In Situ Device for Real-Time Catalyst Deactivation Measurements*

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*** Patent Pending**

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In Situ Measurement of Catalyst Deactivation

- The in situ technique allows measurement of catalyst activity at any time the SCR is in operation
- For year-round operation, opportunities for physical catalyst sampling will be extended to 12 to 18 months
- The in situ technique can fill the information gap between laboratory analysis opportunities
- The in situ technique should not be thought of as a replacement for laboratory analysis of catalyst samples, but as a companion measurement

Measuring Catalyst Activity

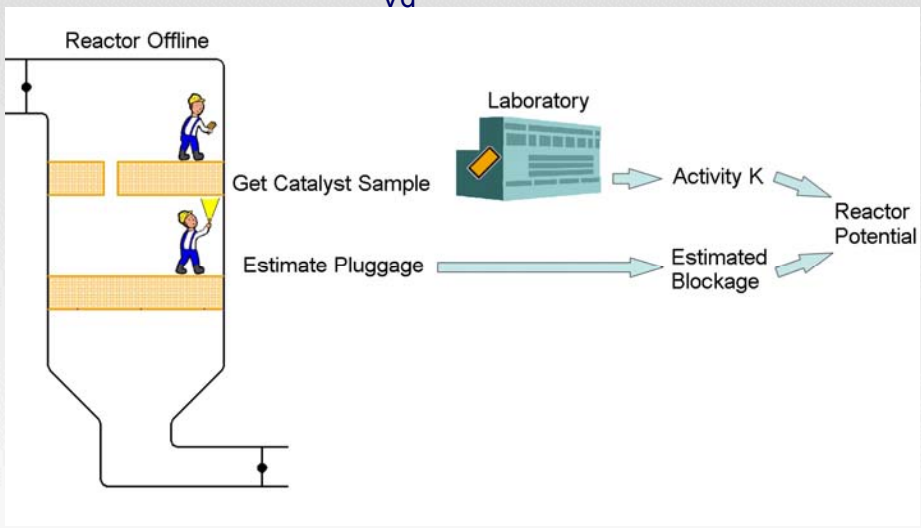
Laboratory:

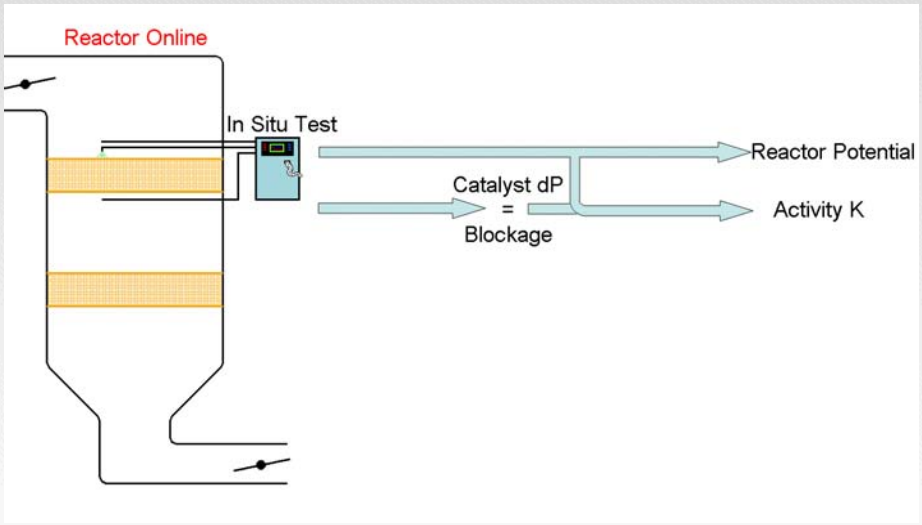
- Test Conditions:
  - A_V = Design
  - $NH_3/NO_x = 1$
- Measure:
  - ΔNO_x
- Calculate:
  - $K = -A_{vd} \ln(1-\Delta NO_x)$
  - $RP = \frac{K}{A_{Vd}}(1-B)$

In Situ:

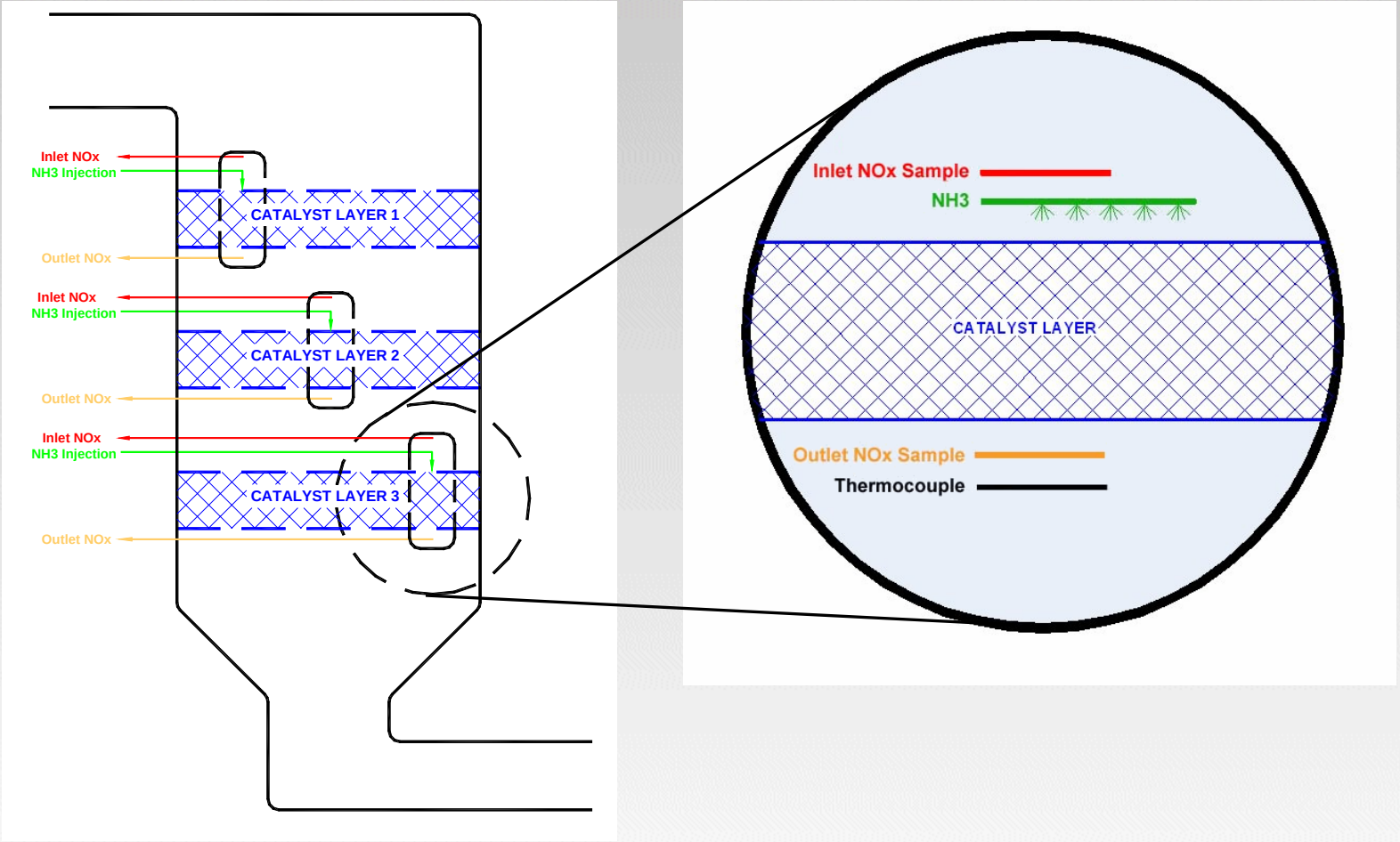
- Test Conditions:
  - $A_{V,FS}$
  - $NH_3/NO_x > 1$

  (NH_3 added only in test sections)
- Measure:
  - ΔNO_x
- Calculate:
  - $RP = K/A_{V,FS} = -\ln(1-\Delta NO_x)$



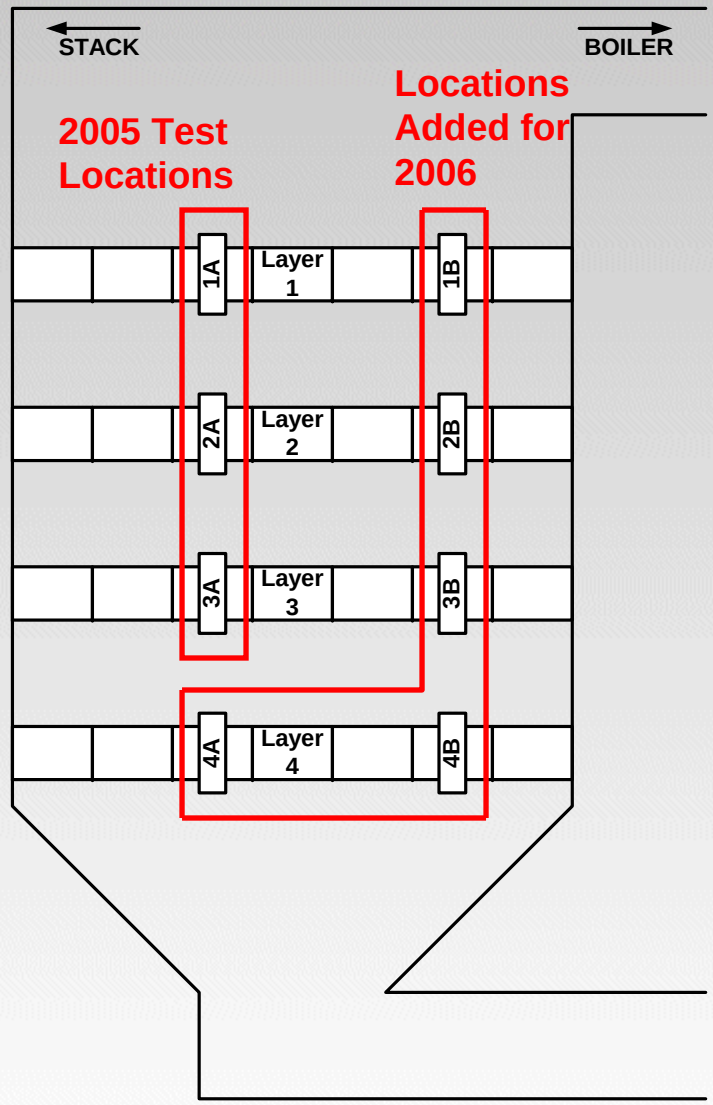


Multiple In Situ Test Modules - General Approach



Demonstration Host Site Provided by Southern Company

- Alabama Power Company's Gorgas Unit 10
  - 700 MW
  - Alabama bituminous coal
- SCR on-line May 2002
  - Seasonal operation
  - Two reactors
  - 3 + 1 configuration
  - Initial load: 3 layers honeycomb catalyst
  - Fourth layer plate catalyst added prior to 2006 ozone season



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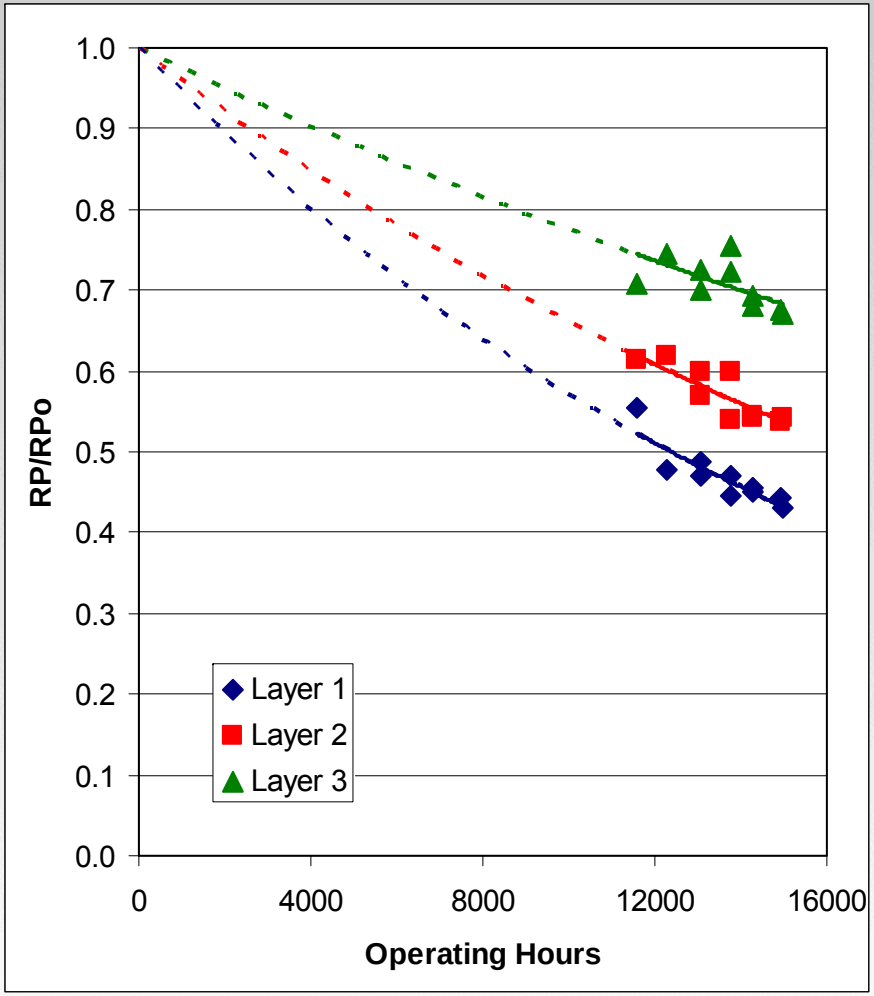
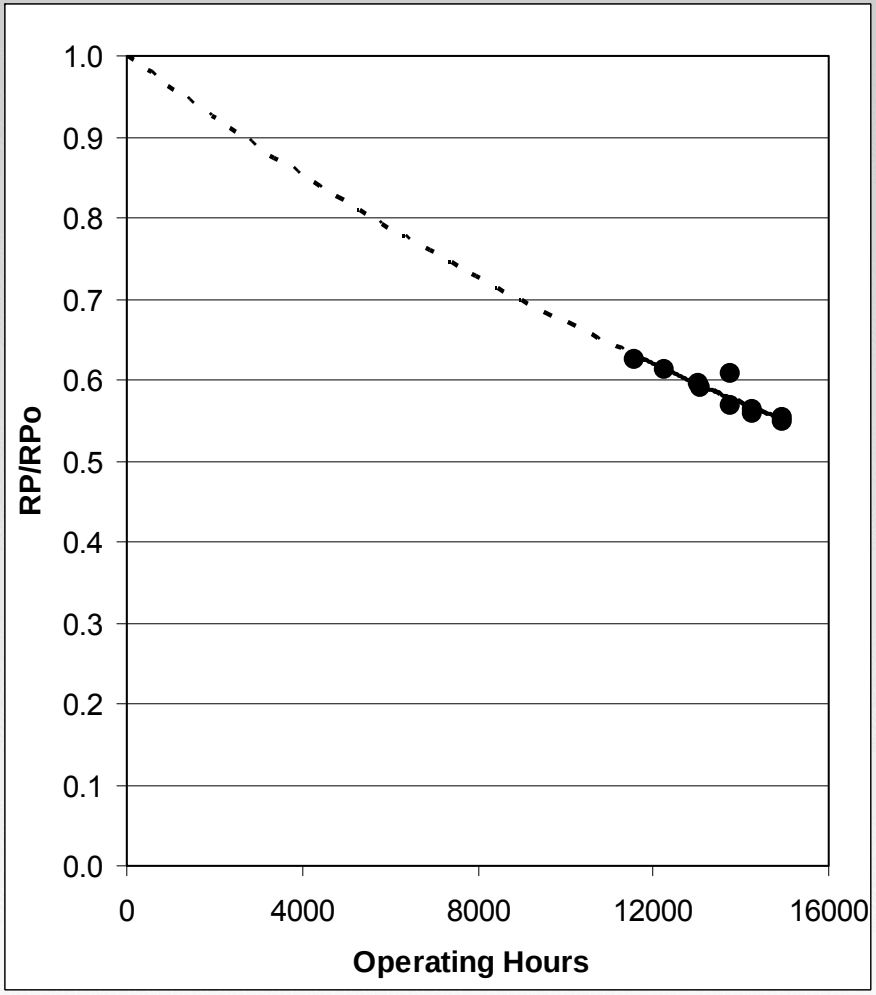
In Situ Reactor Potential Results - 2005

Individual Layers

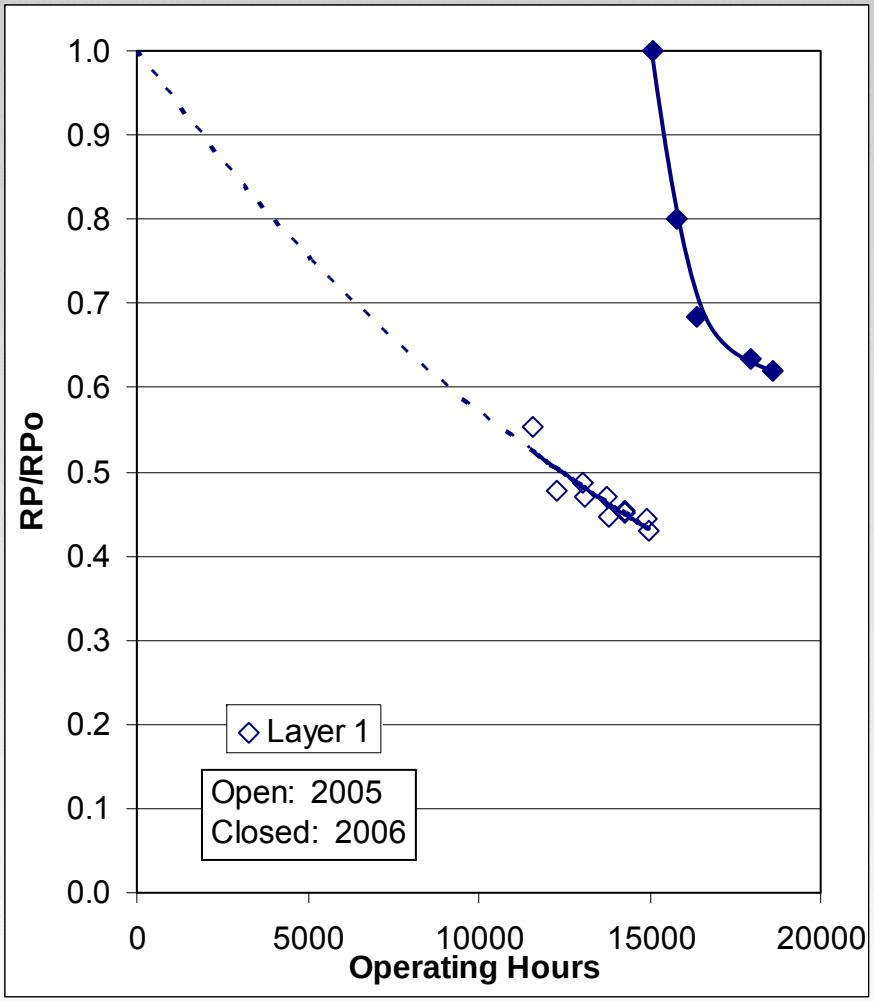


Overall Reactor



In Situ Reactor Potential Results – Layer 1

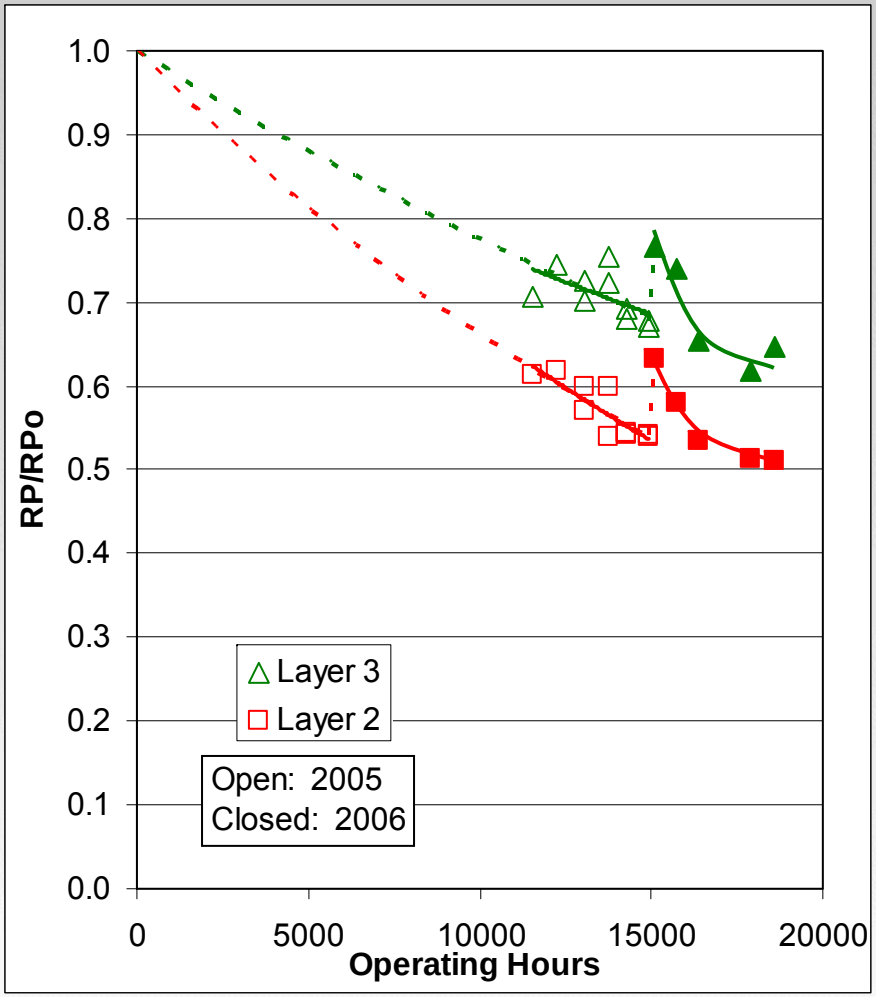
New Catalyst Material Installed before 2006 Ozone Season



- **Rapid decline early in 2006 season due to soot blower non-operation issues**
- **Boiler-side soot blowers for Layers 1, 2 and 3 OOS for 80 to 100 days through August**
- **Loss of reactor potential likely due to catalyst plugging, not true catalyst deactivation**

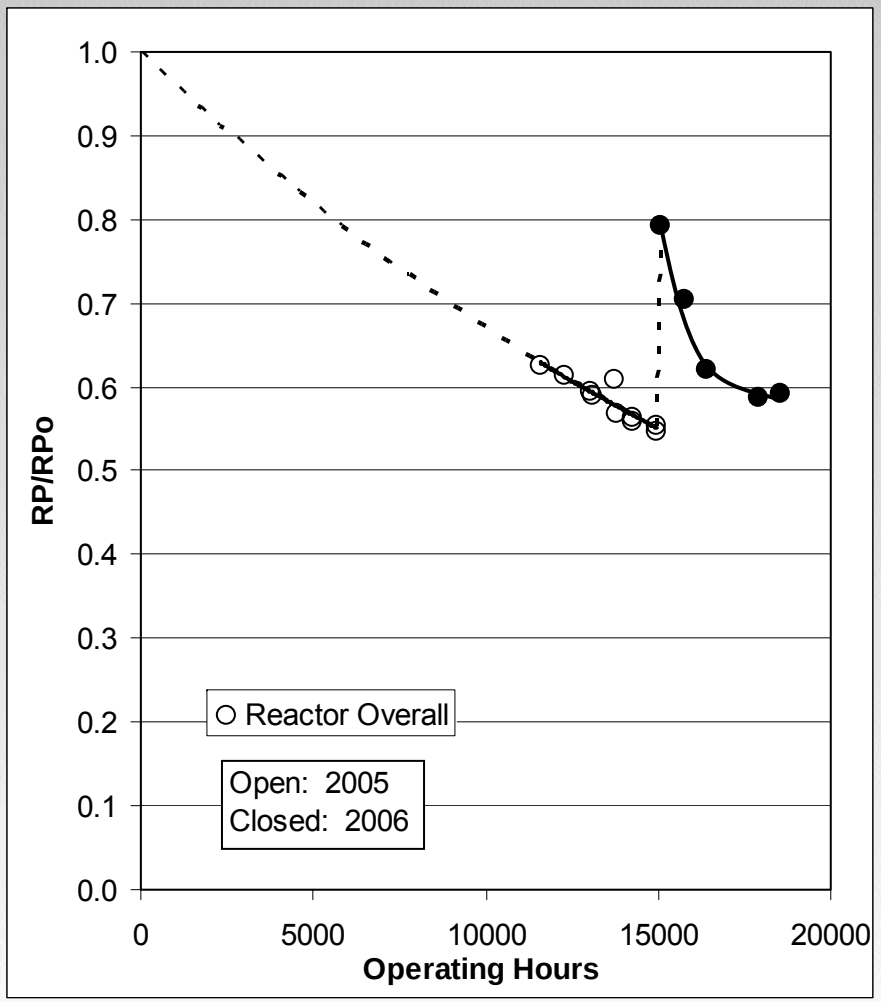
In Situ Reactor Potential Results - Layers 2 & 3

Same Catalyst Material for 2005 and 2006 Ozone Seasons



- **Rapid decline early in 2006 season due to soot blower non-operation issues**
- **RP at the start of 2006 is close to that at the start of 2005**
- **Indicates RP decrease in 2005 due primarily to catalyst plugging, and not deactivation**

In Situ Reactor Potential Results – Overall Reactor



- New layer 1 material and vacuuming of others resulted in 45% increase in overall RP
- Rate of 2006 RP decline after soot blower issues resolved is similar to rate seen throughout 2005

Comparison of In Situ RP to Laboratory K Values

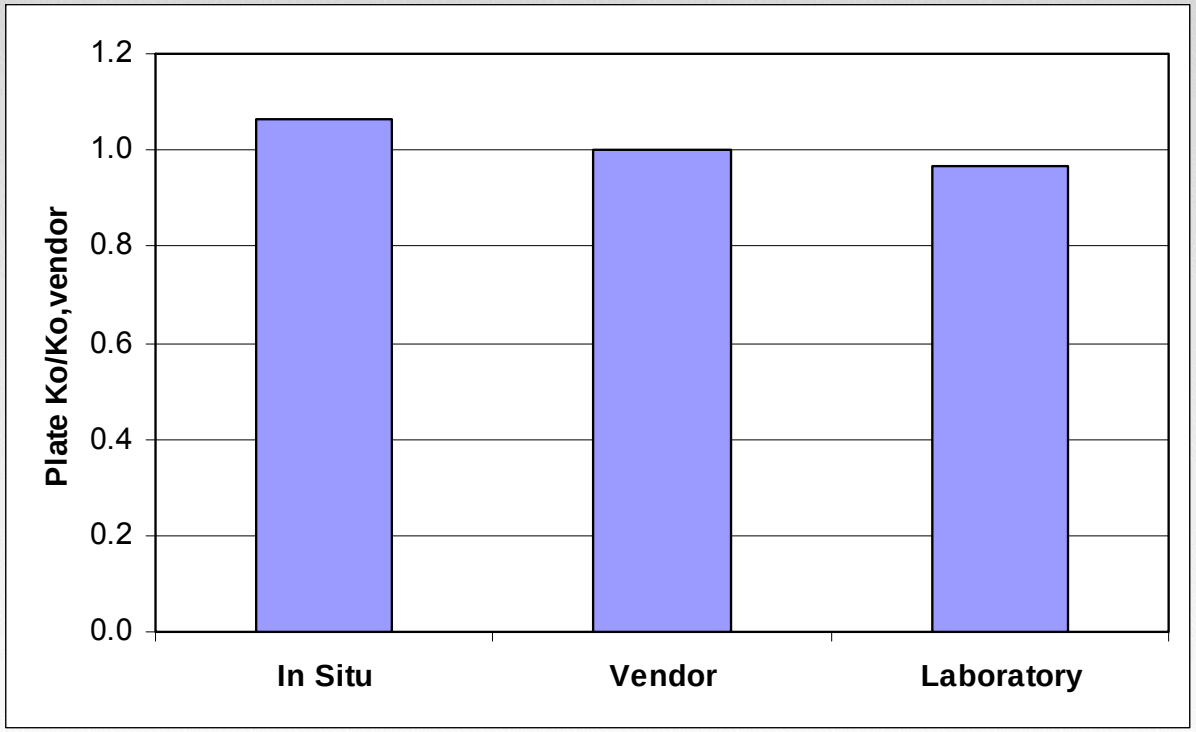
Reactor potential can also be calculated from $RP = \frac{K}{A_{V,cln}}(1-B)$, *where*

- K is the catalyst activity value determined from the laboratory analysis of a sample removed from the catalyst layer
- B is the fractional blockage value for the catalyst layer
  - Calculated from the change in catalyst layer pressure drop from the new (or clean) condition
- $A_{V,cln}$ is the area velocity for the full-scale SCR reactor under clean (i.e. zero blockage), full-load operating conditions
  - Note, the area velocity at which the SCR reactor operates on a day-to-day basis might not be the "design" value.

In Situ Assessment of K_0 for New Plate Catalyst

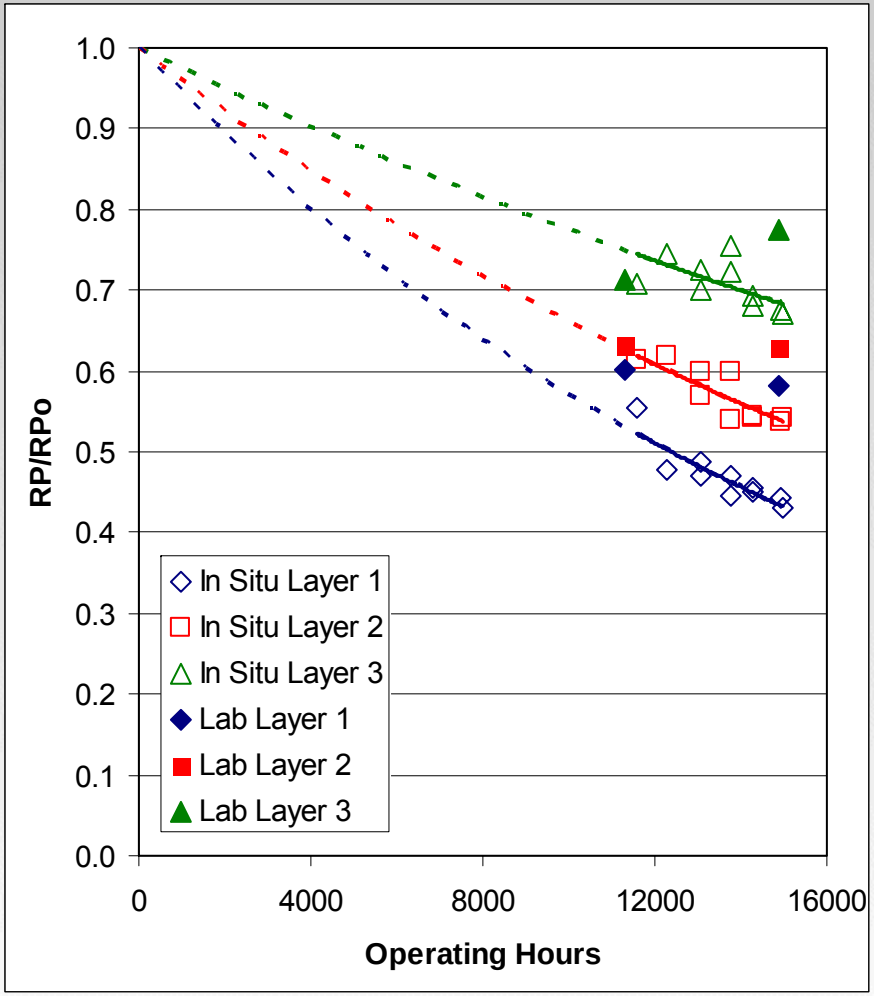
The validity of the relationship between "In Situ RP" and "Lab K" can be assessed by calculating K_0 for the new Layer 1 plate catalyst and comparing the value to the vendor's own value.

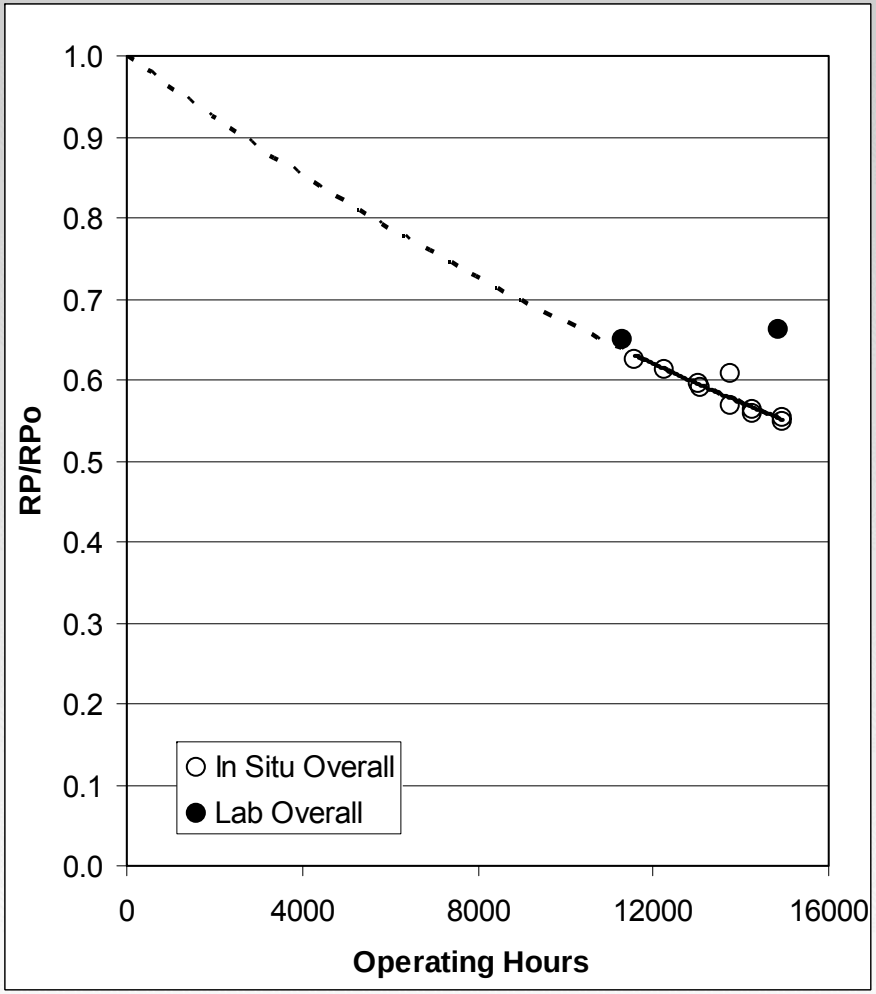
- **K_0 for this material may be calculated from the first set of In-Situ Reactor Potential measurements performed in 2006**
- $$K_0 = \frac{RP_0 A_{V,cln}}{(1-B)}$$



Comparison of 2005 Laboratory and In Situ RP Values

Laboratory Reactor Potential = $K(1-B)/A_{V,cln}$





Why do the In Situ and Laboratory RPs Differ?

Laboratory technique measures K at the design A_V

- Estimated blockage needed to calculate RP may be in error
- Actual flue gas flow may differ from the design flow

In Situ technique measures RP for the same piece of catalyst

- Laboratory uses a different piece for each test
- Possible variations in K across the catalyst layer

Operating Hours	K/K_0 Layer 1	K/K_0 Layer 2	K/K_0 Layer 3
11317 (end 2004)	0.71	0.75	0.79
14870 (end 2005)	0.80	0.78	0.90

In Situ tests at NH_3/NO_x ~ 1.5, laboratory tests at NH_3/NO_x = 1.0

- Increasing NO_x removal at $NH_3/NO_x > 1$ may yield higher RP, but the RP/RP_0 should be the same

Summary

- Prototype in situ system completed operation through two full ozone seasons
- In situ system provided:
  - Real-time tracking of reactor potential
  - Tracking of each catalyst layer independently
  - Larger deactivation data set (not limited to outages)
- 2006 RP data clearly showed the effect of soot blowers being out of service early in the season
- Results indicate RP decrease for Layers 2 and 3 in 2005 was primarily due to catalyst plugging, not deactivation
- The in situ technique should not be thought of as a replacement for laboratory analysis of catalyst samples, but as a companion measurement

Commercial System – Available Early 2007

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