

REINHOLD ENVIRONMENTAL Ltd.



**2013 NO_x-Combustion Round Table
& Expo Presentations**

February 18 & 19, 2013, in Salt Lake City, UT / Hosted by PacifiCorp

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Multi Pollution Control using Mitagent™ Combustion Additive

***2013 Reinhold NO_x Combustion Round Table
Salt Lake City, Utah , February 18-19, 2013***

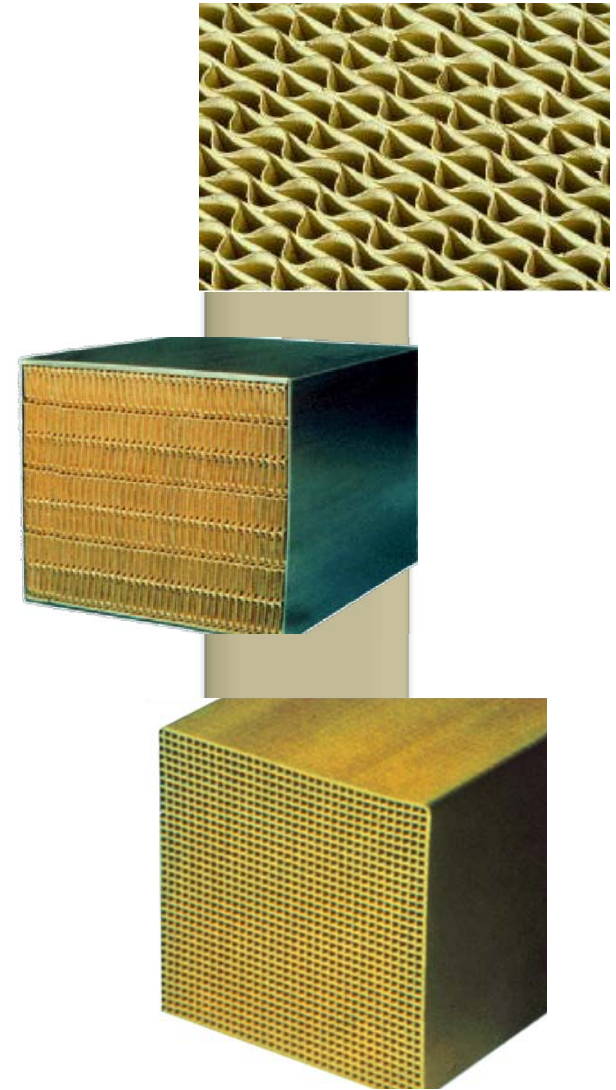
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Mandar Gadgil
Air Quality Control System, Engineer

Presentation Agenda

- **Mitagent™ combustion additive development**
- **Field test results**
- **Economic analysis of combustion additive injection**
- **Selenium mitigation**



Periodic Table of the Elements

1 H 1.01																	18 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (97.91)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (208.98)	85 At (209.99)	86 Rn (222.02)
87 Fr (223.02)	88 Ra (226.03)	89 Ac (227.03)	104 Rf (261.11)	105 Ha (262.11)	106 Sg (263.12)												
58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (144.91)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97				
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237.05)	94 Pu (244.06)	95 Am (243.06)	96 Cm (247.07)	97 Bk (247.07)	98 Cf (251.08)	99 Es (252.08)	100 Fm (257.10)	101 Md (258.10)	102 No (259.10)	103 Lr (262.11)				

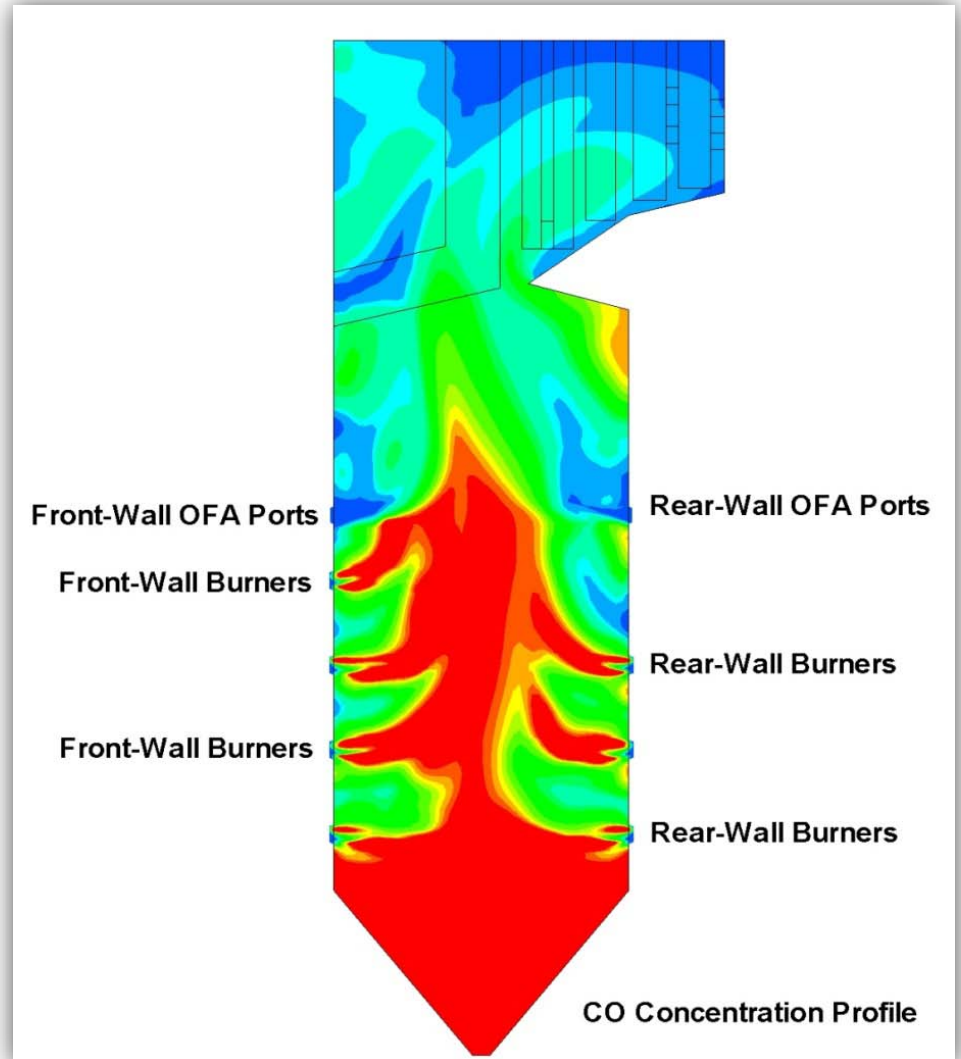
Deactivation of SCR Catalyst by Phosphorus

- Deactivation by phosphorus many times experienced with PRB coal
- Combustion conditions play major role in deactivation process
- Deactivation observed more often under staged combustion conditions as compared to unstaged combustion
- Staged or poor combustion can lead to deactivation of catalyst by phosphorus
- Gas phase phosphorus at SCR inlet is important contributor to deactivation

B 10.81	C 12.01	N 14.01	O 16.00	P 30.97
Al 26.98	Si 28.09	P 30.97	S 32.07	Cl 35.45
31	32	33	34	35
Ge	As	Se	Br	Kr

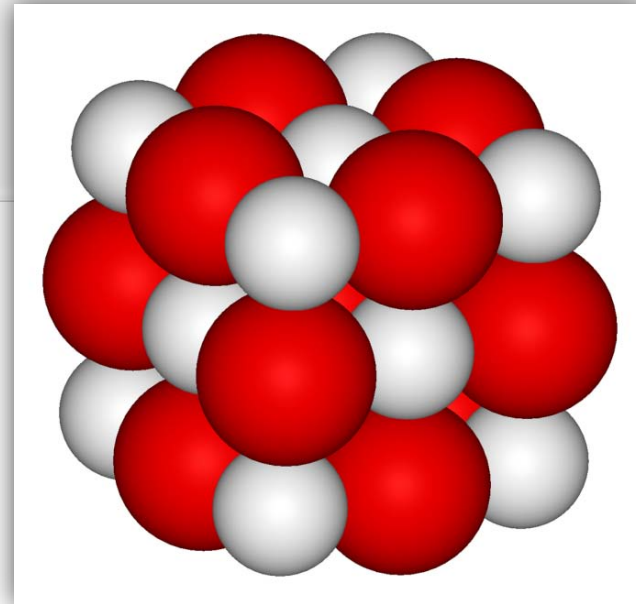
Staged/Poor Combustion Effects

- Carbothermic reduction of phosphorus-bearing minerals due to staging in lower furnace
- Even unstaged, if poor combustion exists in furnace the same effect of carbothermic reduction of phosphorus bearing minerals can be observed

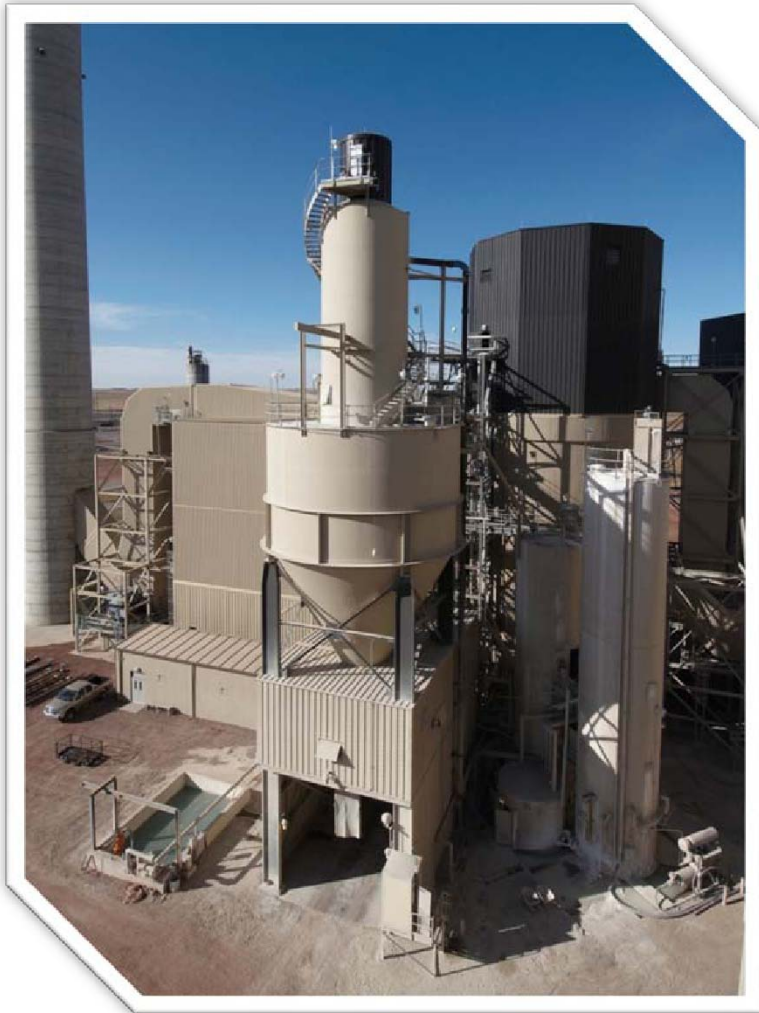


Combustion Additive Development

- **B&W investigations for binding gas phase phosphorus**
- **Impact on boiler performance**
- **Technical feasibility of injection**
- **Short term testing**
- **Long term testing**



Long Term Injection



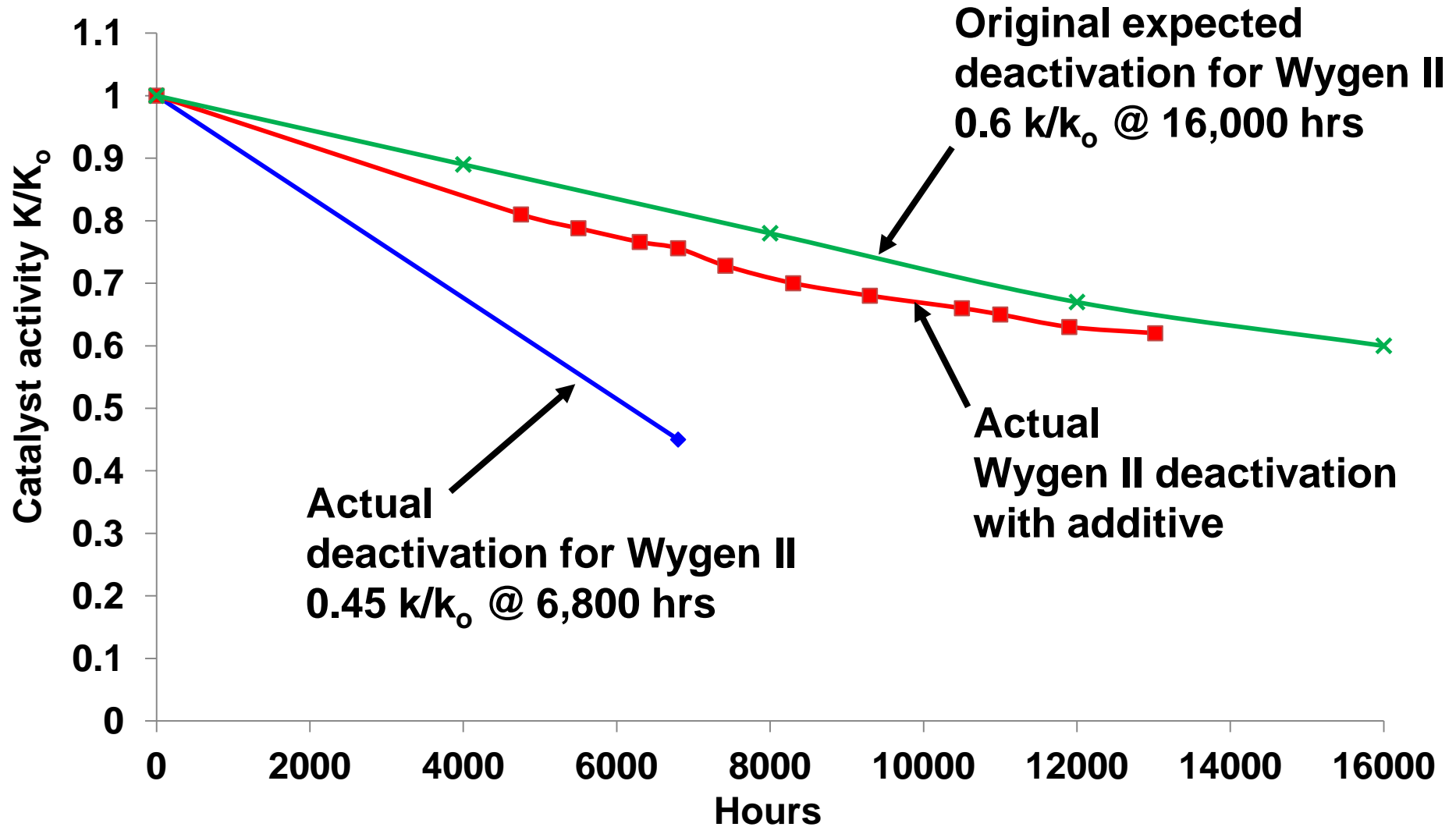
- To demonstrate reduction in rate of catalyst deactivation
- Wygen II – 100 MW unit with SCR, SDA and fabric filter
- Wyodak mine PRB coal
- Staged combustion
- Experienced rapid catalyst deactivation due to phosphorus previously with new catalyst
- At time of testing, catalyst was 6.9 mm pitch, single layer, regenerated

Using Combustion Additive for SCR Catalyst Deactivation Mitigation



Results

Wygen II – Catalyst Performance



Projections of Catalyst Life

- Based on deactivation rate at Wygen II with additive injection, the theoretical catalyst life for different scenarios:

<i>Unit</i>	<i>No. of Layers</i>	<i>End of Life Activity K/Ko</i>	<i>Theoretical Life Hours</i>
Wygen III – no additive	2	0.43	16,000
Wygen II – with additive	1	0.6	16,000
Wygen II – with additive	2	0.6	24,000
Wygen II – with additive	3	0.6	32,000

- An improvement in life of catalyst can be achieved due to slower rate of deactivation

How Does a Slower Rate of Deactivation Benefit New or Existing SCRs?

- **Having less volume for the same DeNO_x requirement**

<i>Parameter</i>	<i>With Additive</i>	<i>Without Additive</i>
Unit size	> 650 MW	> 650 MW
Inlet NO_x	0.26	0.26
Outlet NO_x	0.05	0.05
Slip	2 ppm	2 ppm
Initial volume	480 m³	680 m³
Number of change events in 20 years	12	12
Replacement volume each event	160 m³ each subsequent replacement layer	230 m³ each subsequent replacement layer

How Does a Slower Rate of Deactivation Benefit New or Existing SCRs?

- **Extending life further with the same volume**

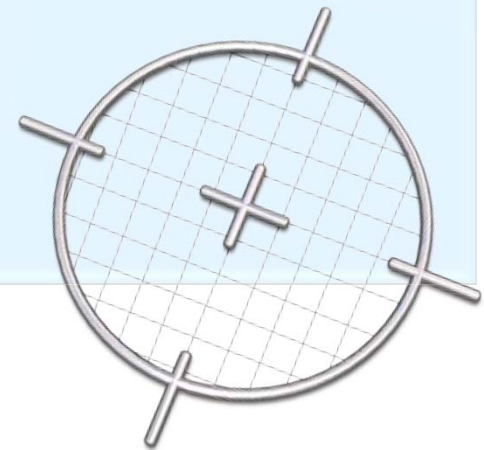
<i>Parameter</i>	<i>With Additive</i>	<i>Without Additive</i>
Unit size	> 650 MW	> 650 MW
Inlet NO _x	0.26	0.26
Outlet NO _x	0.05	0.05
Slip	2 ppm	2 ppm
Initial volume	680 m ³	680 m ³
Theoretical life	26,000	16,000
Number of change events in 20 years	6	12

Blended Additive Development

- **Demonstrate reduction in gas phase phosphorus entering SCR and simultaneous increase in Hg oxidation due, in part, to additive to control gas phase phosphorus**
- **Demonstrate Hg emissions compliance with oxidation and removal using FGD only**
- **Developed a patent pending blended additive to achieve simultaneous phosphorus reduction and Hg oxidation**
- **Tested at 300 MW PRB unit with SCR, CDS and fabric filter air quality control system**

Observations from Blended Additive Testing

- **Able to achieve stack Hg below 1.2 lb/Tbtu compliance limit set by MATS along with 45% reduction in gas phase phosphorus at SCR inlet**
- **Confirms capability to achieve Hg compliance using SCR, CDS and fabric filter without ACI injection**
- **No increase in undesirable hydrogen halide stack emissions observed with injection**



Economic Benefits of Blended Additive

- **Significant savings in compliance cost due to elimination/reduction in use of activated carbon injection**
- **As poisoning of catalyst is mitigated, Hg oxidation with halogen or halogen composition should achieve reduced Hg emissions without carbon for long-term**
- **Additional revenue from sale of ash due to elimination of carbon**
- **In particular for units with circulating dry scrubber (CDS) reduction in carbon use will reduce the concern with bag house and air slide fire**

Effect of Bromine Injection on Selenium

- **Bromine or bromine compound injection is very effective method for Hg oxidation on low halogen coals**
- **It was observed that as a result of bromine or bromine compound injection, selenium speciation was changed resulting in more selenium in gas phase**
- **On units with wet scrubbers this resulted in high selenium in scrubbers**
- **Selenium in Se(VI) oxidation state cannot be removed effectively from scrubber waste water discharge**

Selenium Mitigation

- **Long-term Mitagent™ testing at Wygen II, observed an increase in particulate bound selenium as a result of injection**
- **At Springfield test even with Mitagent™ 95 injection, particulate bound selenium increased as compared to baseline at air heater outlet**
- **As a result, it is possible to use bromine or bromine compound injection for Hg oxidation without negative impact on selenium speciation**



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THANK YOU. QUESTIONS?

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