Determining SCR Reactor Potential *In Situ**

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In Situ Measurement of Catalyst Deactivation – Why?

- **Allows measurement of catalyst activity any time the SCR is in operation**
- **For year-round operation there are limited opportunities for physical catalyst sampling**
- **The *in situ* technique supplements laboratory analysis, providing a larger and more complete set of deactivation data from which to base catalyst management decisions**
- **The *in situ* technique should not be thought of as a replacement for laboratory analysis of catalyst samples, but as a companion measurement**

Catalyst Activity and Reactor Potential

Catalyst Activity (K)

- Measure of how active the catalyst material is for reducing NO_x

Reactor Potential (RP)

- Measure of the overall potential of the reactor to reduce NO_x
- Inherently accounts for both catalyst deactivation (K/K_0) as well as catalyst layer blockage, thereby providing a true assessment of the condition of the SCR reactor
- $RP = \frac{K}{A_{V,cln}}(1-B)$ where,

  B = catalyst blockage

  $A_{V,cln}$ = clean area velocity (zero blockage)
- RP is the quantity utilized by catalyst management software programs such as EPRI's CatReact product in the evaluation of various catalyst management strategies

Measuring Reactor Potential

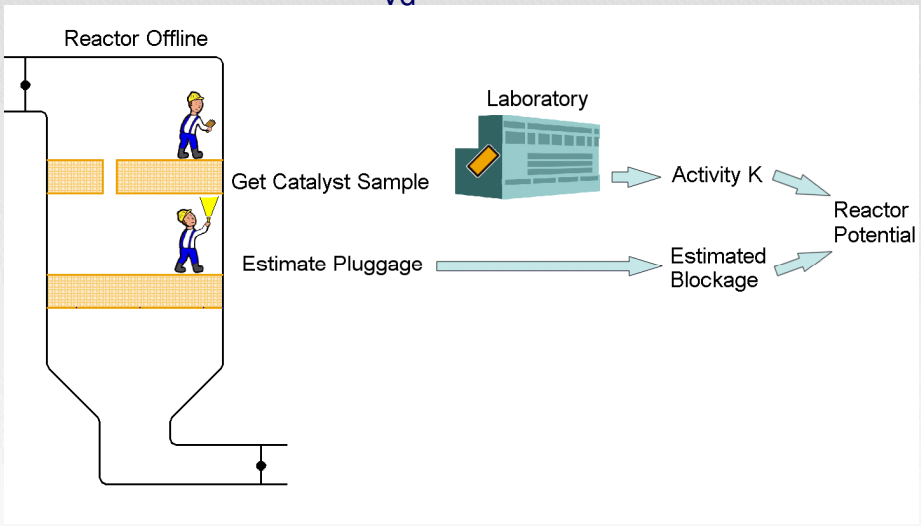
Laboratory:

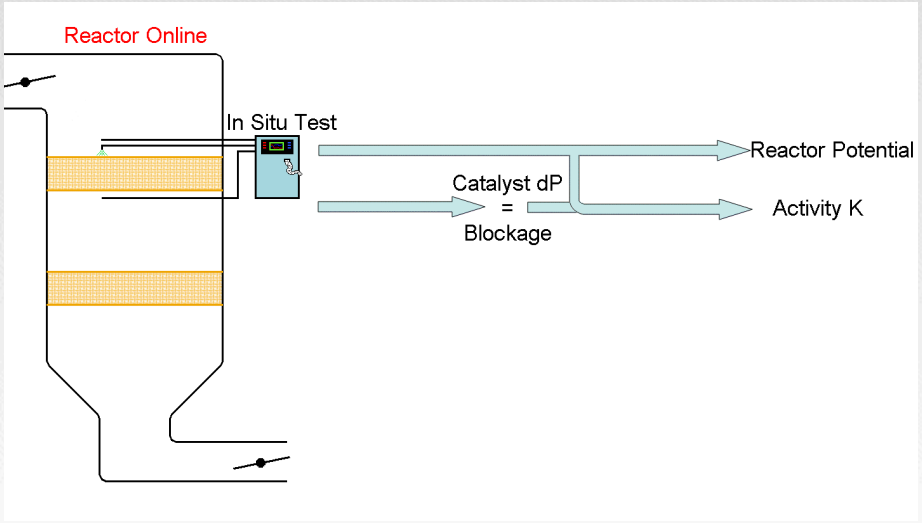
- Test Conditions:
  - A_{Vd} = Design Area Velocity
  - $NH_3/NO_x = 1$
- Measure:
  - ΔNO_x
- Calculate:
  - $K = -A_{Vd} \ln(1-\Delta NO_x)$
  - $RP = \frac{K}{A_{Vd}}(1-B)$

In Situ:

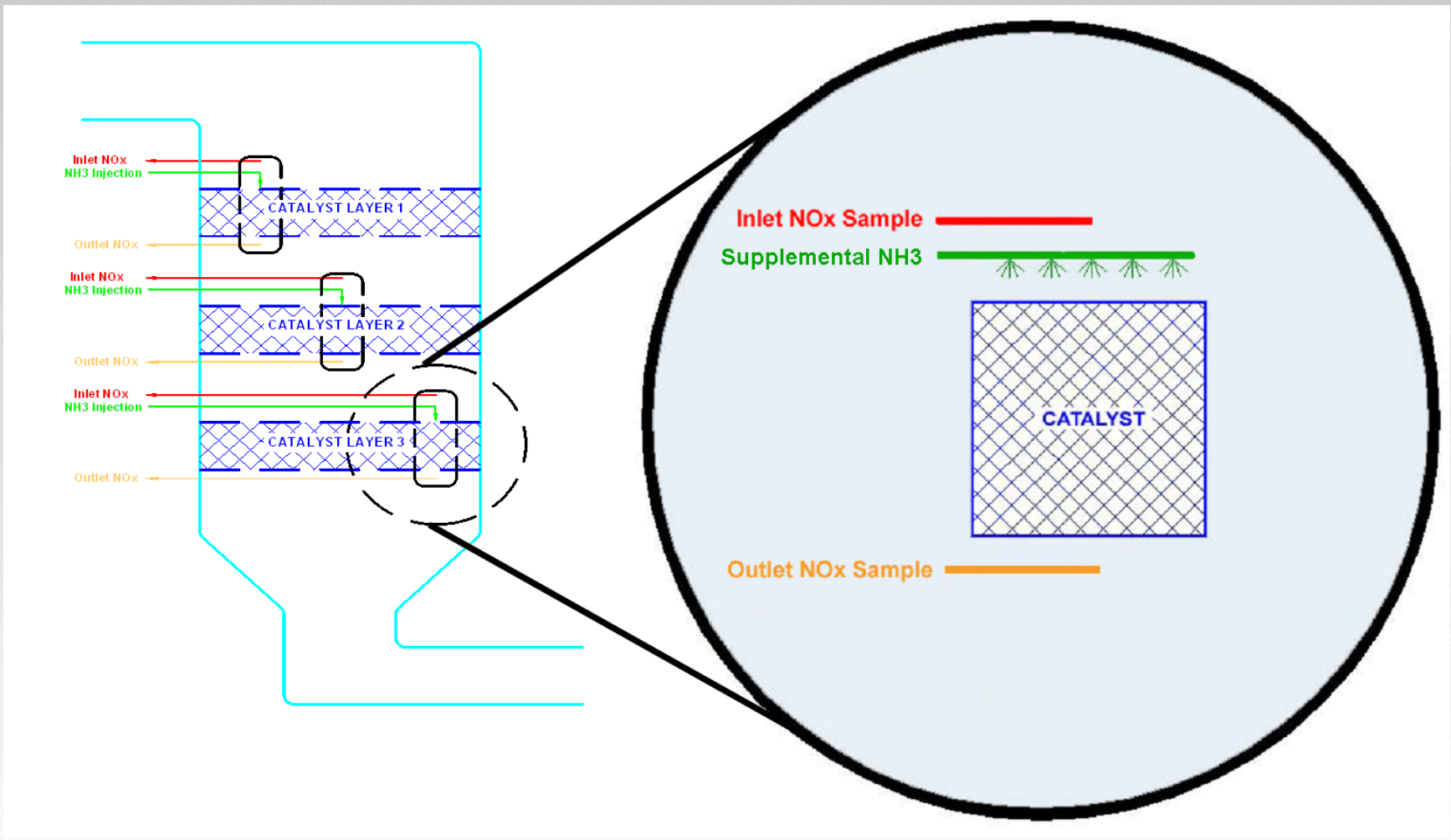
- Test Conditions:
  - $A_{V,FS}$ = Full-Scale Area Velocity
  - $NH_3/NO_x > 1$

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



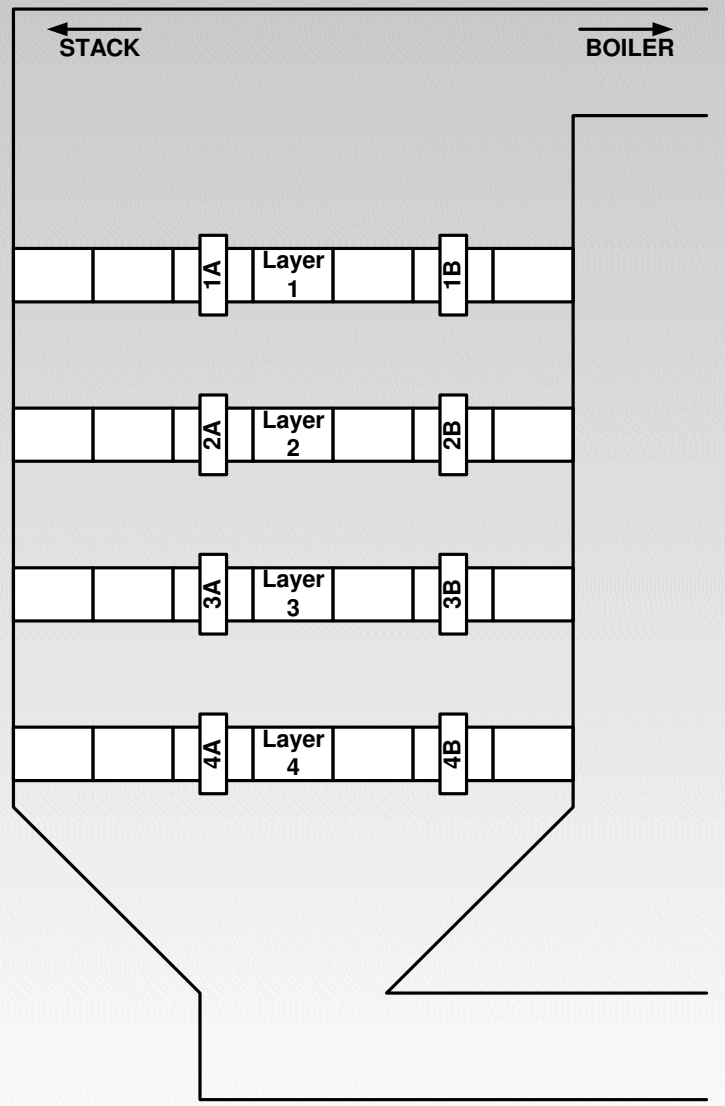


In Situ Test Modules - General Approach



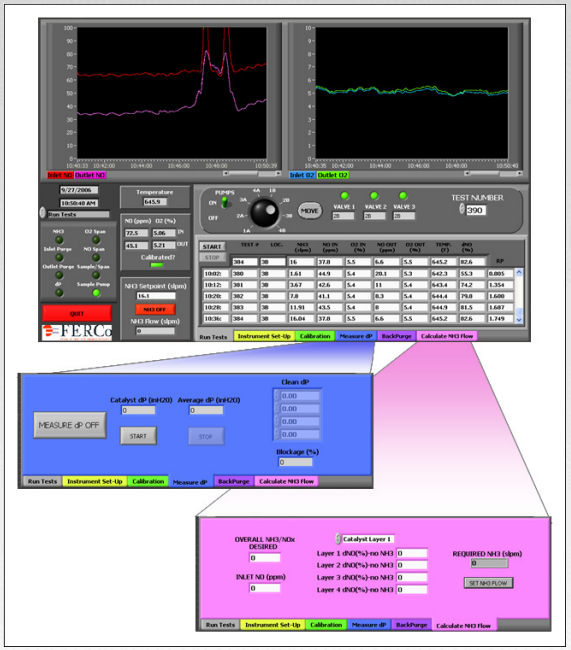
Demonstration Host Site Provided by Southern Company

- 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



In Situ Measurement Hardware

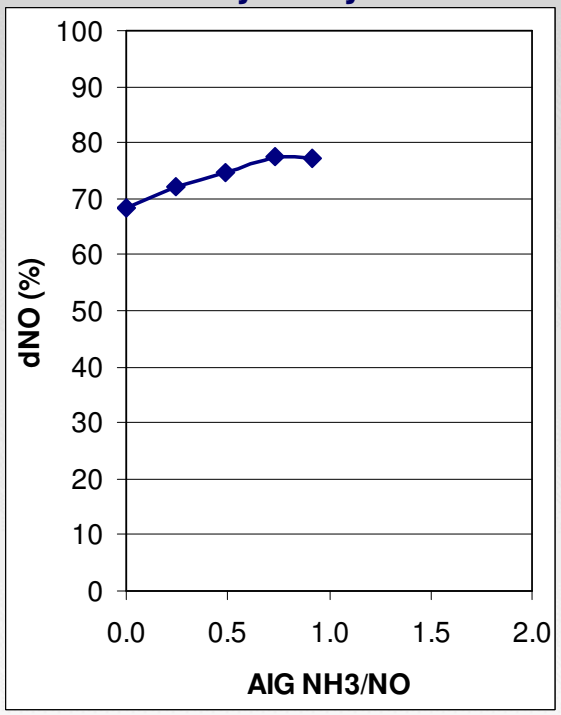
- Stationary NEMA 4 enclosure housing multi-position sampling valves
- Portable "cart" housing gas analysis instrumentation and control system



In Situ Test Protocol and Typical Test Results

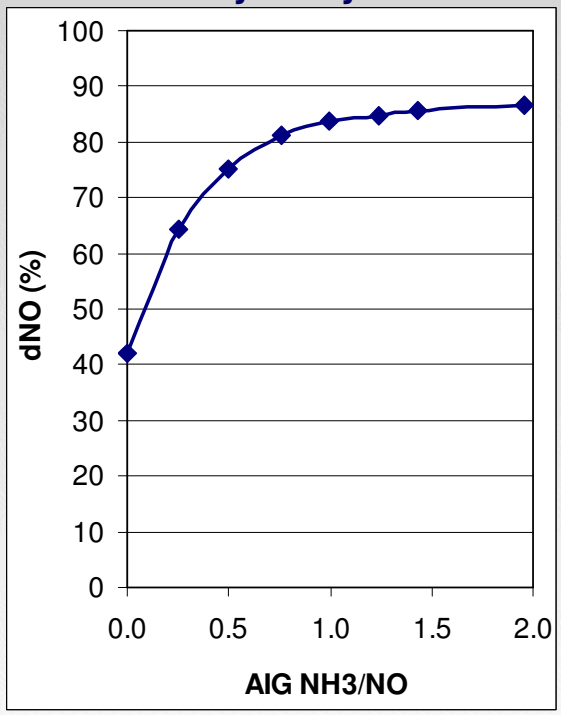
- Measure NO removal across test module without NH_3 injection
- Add NH_3 via test module AIG to point of maximum NO removal
- Calculate reactor potential from RP = -ln(1- ΔNO)

Catalyst Layer 1



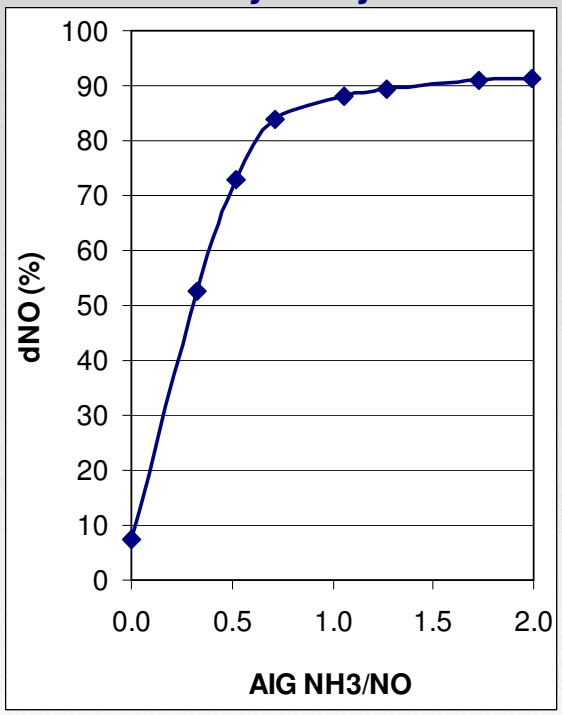
- dNO maximum = 77.3%

Catalyst Layer 2



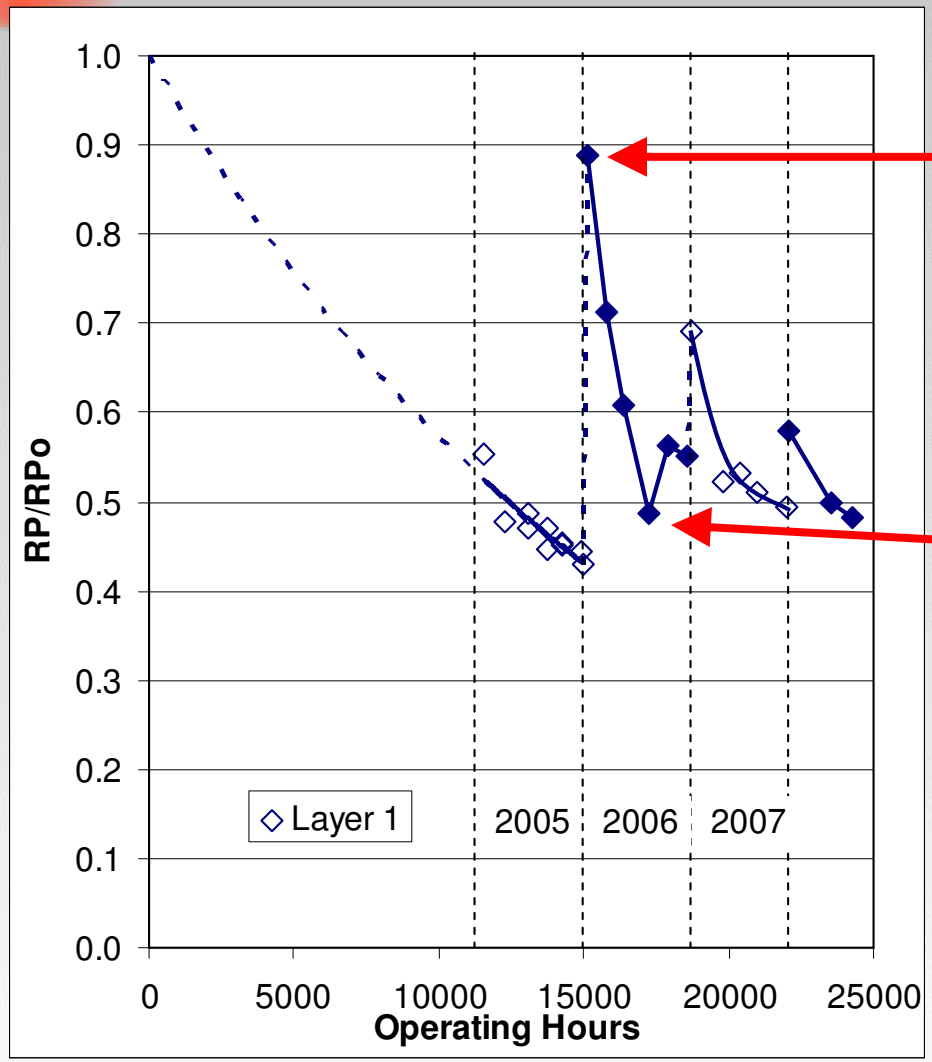
- dNO maximum = 86.6%

Catalyst Layer 3



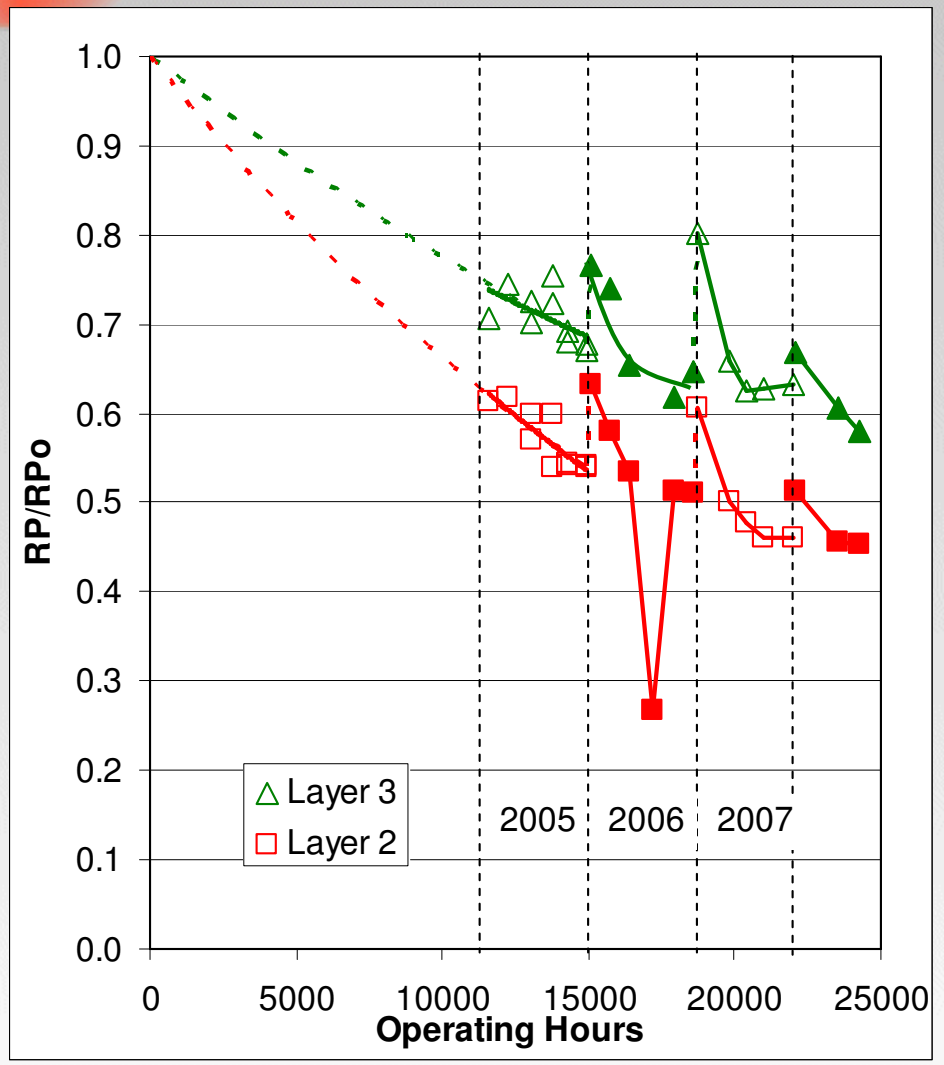
- dNO maximum = 91.3%

Reactor Potential Results for Layer 1



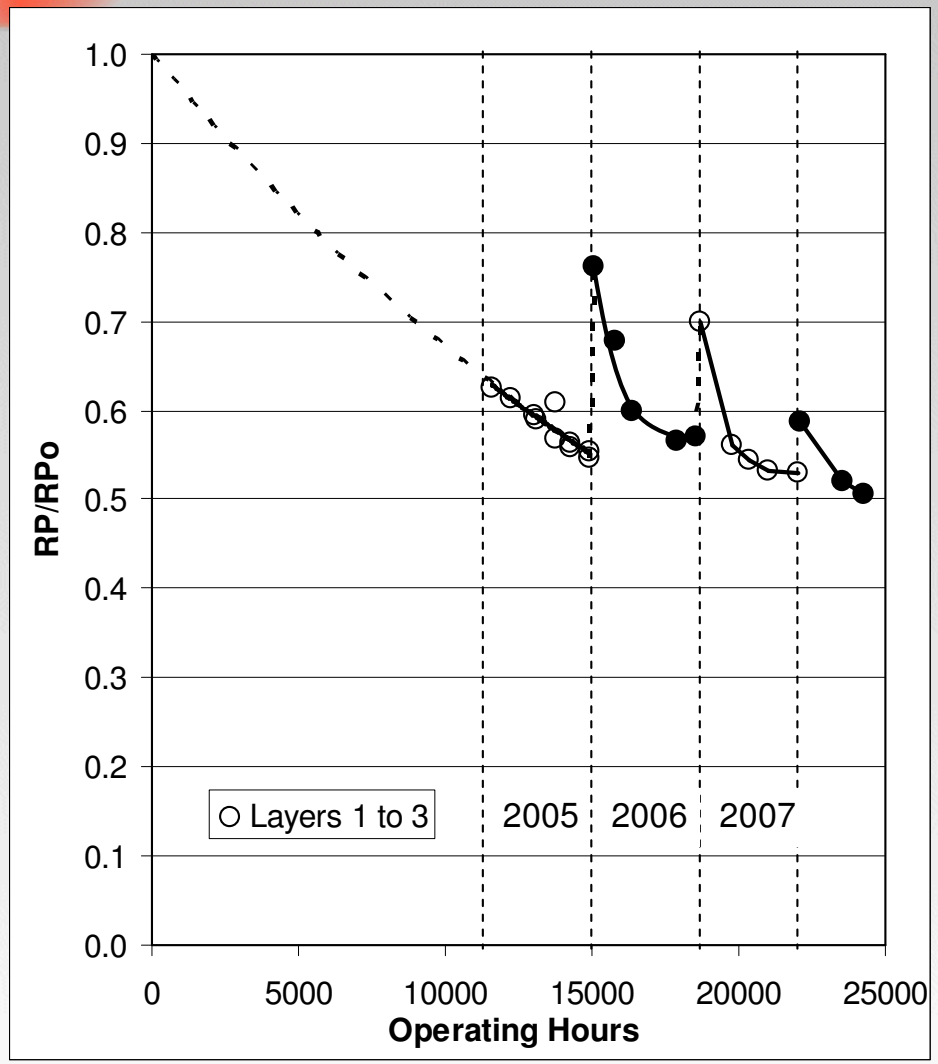
- The original Layer 1 honeycomb catalyst was replaced with a new layer of plate catalyst prior to the 2006 ozone season, resulting in a significant increase in reactor potential for that layer.
- In early 2006, a number of SCR sootblowers were inoperable for a short period of time, resulting in a reduction in reactor potential.
- Once the sootblowers were brought back online, the blockage was reduced, and the reactor potential increased.

Reactor Potential Results for Layers 2 and 3



- The *in situ* measurements for all three catalyst layers indicate an increase in reactor potential at the start of each ozone season relative to the end of the prior season.
- Initially, this was attributed to the plant's O&M procedure of vacuuming the catalyst layers between ozone seasons.
- However, pressure drop data do not indicate a large amount of material was removed during the vacuuming prior to the start of each season.

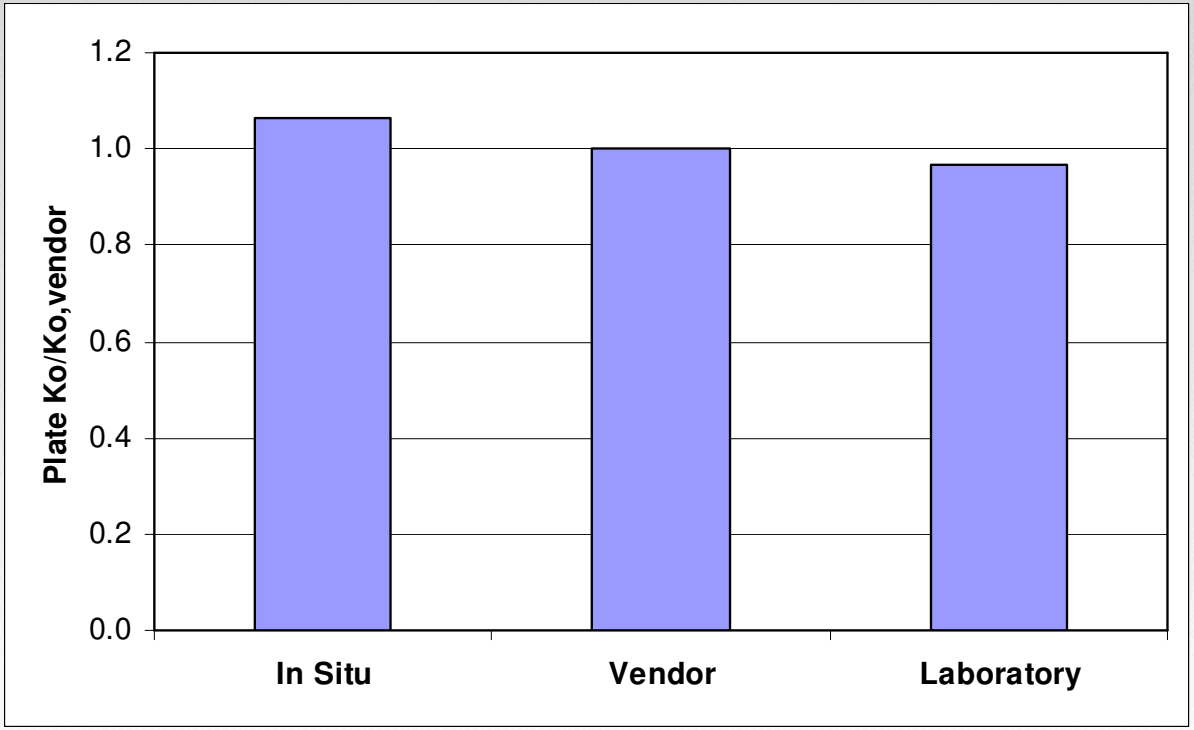
Summary Overall Reactor Potential Results



- The overall RP/RP_0 values are based on Layers 1, 2 and 3 only, and do not include any contribution from Layer 4 as measurements at this location did not yield valid test results.
- Measurements show a fairly rapid decrease in the activity of the new Layer 1.
- Looking past the temporary increases at the start of 2007 and 2008, the measurements show a smooth trend in overall RP.

Comparison of *In Situ* and Laboratory Activities

- 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 as well as a third-party laboratory measurement.
- K_0 for this material may be calculated from the first set of *in situ* RP measurements performed in 2006, where blockage was not an issue.



Additional Benefit: Low-Load SCR Operation

- At temperatures below Minimum Operating Temperature (MOT) recommended by the catalyst vendor:
  - ABS formation
  - Loss of catalyst surface area
  - Reduction in catalyst activity
- At full-load operating conditions, ABS will sublime, leading to a restoration of catalyst activity
- The extent of catalyst activity recovery will be a function of temperature and cycle duration
- *In Situ* measurement technique can be used for real-time tracking of catalyst activity reduction and restoration

Summary and Conclusions

- The *in situ* technique directly measures the true reactor potential of the SCR system. The reactor potential is the parameter that determines the overall performance of the SCR reactor. With the laboratory catalyst activity measurement, an estimate of the catalyst blockage is needed to determine reactor potential.

- *In Situ* measurements can be made on a layer-by-layer basis within the reactor anytime the SCR system is in operation. This can provide a much larger data set upon which to quantify deactivation rates compared to once-a-year physical sampling.

- There was good quantitative agreement between the *in situ* and laboratory catalyst activity measurements of a new layer of plate catalyst installed at the start of the 2006 ozone season.

Summary and Conclusions (continued)

- The *in situ* technique was able to monitor the decrease in reactor potential during the 2006 ozone season when a number of the sootblowers in the SCR reactor were inoperable for a short period of time.

- The *in situ* measurements also showed an increase in activity at the start of each ozone season relative to the end of the prior season. It is not clear if this is due to vacuuming that occurred between ozone seasons, as plant data indicate there was no reduction in pressure drop across each layer.

- The in situ technique should not be thought of as a replacement for laboratory analysis of catalyst samples, but as a companion measurement.

Questions?

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