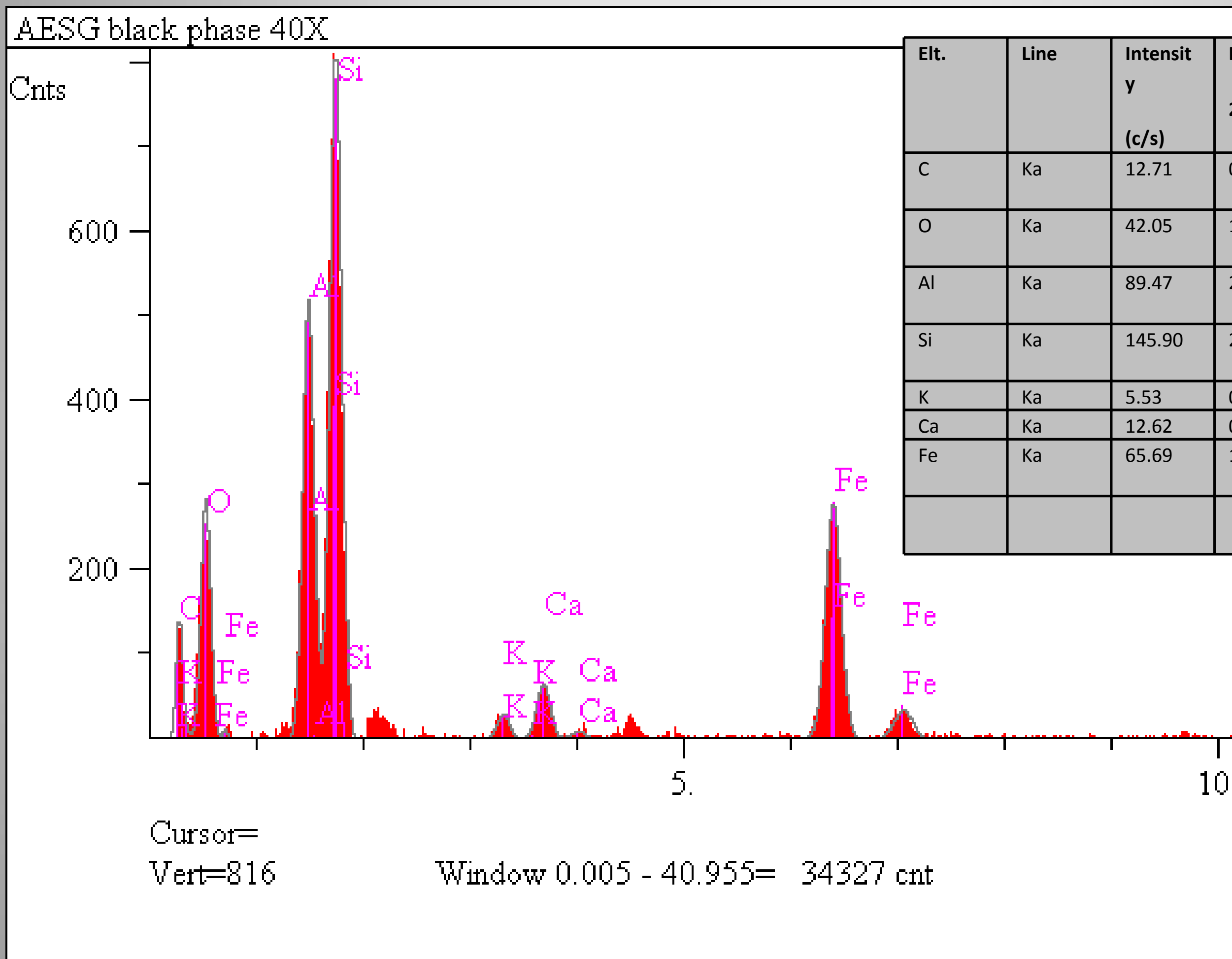
AES - Black Phase

- Solidified liquid
- Burner origin
- Direct combustion



AES - Black Phase

EDS (Semi-Quantitative Analysis)

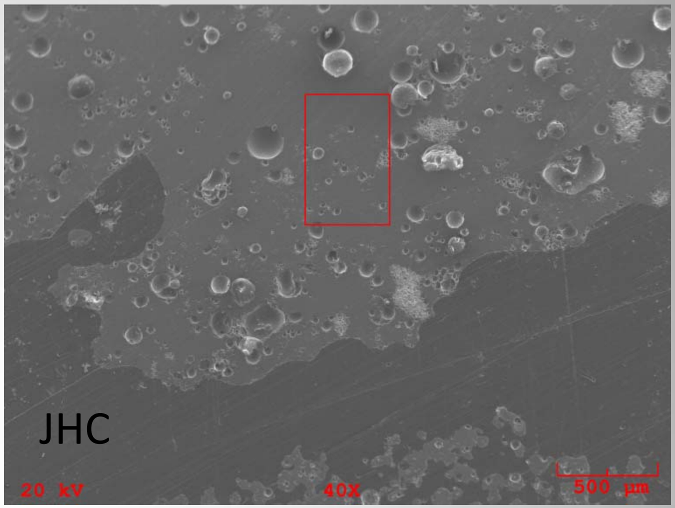


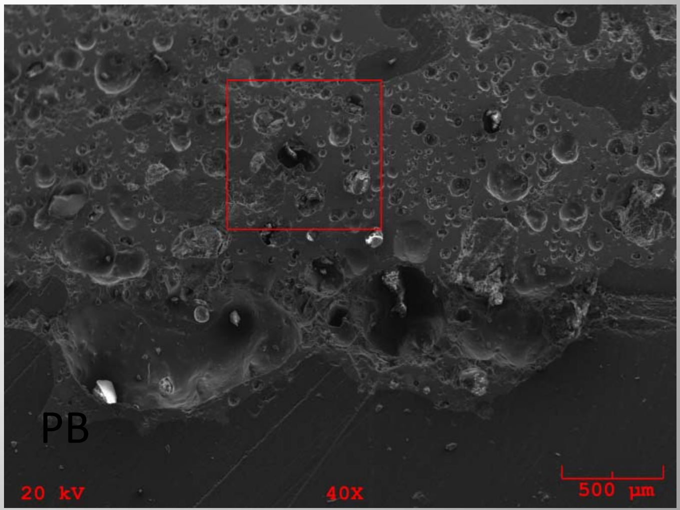
Elt.	Line	Intensity (c/s)	Error 2-sig	Conc	Units	
C	Ka	12.71	0.810	19.073	wt.%	
O	Ka	42.05	1.473	26.025	wt.%	
Al	Ka	89.47	2.148	12.706	wt.%	
Si	Ka	145.90	2.743	21.405	wt.%	
K	Ka	5.53	0.534	0.803	wt.%	
Ca	Ka	12.62	0.807	1.850	wt.%	
Fe	Ka	65.69	1.841	18.138	wt.%	
				100.000	wt.%	Total

Comparative Black Phase Analysis

Black Phase - Molten Slag like

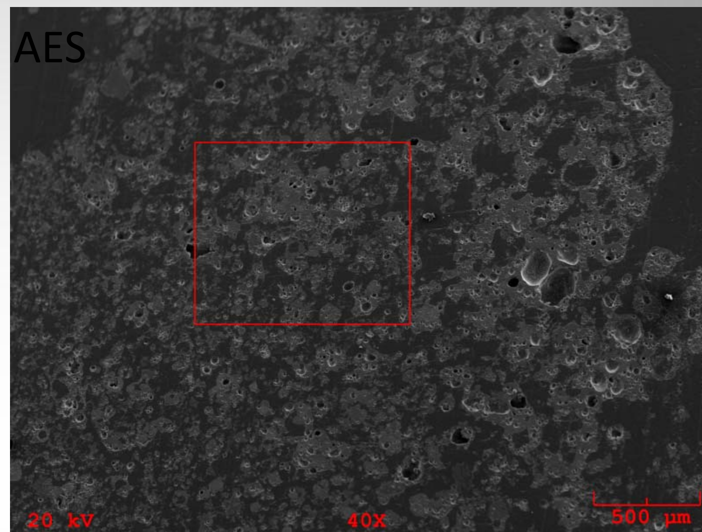
Elmt	AES	JHC	PB	HEM
C	19.07		16.59	27.62
O	26.03	28.47	29.67	
Al	12.71	11.42	12.05	13.69
Si	21.41	33.69	30.70	33.26
K	0.80		1.16	2.04
Ca	1.85	17.43	2.71	4.73
Fe	18.14	6.91	7.13	17.61
Na		0.34		0.32
Mg		1.75		0.30
Cl				0.42

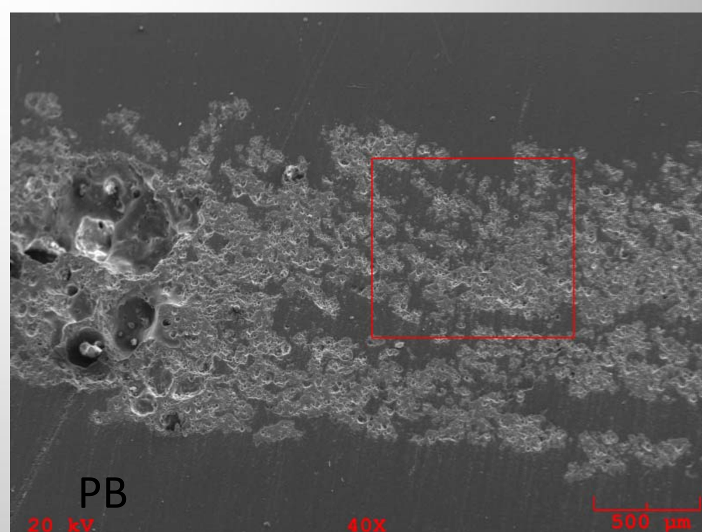




Comparative Brown Phase Analysis

Brown	Brown Phase AES	JHC	KCPL	PB
C	18.32	12.11	31.11	35.42
O	23.71	28.64	25.53	26.73
Al	14.72	10.94	6.62	8.16
Si	27.18	23.54	16.61	19.81
K	1.15			1.21
Ca	1.88	17.04	13.32	1.64
Fe	13.05	5.14	4.49	4.64
Mg		1.77	1.69	
Cl		0.82		1.86
Na			0.62	
S				0.54

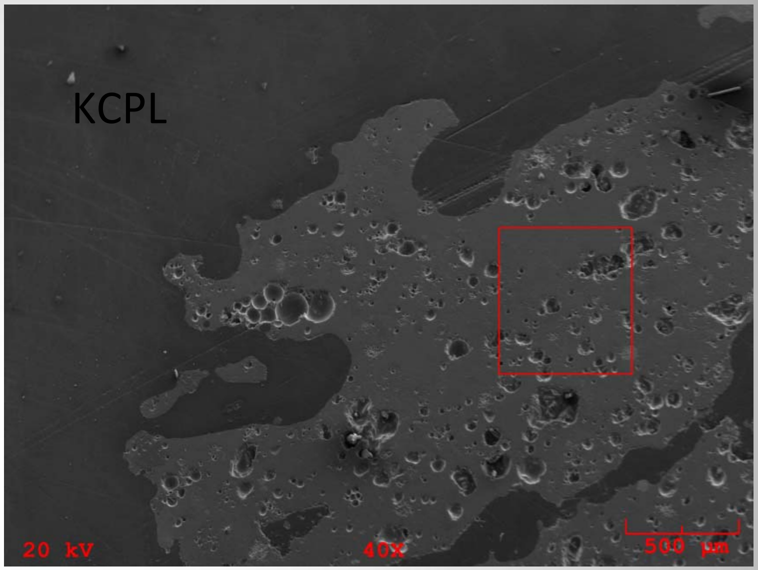




- Course Sandy Particle accretion
- Combustor origin-waterwalls
- Varied make up
- Often stratified indicating loose surface adhesion

Comparative Grey Phase Analysis

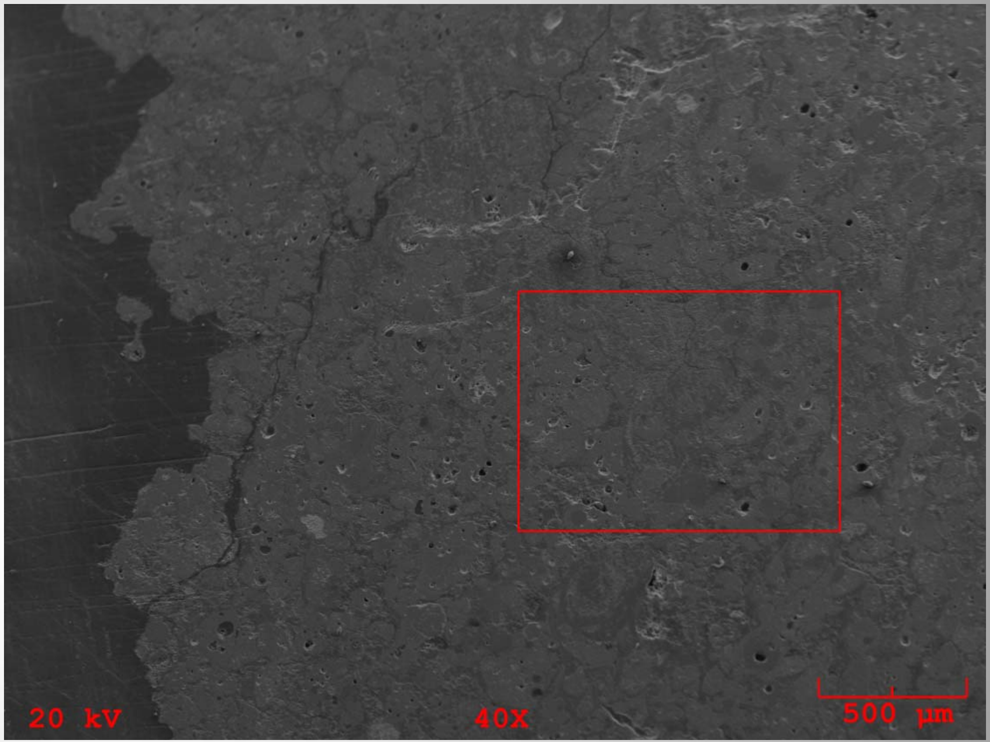
	Grey Phase AES	JHC	KCPL	PB	HEM
C	29.61		4.83	9.78	23.17
O	21.72	31.67	27.74	26.94	26.98
Al	11.68	13.10	11.34	13.73	9.62
Si	23.29	35.68	30.62	40.12	24.06
S	4.63				
K	1.00		0.17	1.74	1.83
Ca	2.70	14.12	17.71	2.20	1.71
Fe	5.38	3.75	5.49	5.50	12.53
Na		0.39			
Mg		1.30	2.11		



- Liquid Solidification/partial accretion
- Combustor origin adjacent to fireball
- Varied make up

Comparative Red Phase Analysis

	Red Phase		
	AES	JHC	HEM
C	11.13		
O	28.03	32.41	21.12
Al	15.21	6.70	9.36
Si	25.05	7.05	16.18
S	7.36	22.29	1.57
K	1.53		1.39
Ca	3.77	25.78	1.33
Fe	7.92	5.76	47.14
Ti			0.86
Na			0.29
Mg			0.78

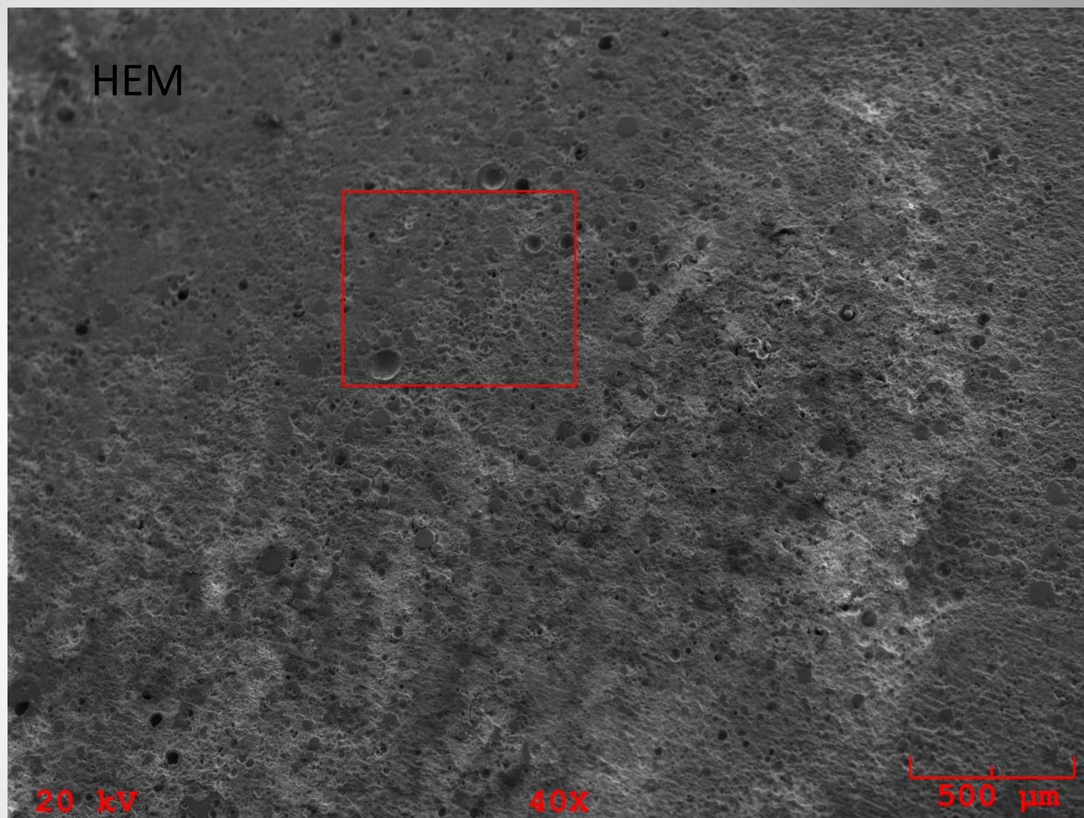


- Fine ash particle accretion
- Superheater/Backpass origin
- High density - occasionally high iron content

White Phase Analysis

White Phase - HEM

O	37.07
Na	0.20
Mg	0.21
Al	4.55
Si	11.72
S	20.17
K	1.04
Ca	18.65
Fe	6.39

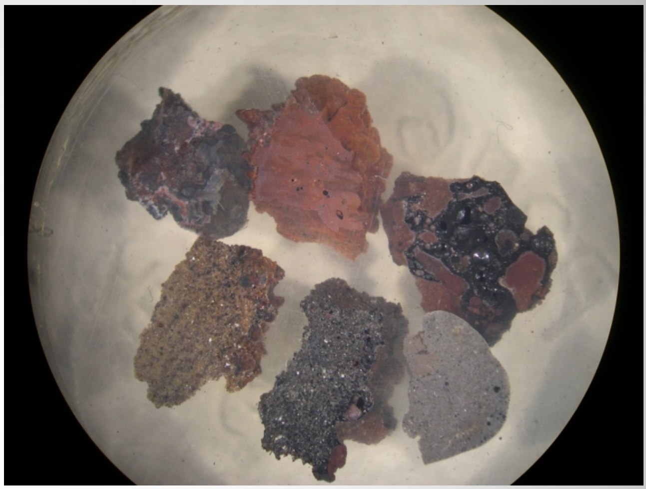


- Dry slurry
- Calcium Carbonate Reagent Injection?

LPA – Unit Specific Analysis

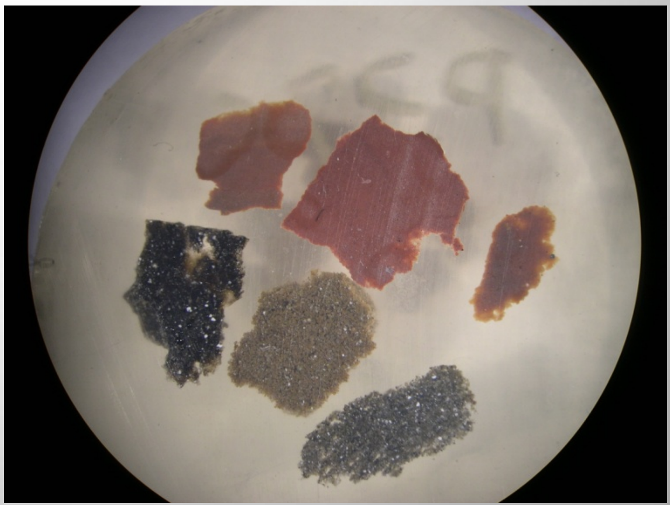
AES LPA

	Black	Brown	Grey	Blk/Gry	Red
C	19.07	18.32	29.61	8.40	11.13
O	26.03	23.71	21.72	24.28	28.03
Al	12.71	14.72	11.68	15.85	15.21
Si	21.41	27.18	23.29	30.83	25.05
K	0.80	1.15	1.00	1.35	1.53
Ca	1.85	1.88	2.70	3.29	3.77
Fe	18.14	13.05	5.38	16.00	7.92
S			4.63		7.36



JHC LPA

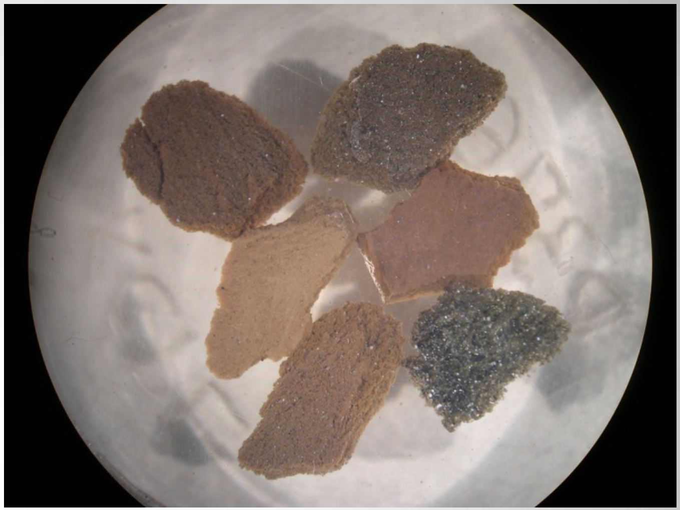
	Black	Brown	Grey	Red
C		12.11		
O	28.47	28.64	31.67	32.41
Al	11.42	10.94	13.10	6.70
Si	33.69	23.54	35.68	7.05
K				22.29
Ca	17.43	17.04	14.12	
Fe	6.91	5.14	3.75	5.76
Na	0.34		0.39	25.78
Mg	1.75	1.77	1.30	
Cl		0.82		



LPA – Unit Specific Analysis

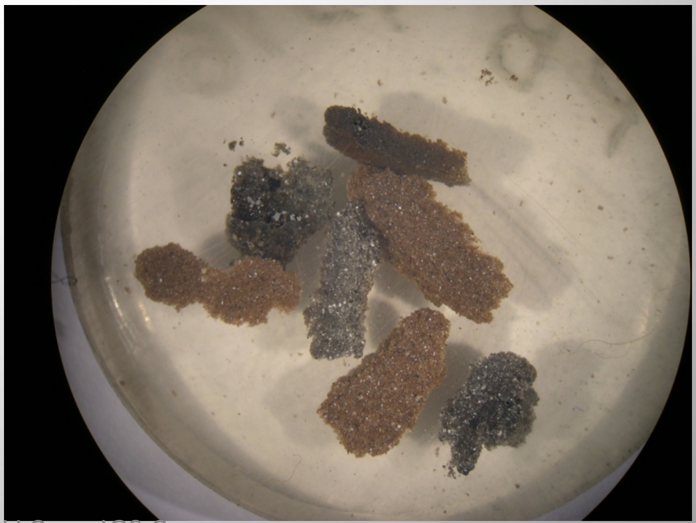
KCP&L LPA

	Brown	Grey	Yellow
C	31.11	4.83	32.27
O	25.53	27.74	25.79
Al	6.62	11.34	5.99
Si	16.61	30.62	13.90
K		0.17	
Ca	13.32	17.71	12.22
Fe	4.49	5.49	2.74
Na	0.62		0.47
Mg	1.69	2.11	1.77
S			4.85



PB LPA

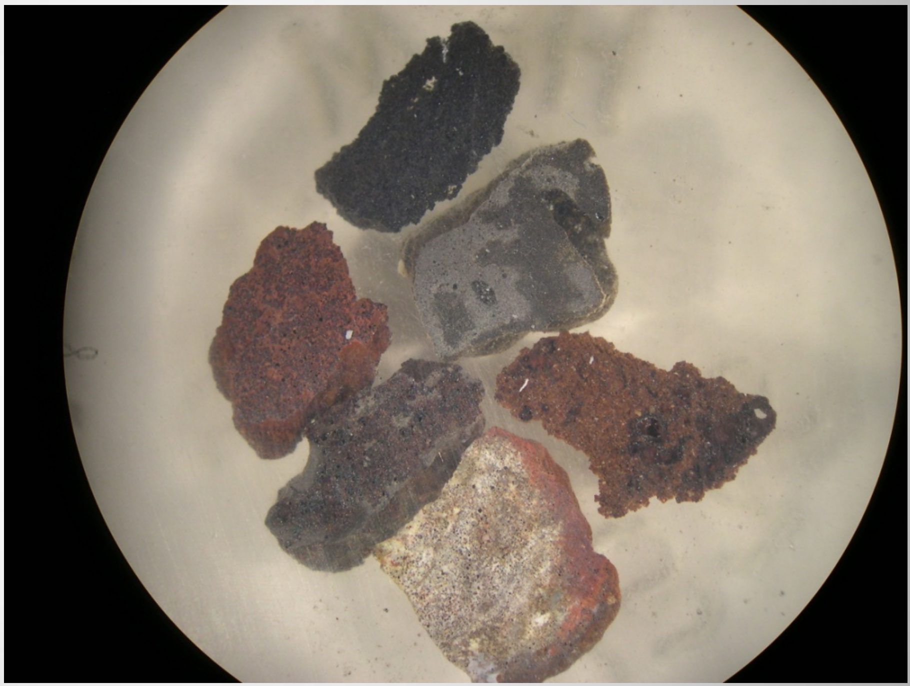
	Black	Brown	Grey
C	16.59	35.42	9.78
O	29.67	26.73	26.94
Al	12.05	8.16	13.73
Si	30.70	19.81	40.12
K	1.16	1.21	1.74
Ca	2.71	1.64	2.20
Fe	7.13	4.64	5.50
Na		0.34	
Mg		1.75	
Cl			



LPA – Unit Specific Analysis

HEM LPA

	Black	Grey	Red	White
C	27.62	23.17		
O		26.98	21.12	37.07
Al	13.69	9.62	9.36	4.55
Si	33.26	24.06	16.18	11.72
K	2.04	1.83	1.39	1.04
Ca	4.73	1.71	1.33	18.65
Fe	17.61	12.53	47.14	6.39
Na	0.32		0.29	0.20
Mg	0.30		0.78	0.21
Ti			0.86	
S			1.57	20.17



Concluding comments on LPA Analysis:

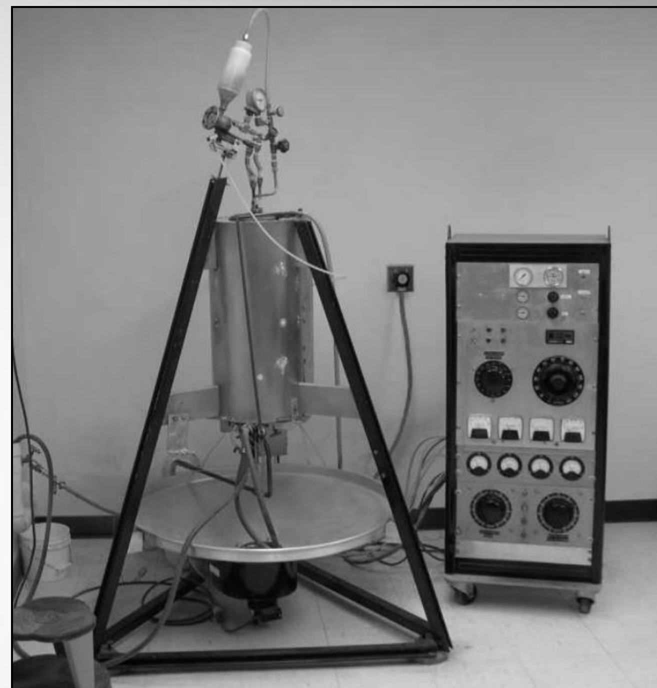
- All units surveyed showed significantly different LPA types.
- LPA formation mechanisms can be traced to combustion and post combustion conditions in the boiler and clay like fly ash deposits on superheater tubes and the backpass.
- Emmision control measures through reagent injection may also contribute to LPA formation.
- Given the genetic diversity of LPA in all units studied, it is unlikely that any simple solutions for the prevention on LPA formation exist.

Duct and Filtration System erosion resistance

- Understanding the erosivity of the system fly ash provides the data for material design to ensure longevity not only of filtration systems, but also of duct and support structures between the economizer outlet and the SCR.
- Erosion tests at fixed velocity, impact angle and substrate material tests were conducted to compare the impact of plant ash.

Erosion Test Results

(ASTM G76)



Erodent: 500g Prepared Ash
Impact angle : 30°
Temperature : 370C (700F)
Velocity : 72m/s

Peak Crater loss (um)

	1018 CS	UTEx 5-500	Fused Coating	UTEx 1-120LPA
AES	153.11			
JHC	363.22	88.9	20.32	12.5
KCPL	202.5			
PB	180			
HEM	87.85			

Coupon Mass Loss (g)

	1018 CS	UTEx 5-500	Fused Coating	UTEx 1-120LPA
AES	0.0325			
JHC	0.1081	0.0222	0.0045	0.0028
KCPL	0.0434			
PB	0.047			
HEM	0.0102			

Comparative Erosion Rate for Screen and Structural Materials

Baseline Relative Erosivity of fly ash from units surveyed.
(Erosion rate per unit mass of ash)

	1018 CS	UTEx 5-500	Fused Coating	UTEx 1-120LPA
AES	12.2488			
JHC	29.0576	7.112	1.6256	1
KCPL	16.2			
PB	14.4			
HEM	7.028			

Improving system performance through materials and design

- The erosion rate of screens or structural duct members is a function of the baseline erosivity of the material multiplied by the local ash loading with the erosion rate increasing with an exponent of 2.4 – 2.8 of the impact velocity.
- Mitigating the impact of high velocities with design for uniform flow conditions in conjunction with the use of high performance erosion resistant surface treatments will lead to substantially reduced metal wastage.

NoNOx Components LLC
2707 Oak Lake Blvd
Midlothian
Virginia
23114

Tel: +1 804 639 2600
Fax: +1 804 269 2601
Email: solutions@nonox.biz

Direct Contacts: Michael Edwards – michael.edwards@nonox.biz
Iain Hall – iain.hall@nonox.biz