

REINHOLD ENVIRONMENTAL Ltd.



**2018 NO<sub>x</sub>-Combustion Round Table  
& Expo Presentation**

February 19-20, 2018, in St. Louis, MO / Hosted by Dynegy

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# Mitigating Arsenic Poisoning of SCR Catalyst from Burning Gibson IB Coal

Jason Bookout (Technical Services)  
February 19<sup>th</sup> 2018





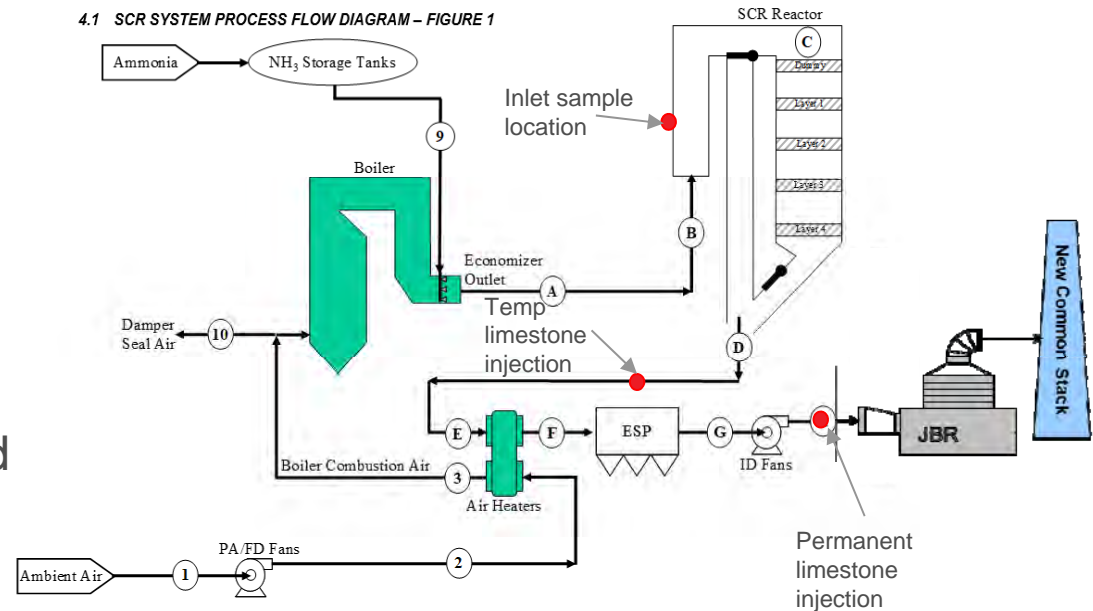
## Table of Contents

- Plant Crist Overview/ History
- Air heater washing
- Economic Analysis?
- Catalyst activity/ deactivation rates (predicted vs. actual)
- Test setup/ test plan/ test limitations (constraints)
- Test results/ Conclusions?
- Path forward



## Plant Crist Unit 7

- Capacity: 520 MW
- Fuel: Bituminous with a changeover to Gibson fuel in early 2017.
- Process Flow diagram:
  - Opposed-wall fired
  - High dust SCR
  - Vertical airheater
  - Limestone injection downstream of air heater
  - Temp limestone installed upstream of air heater





# Gibson Coal

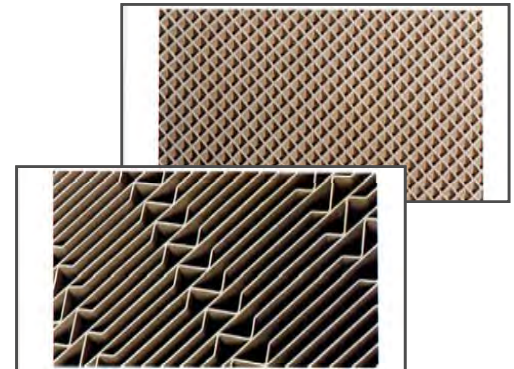


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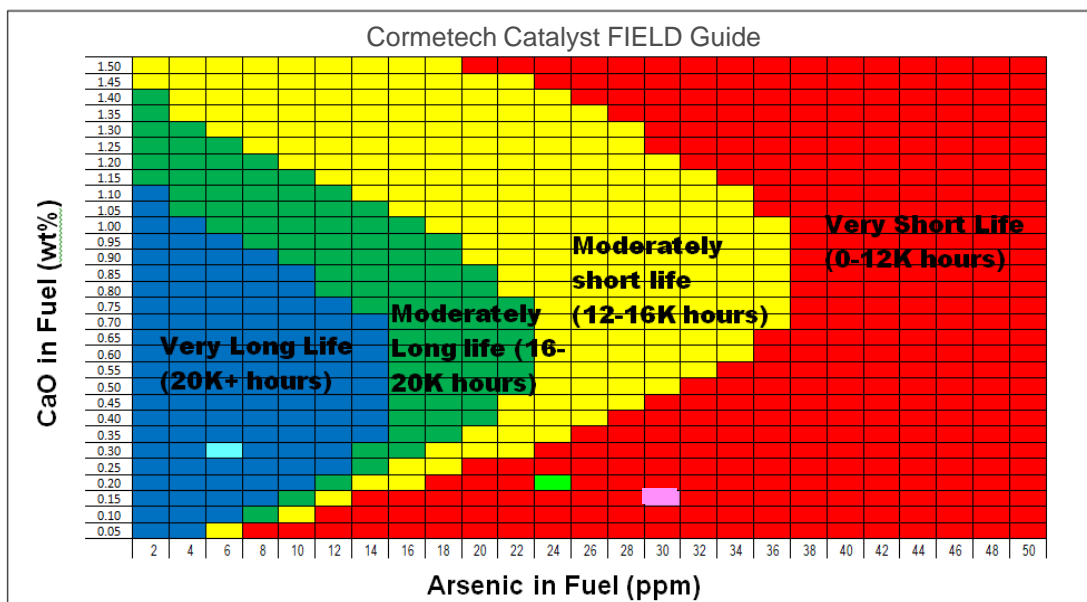
Limestone

# Catalyst



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# Coal Comparisons



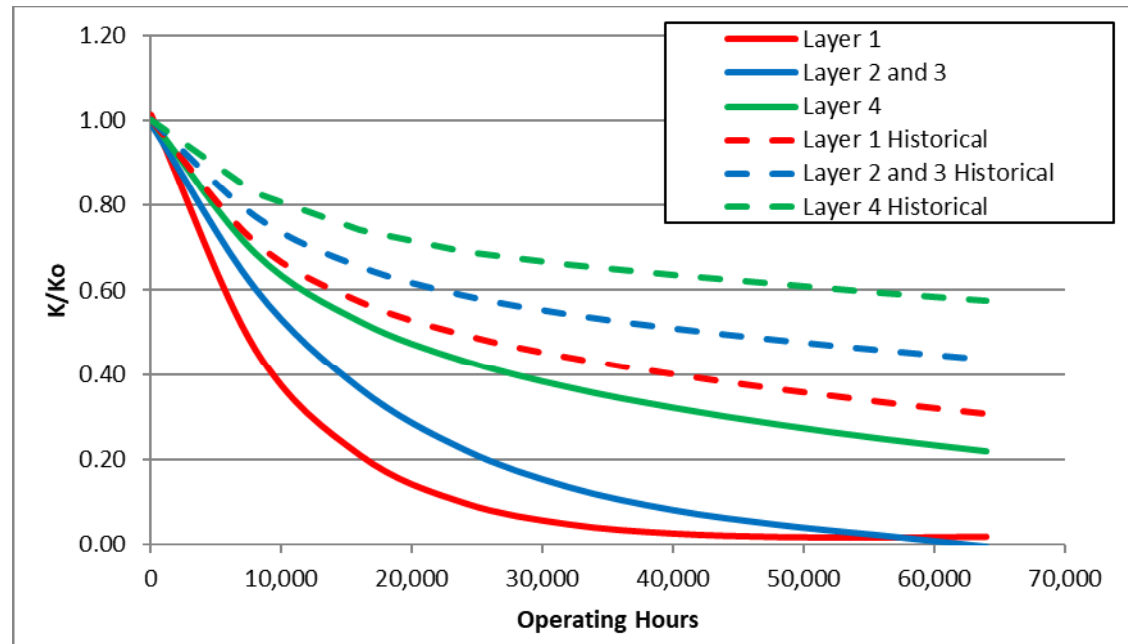
Gibson Coal
Crist Historical
Gorgas - AL coal

Fuel	Gibson Coal	Crist Historical	Gorgas (AL coal)
CaO in Ash (% dry)	1.66%	3.13%	1.78%
Ash% (dry)	8.01%	9.79%	12.46%
CaO in Fuel (% dry)	0.13%	0.31%	0.22%
As in fuel (ppmw, dry)	29.69	4.53	23.97
CaO/As Ratio (x 10 <sup>5</sup> )	4.5	67.6	9.3
Deactivation rate @ 16k hrs.	0.35	0.65	0.485



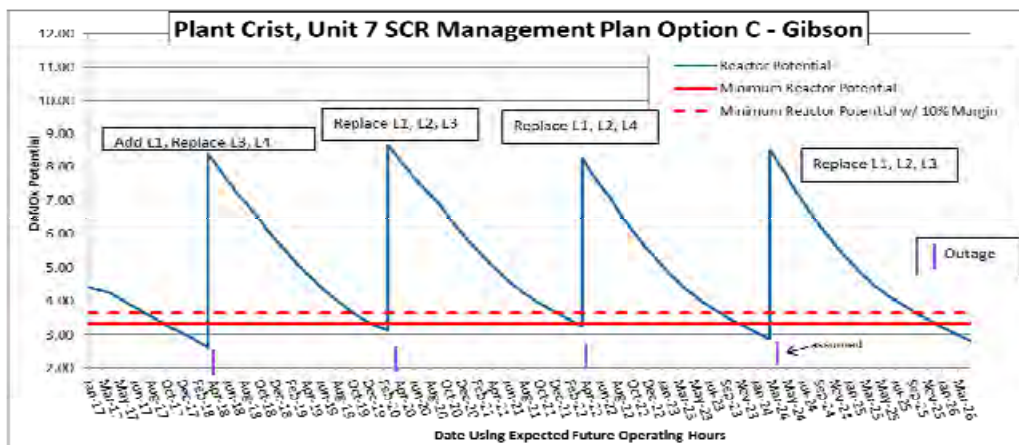
## Deactivation Rates- Predicted

- Historical deactivation rate.  
Crist 7= 0.65 @ 16k hrs
- Predicted deactivation rate.  
Crist 7= 0.35 @ 16k hrs

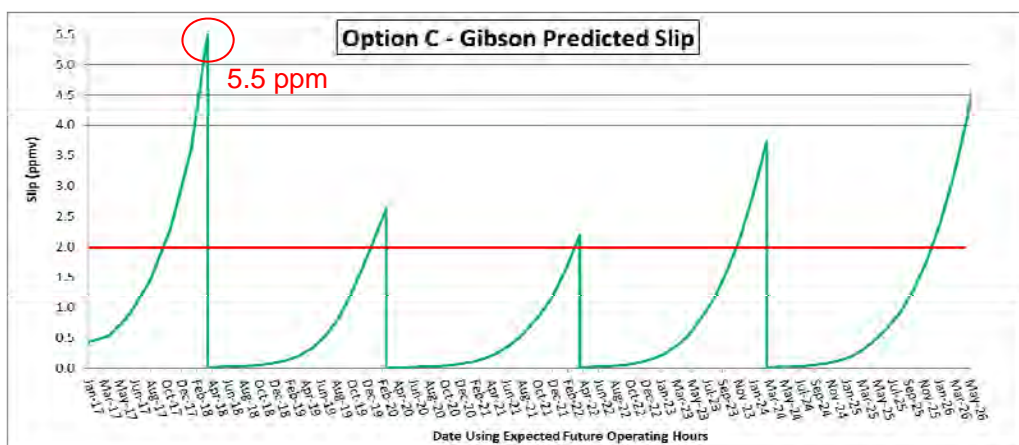




## Catalyst Management Plan @ Predicted Deactivation



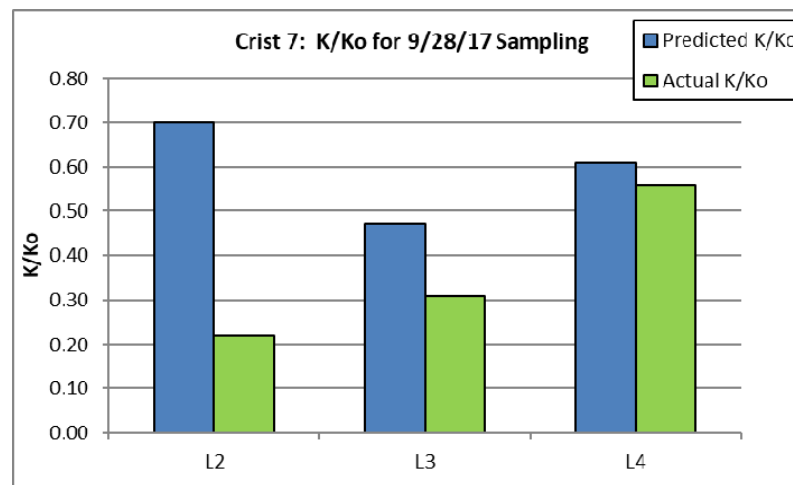
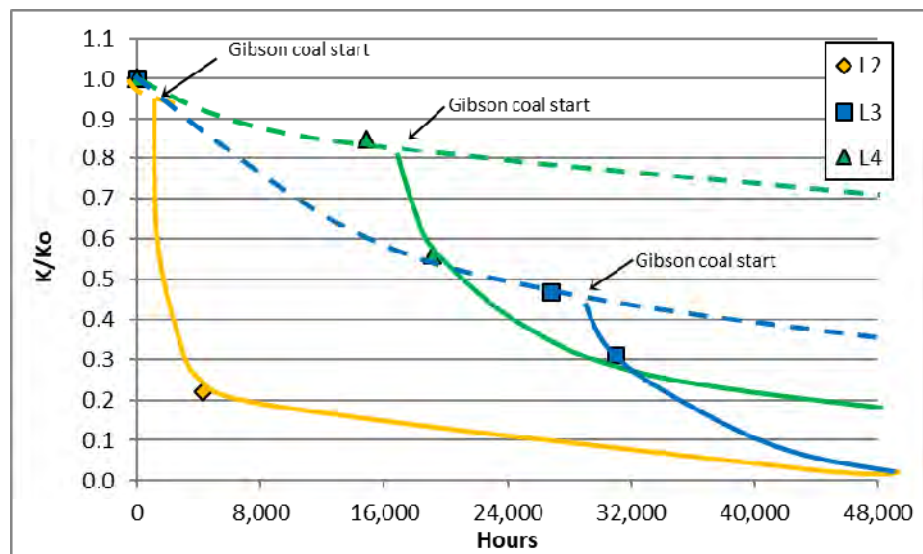
100% Gibson Coal No limestone addition-  
Deactivation rate = 0.35 @  
16k operating hours.  
(Predicted)





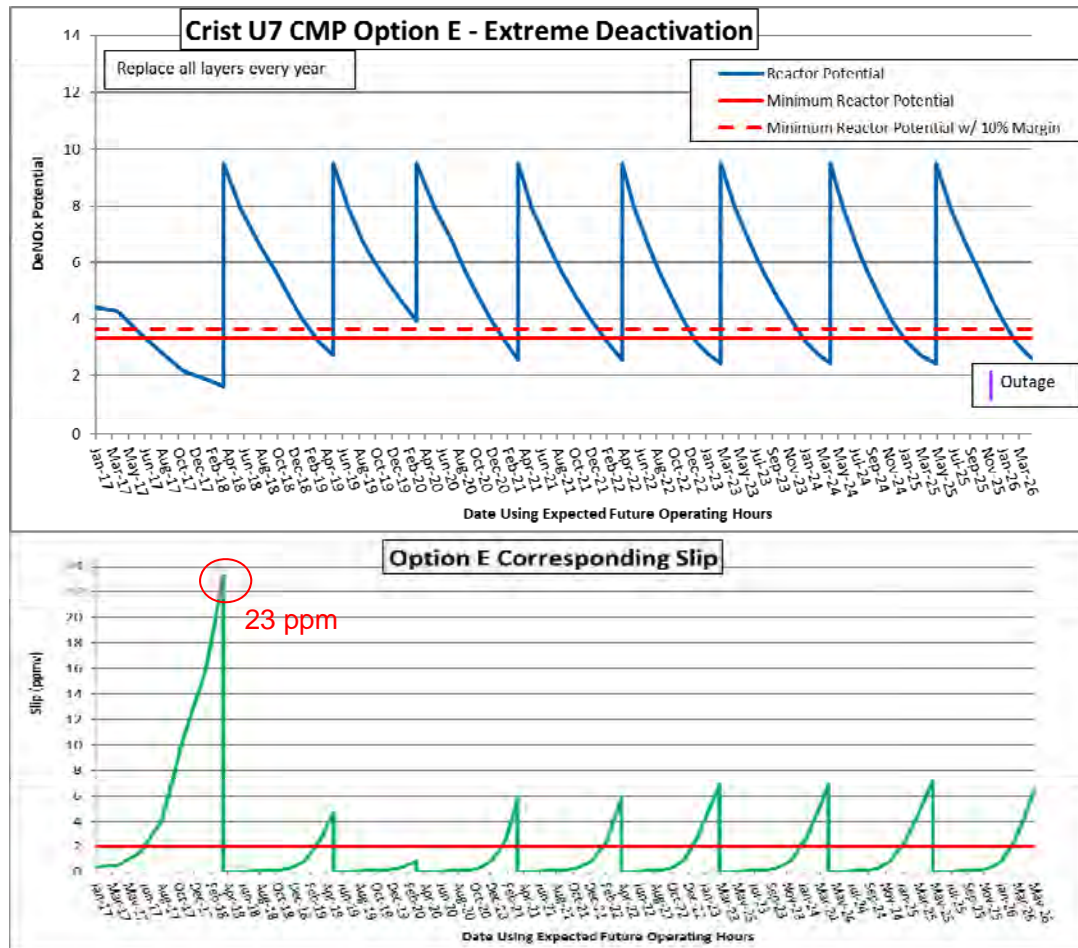
## Deactivation Rates- Actual

- Actual deactivation rate.  
Crist 7~ 0.15 @ 16k hrs (top layer)





## Catalyst Management Plan @ Actual Deactivation

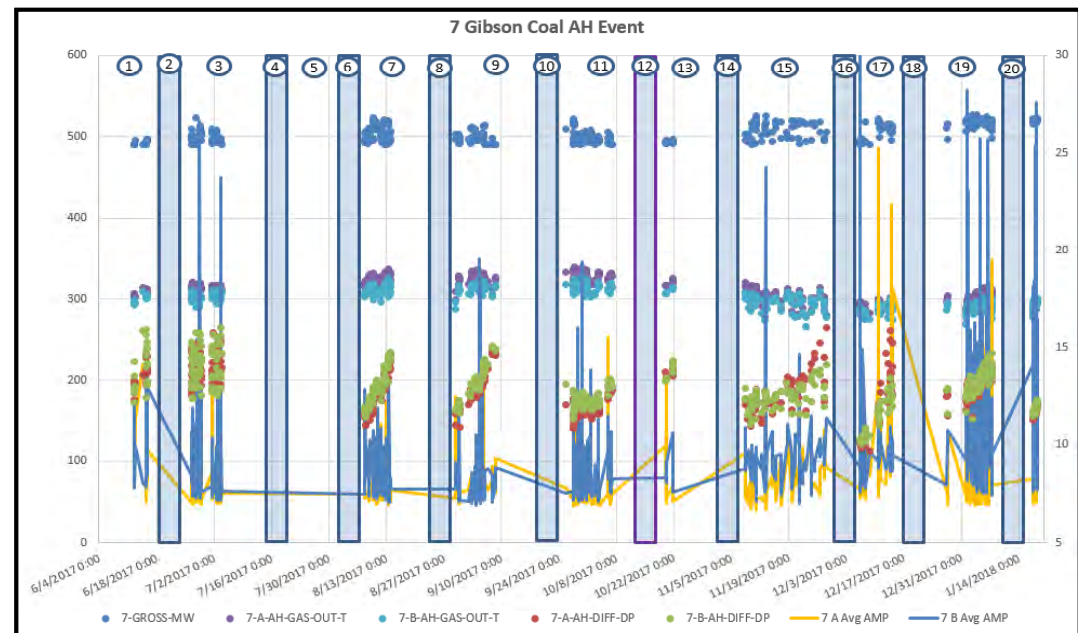


100% Gibson Coal No limestone addition-  
Deactivation rate = 0.15 @  
16k operating hours (Top layer). (Actual based on most recent activity test)



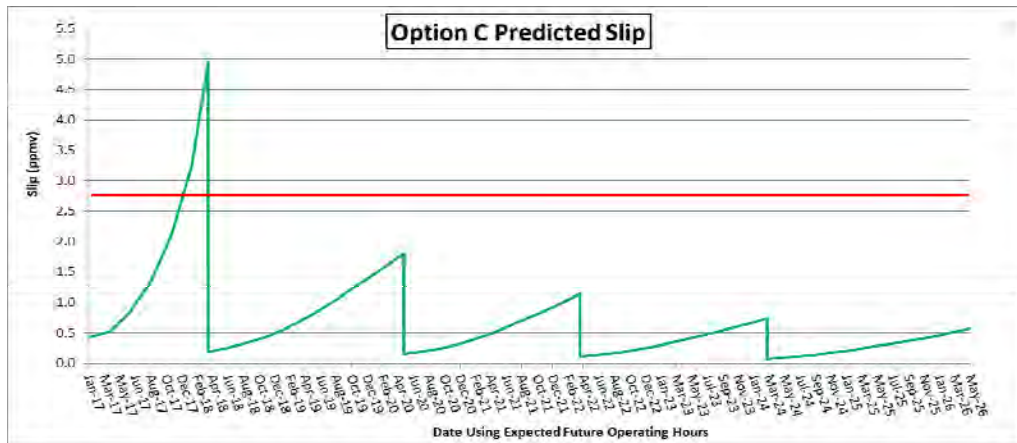
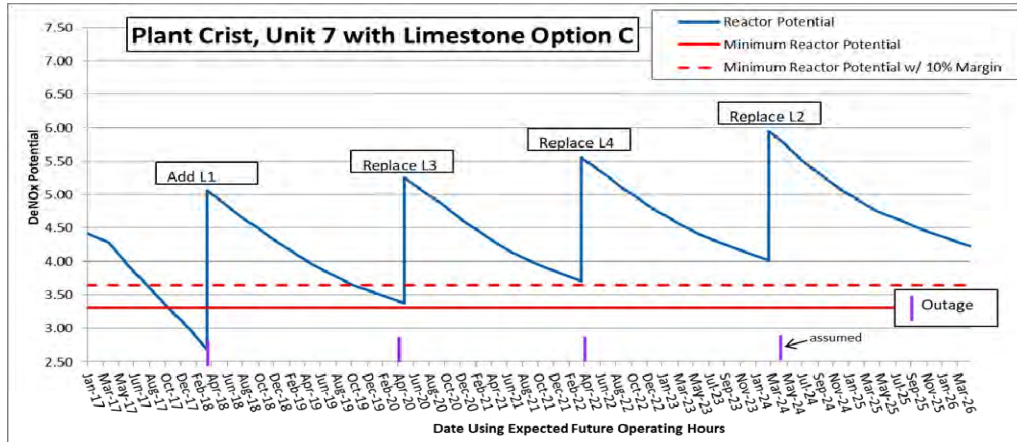
## Severe ABS fouling in the horizontal AH:

- Severe operating conditions seen at Plant Crist over the past 7 months. The Plant has come offline 9 times for air heater washes.
- HLI upstream of AH began at the end of September.
- NH3 slip testing indicated the current NH3 slip ~ 12.5 ppm



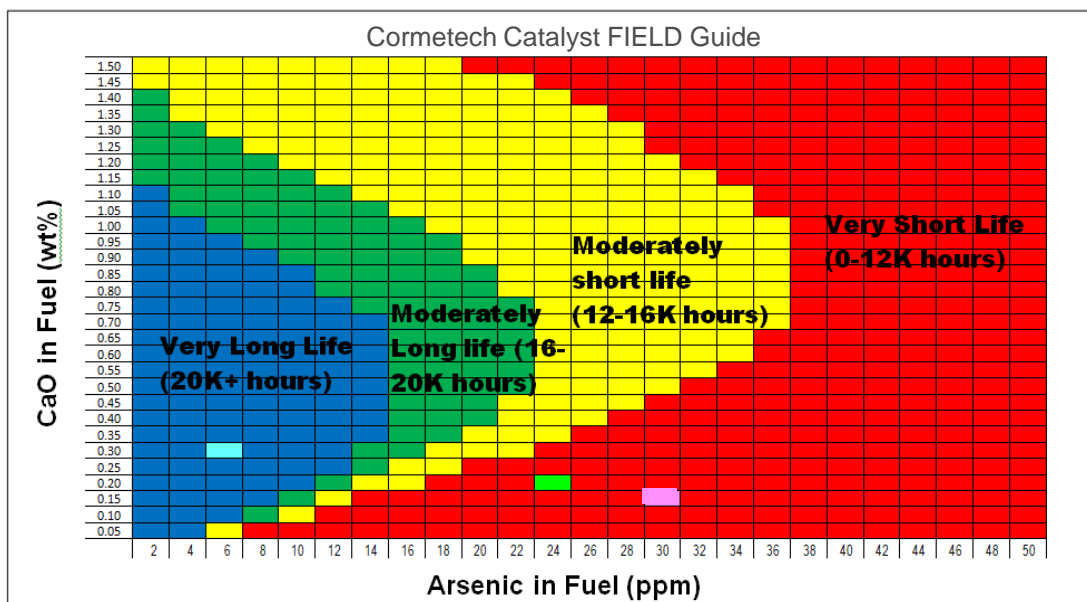


# Catalyst Management Plan Predicted with Limestone mitigation



Limestone Addition-  
Deactivation rate = 0.65 @  
16k operating hours.  
(Predicted- “overly  
optimistic”?)

# Coal Comparisons

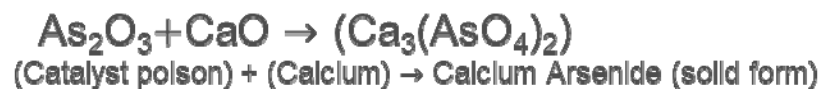
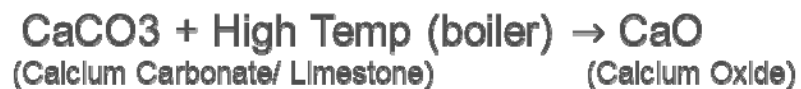


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## Limestone Reactions:



### Poisoning:

Deactivation of active catalyst sites by chemical attack

Pore System Catalyst Surface Active Sites



i.e. Arsenic, Phosphorus,

Not enough calcium

### Masking:

Macroscopic blockage of catalyst surface by dense second-phase coating

Dense Second-phase Coating



i.e. Calcium, Magnesium

Too much calcium

# Crist 7- Limestone Mitigation- Validation Testing

## Challenges:

Lead time on test equipment.

Compressed test schedule. (1-2 weeks of testing time)

No immediate feedback on Test Results

Must complete before upcoming outage.

## Goals:

Verify effectiveness at Plant Crist.

Optimize limestone flowrate for Gibson fuel.

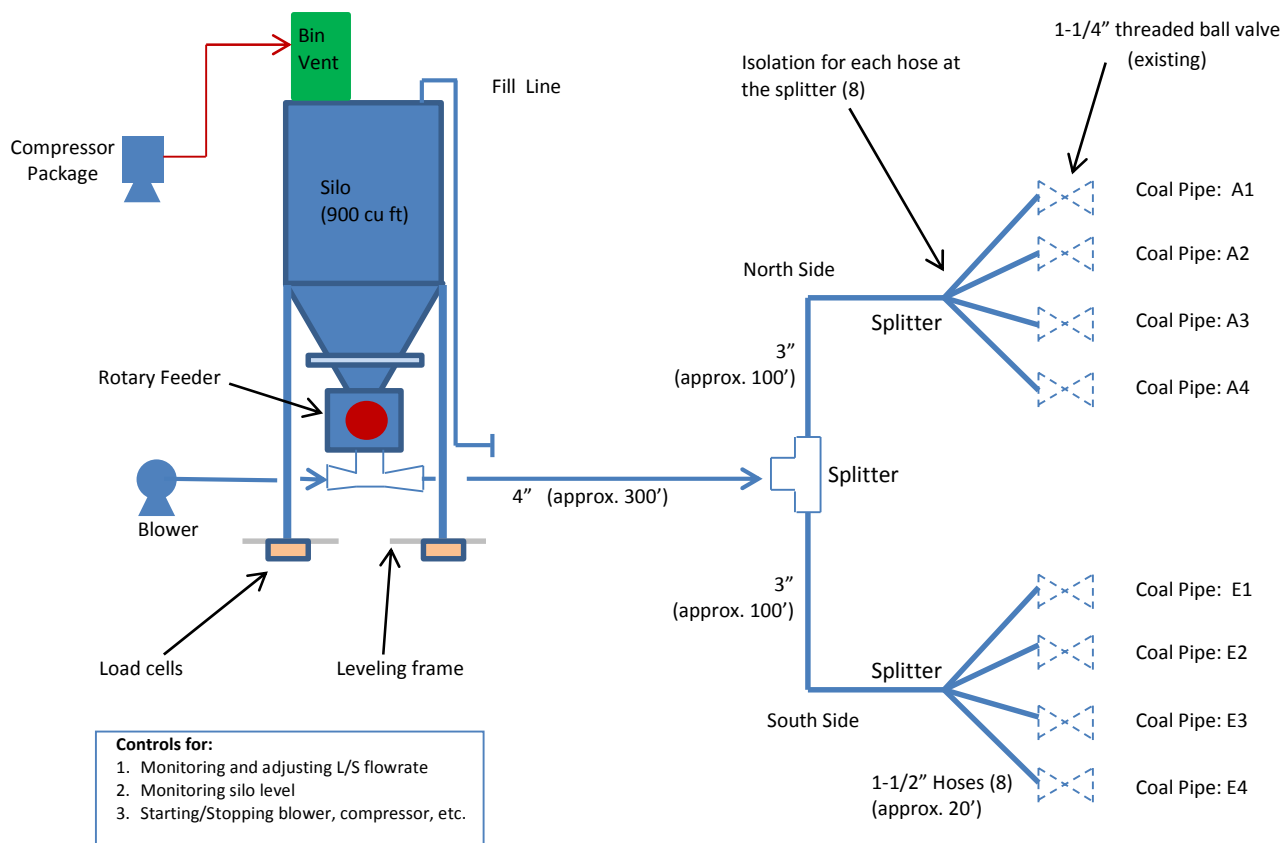
Update economic analysis

# Test Plan



Crist 7 Limestone into Boiler feed pipes															
Rev 10- 2/2/18	UNIT OPERATIONS					Testing									
Week	Date	Day	Test Condition	Target(s)	Load (MW)	Limestone addition		Gas Measurements						Solids Samples	
						Added to coal belt		Pre-SCR			Post-SCR			Unit 7	
						Flow (lb/hr)	Flowrate (%)	Method 29 Metals (As)	SO3	Trap (As)	Method 29 Metals (As)	SO3/ NH3 slip	Trap (As)	Coal Analysis	*ESP Ash (CaO, Cl, SO3 concentrations)
<b>Evaluation of the effectiveness of limestone addition to the coal in order to decrease the concentration of gaseous arsenic going into the SCR.</b>															
1	Tuesday, January 30, 2018	1 - morning	full load baseline	As <sub>2</sub> O <sub>3</sub>	Low	0	0	2 runs	Low (1)	2 runs	1 run			1 per day	Baseline sample
		1 - afternoon		CaO	Full	0	0	2 runs	Full (1)	2 runs	1 run		1 run		
	Wednesday, January 31, 2018	2 - morning	full load at 2 injection rates	"	Full	2,600	0.50%	2 runs	1- up duct	1 run				1 per day	1 sample @ each flowrate
		2 - afternoon		"	Full	3,500	0.60%	2 runs	1- Fgas in	1 run	1 run		1-fgas out	1 run	
	Thursday, February 1, 2018	3 - morning	Full load & low load-2 runs	"	Full/Low	2700/	0.5-0.75%	2 runs	1 run no NH3	2 runs				1 per day	1 sample @ each flowrate
		3 - afternoon		"					<b>Rotary feeder Modification</b>						
	Friday, February 2, 2018	4 - morning	full load at 2 injection rates	"	Full	4,400	0.75%	2 runs		2 runs				1 per day	1 sample @ each flowrate
		4 - afternoon	NH3 slip & SO3- no NH3 injection	"	Full	5,700	1.30%	2 runs		2 runs			NH3 slip test 12.58 ppm		
	Saturday, February 3, 2018	5 - morning	full load at 2 injection rates	"	Full	TBD	TBD	2 runs		1 run				1 per day	1 sample @ each flowrate
		5 - afternoon		"	Full	TBD	TBD	2 runs		1 run					
Sunday, February 4, 2018	6 - morning	low load at 2 injection rates	"	Low	2,700	0.75%	2 runs		1 run				1 per day	1 sample @ each flowrate	
	6 - afternoon		"	Low	3,500	1.30%	2 runs		1 run						
2	Monday, February 5, 2018														
	Tuesday, February 6, 2018														
	Wednesday, February 7, 2018														
	Thursday, February 8, 2018														
	Friday, February 9, 2018														
	Saturday, February 10, 2018														

# Arsenic Control Through Limestone Addition:



## Arsenic Control Through Limestone Addition:



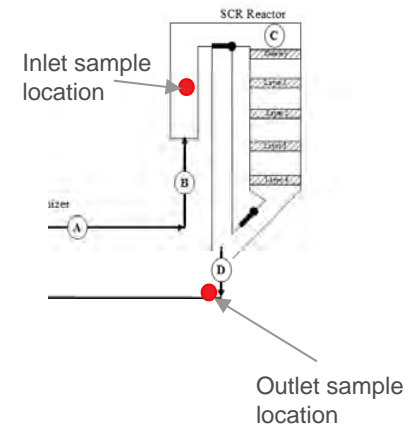
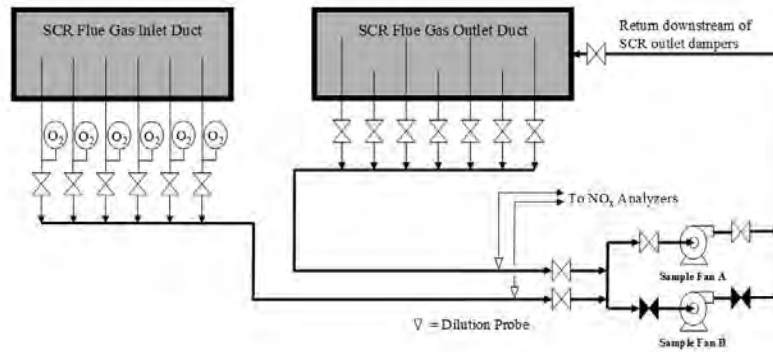
## Arsenic Control Through Limestone Addition:



Test ports were installed at both the inlet & outlet of our fgas system:

- 6 point inlet sample
- 7 point outlet sample

4.10 FLUE GAS ANALYSIS SYSTEM (FGAS) SCHEMATIC – FIGURE 10



## Arsenic Control Through Limestone Addition:



Trap

M29

Inlet

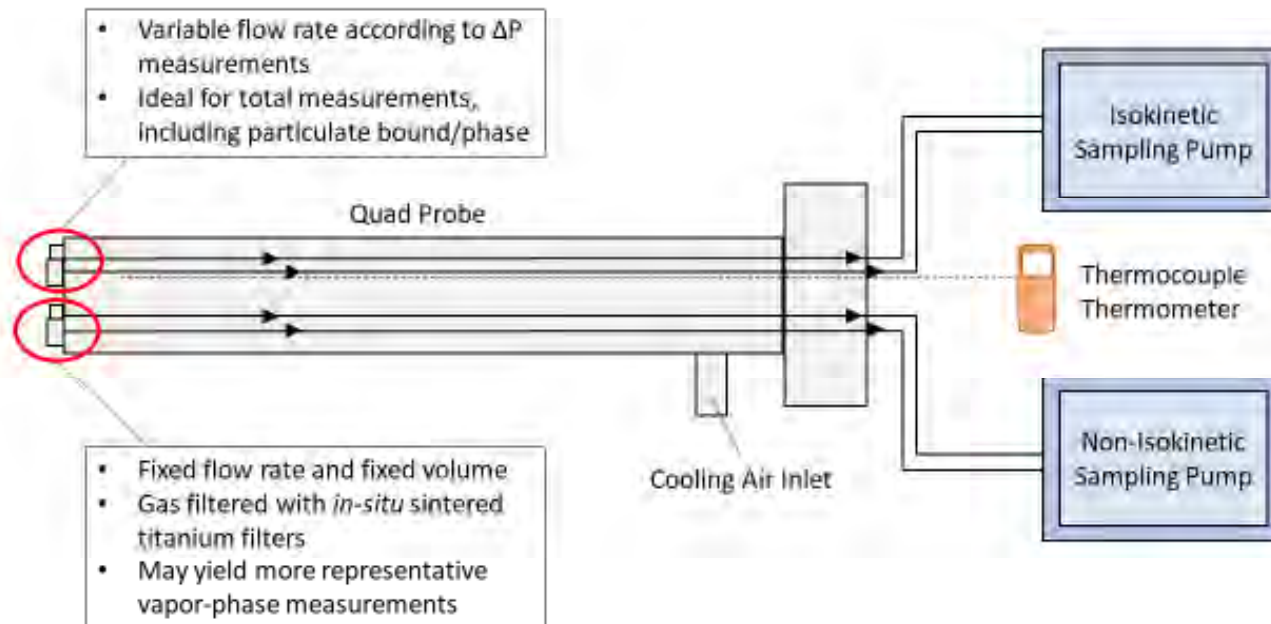
Outlet



## Arsenic Control Through Limestone Addition:



### Ohio Lumex Quadruplet Sampling System for Arsenic Conceptual Overview





## Preliminary Test Data- Data analysis is not complete

### • Method 29 Data Set

- 21 data points taken at inlet of SCR.
- 17 of the 21 data points were below the reporting limit of 1 ( $\mu\text{g}/\text{m}^3$ ) (Suspect values)
- 11 of the data points had arsenic concentrations in the non-detect range. (No value was detected)
- All data points at low load were non-detect.
- More difficult to draw conclusions from results.

### Ohio Lumex- Arsenic Trap Data Set

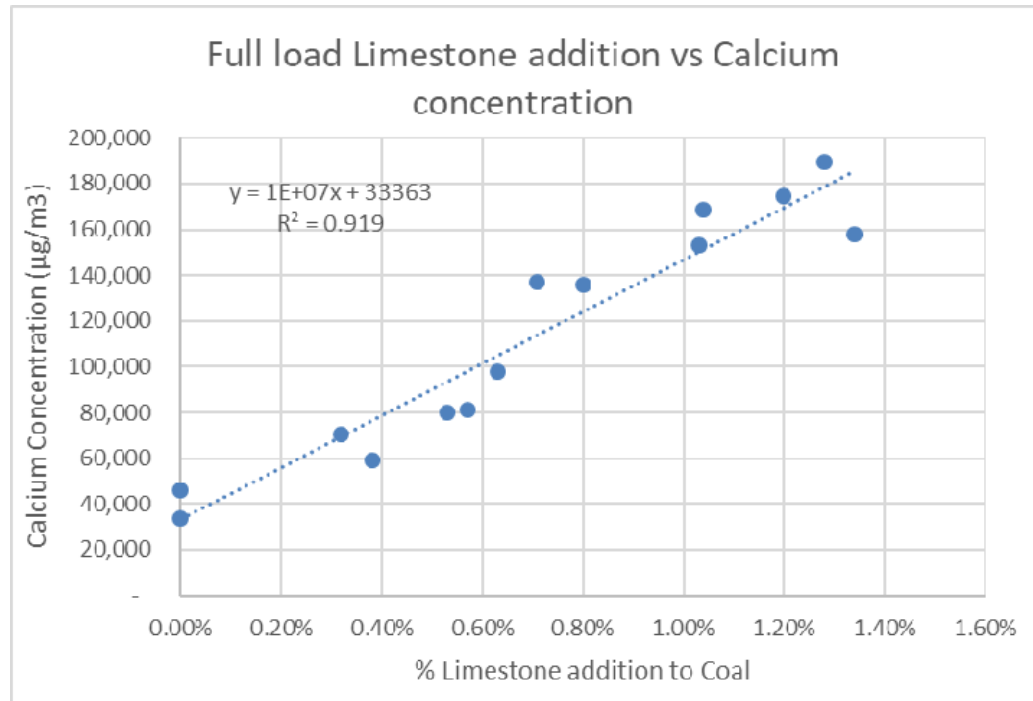
- Tests were performed iso-kinetically and non-isokinetically. Only iso-kinetic tests have been evaluated.
- 30 data points taken at inlet of SCR.
- Data was analyzed all the way down to  $0.09 \mu\text{g}/\text{m}^3$
- Only 3 data points had to be excluded for suspect values or sampling error.



## Results:

As a sanity check the Calcium concentration at the SCR inlet trended as expected with the flowrate increase.

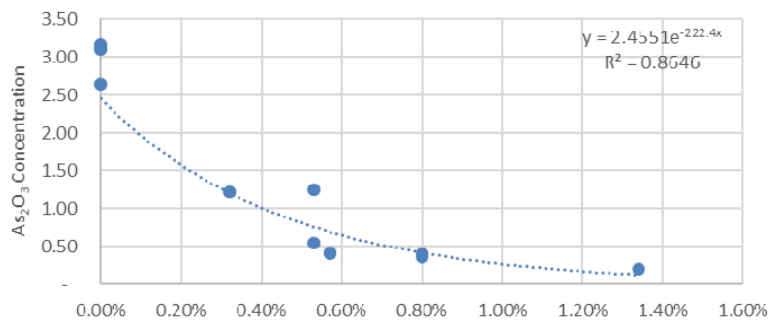
This indicated good mixing, constant equipment feedrate and a representative sample.



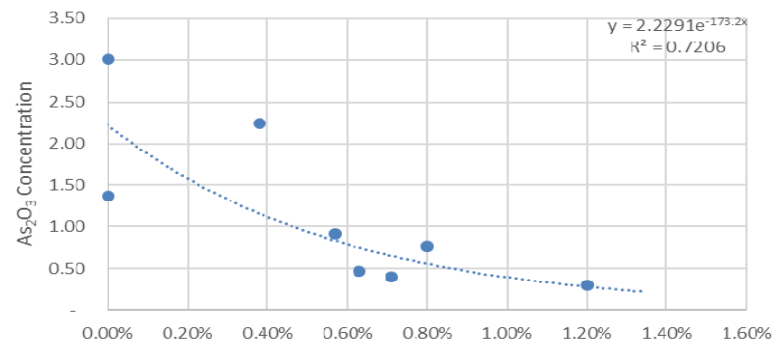
## Results:



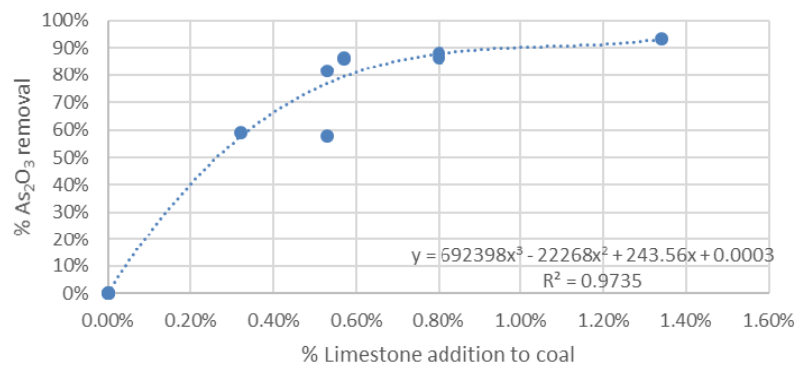
Full load Limestone addition vs arsenic concentration (Trap)



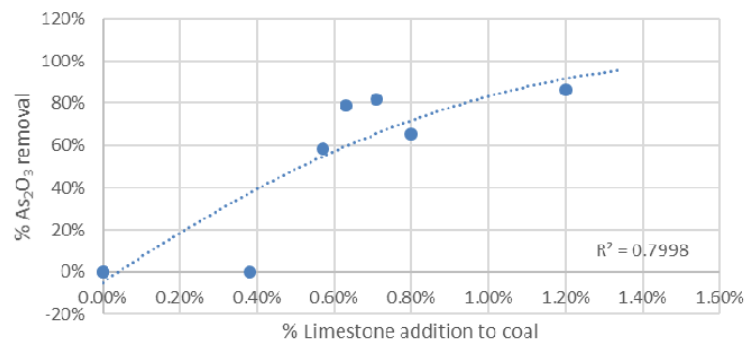
Full load Limestone addition vs arsenic concentration (Method 29)



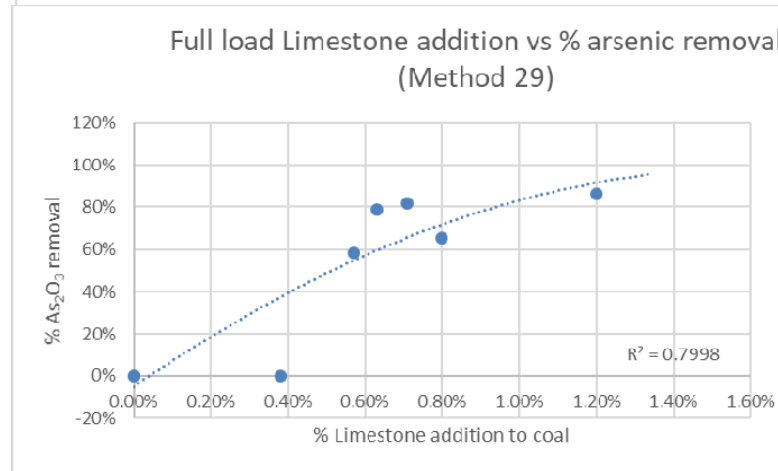
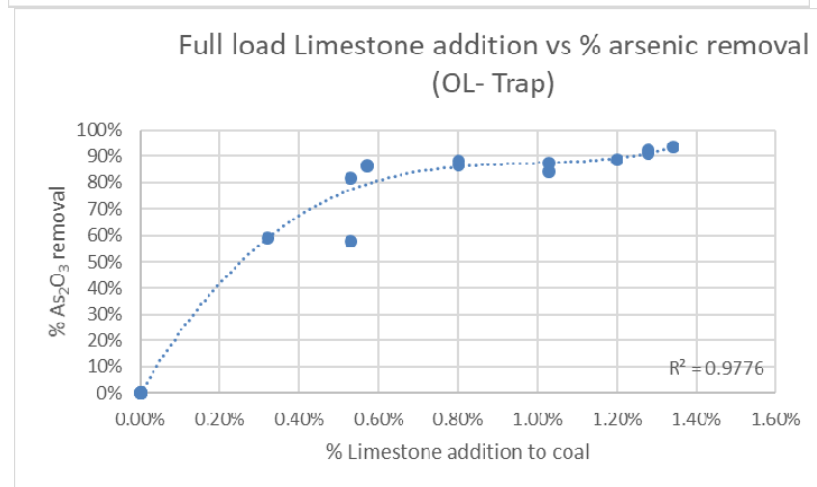
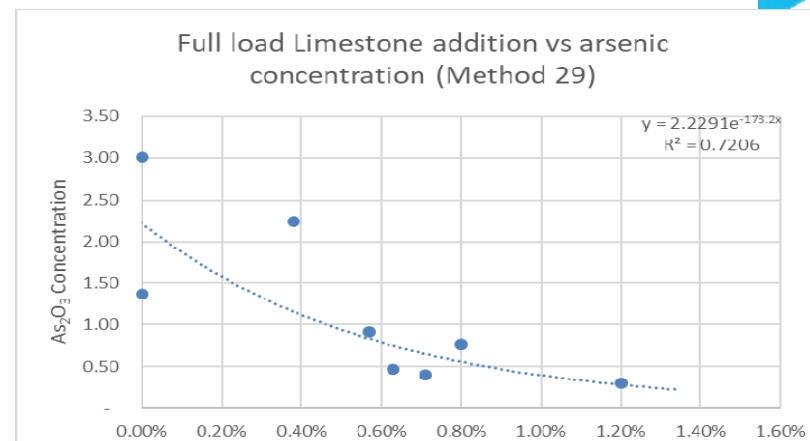
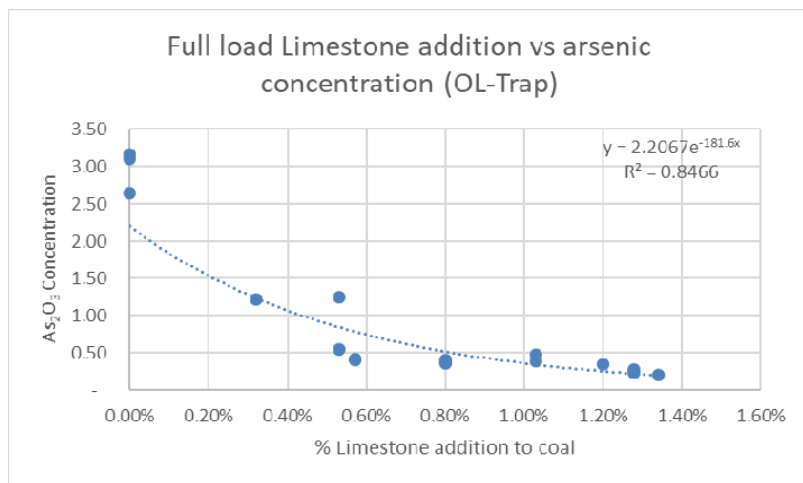
Full load Limestone addition vs % arsenic removal (OL)



Full load Limestone addition vs % arsenic removal (Method 29)



## Results:

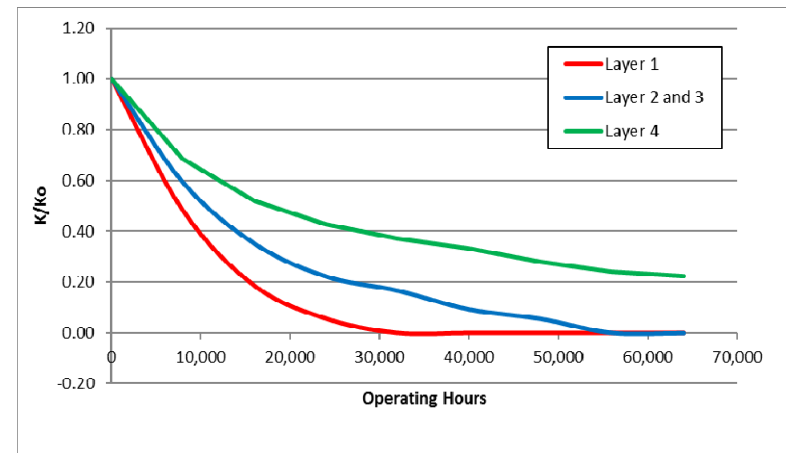
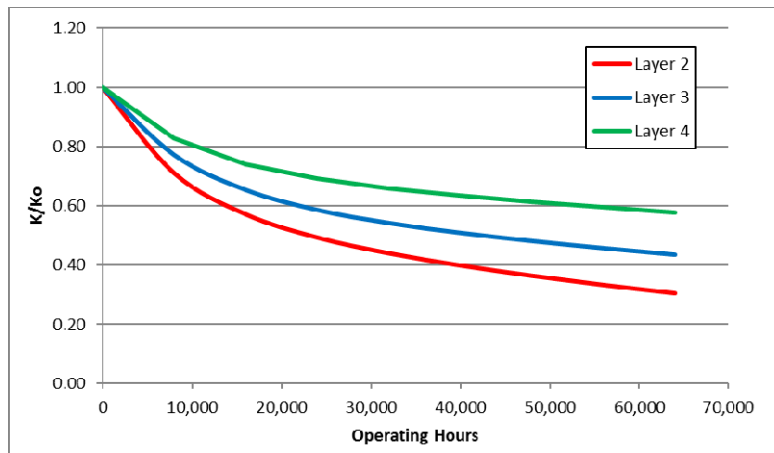






## Deactivation Rates

- Historical deactivation rate Crist 7 = 0.65 @ 16k hrs
- Predicted deactivation rate Crist 7 = 0.35 @ 16k hrs



Deactivation rate acceleration  
factor= 85%

## Arsenic Control Through Limestone Addition:

