Five Years of *In Situ* Reactor Potential Measurements* at Gorgas Unit 10

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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

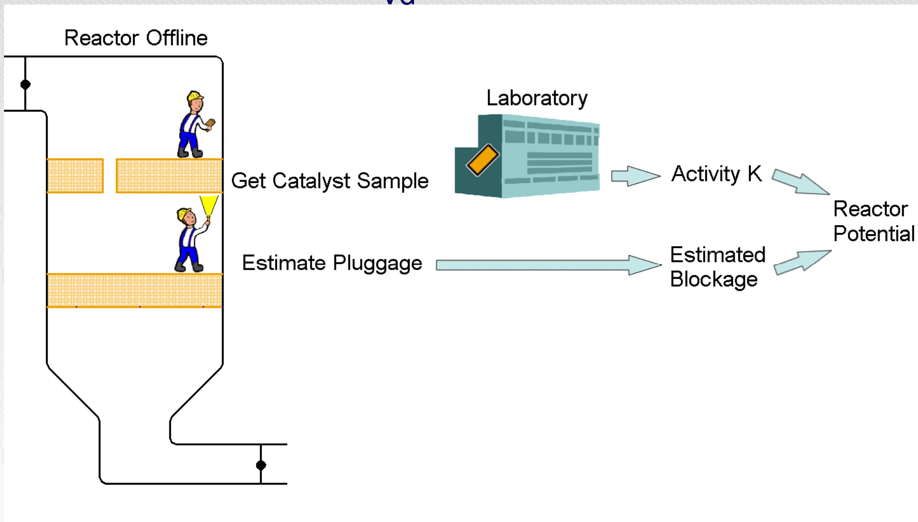
Laboratory:

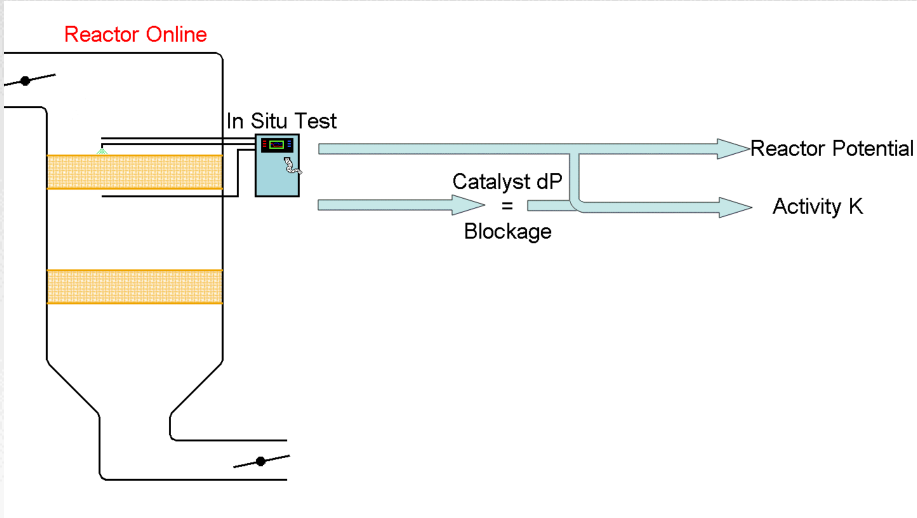
- Test Conditions:
  - A_{Vd} = Design Area Velocity
  - $NH_3/NO_x = 1$
- Measure:
  - ΔNO_x
- Calculate:
  - $K = -A_{Vd} \ln(1-\Delta NO_x)$
  - $RP = \frac{K}{A_{Vd}}(1-B)$

***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:
  - $RP = K/A_{V,FS} = -\ln(1-\Delta NO_x)$





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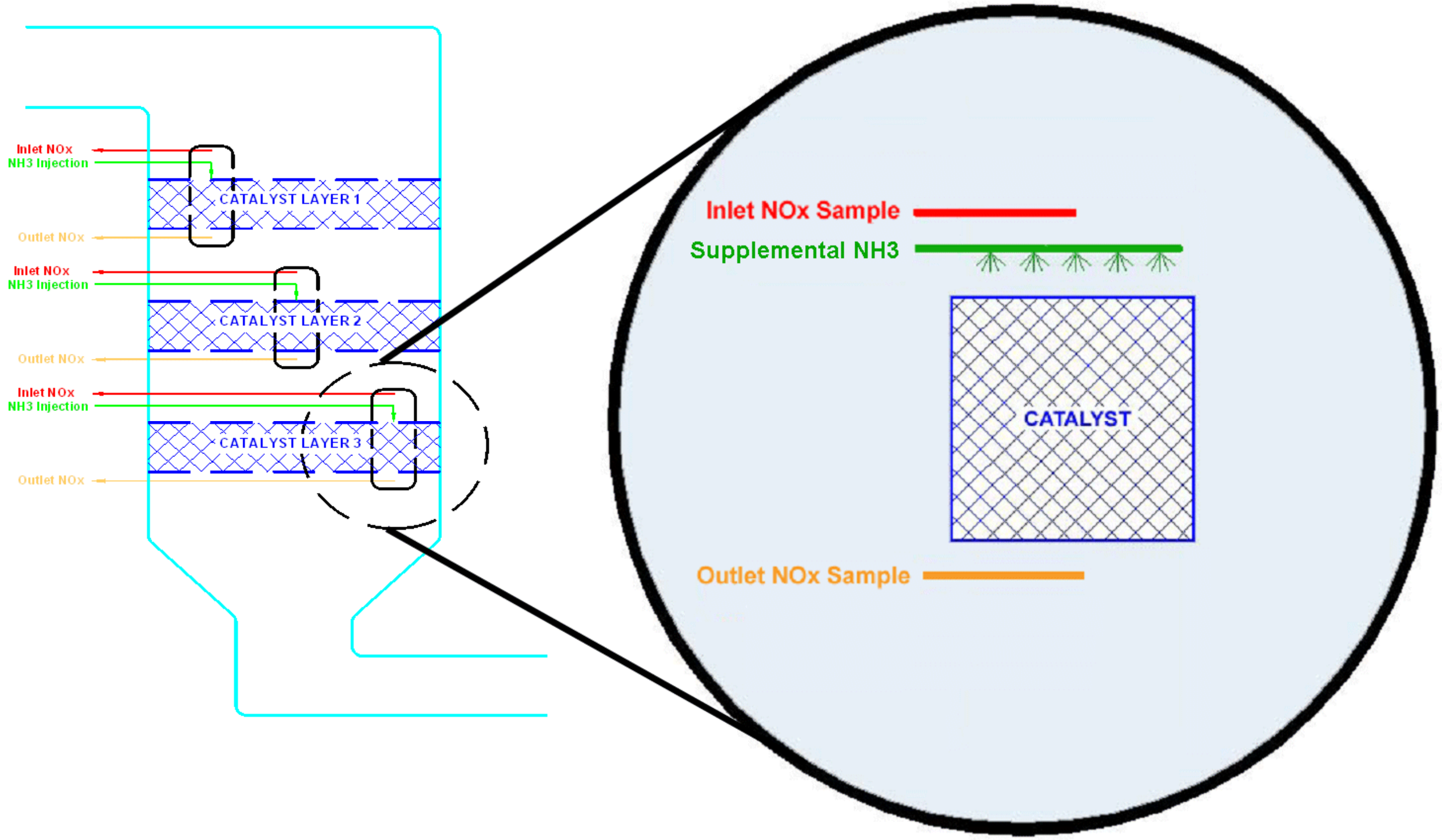
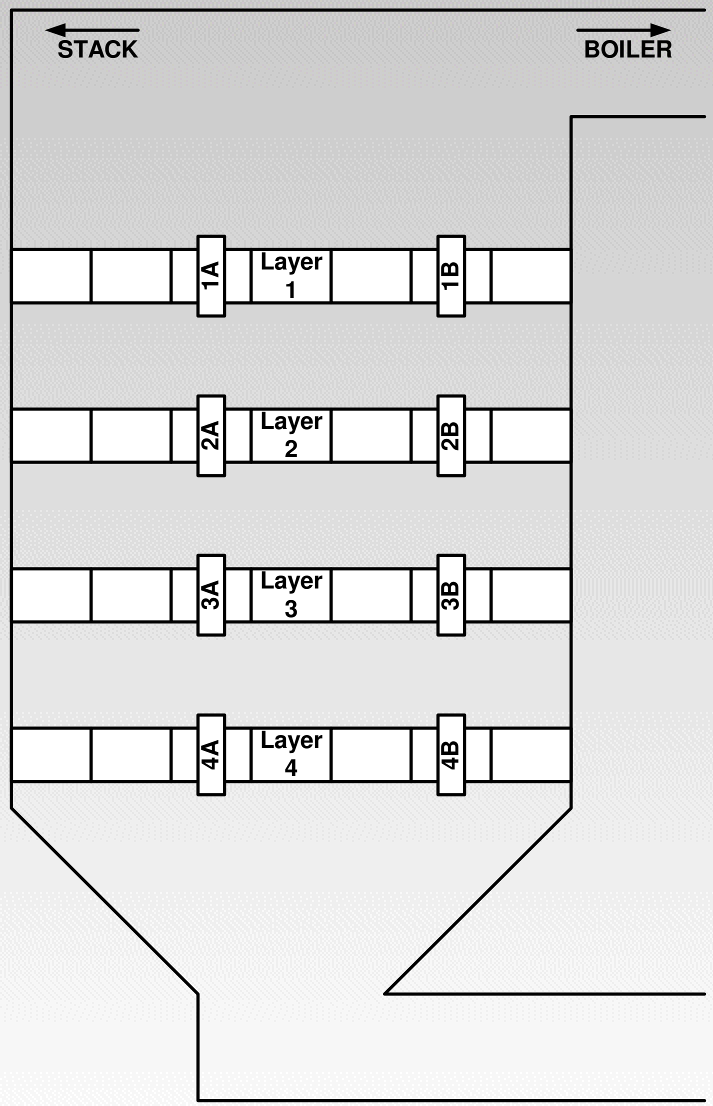
In Situ Test Modules - General Approach



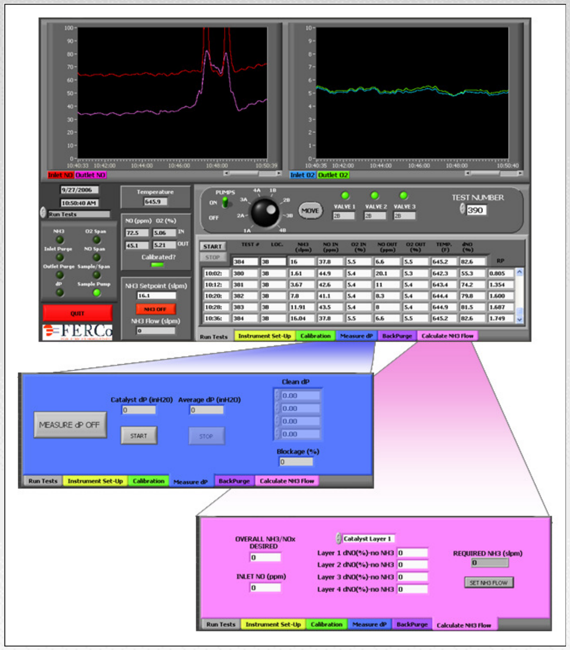
Demonstration Host Site Provided by Southern Company

- Alabama Power Company's Gorgas Unit 10
  - 700 MW
  - Alabama bituminous coal
- SCR on-line May 2002
  - Two reactors
  - 3 + 1 configuration
  - Initial load: 3 layers honeycomb catalyst
  - Fourth layer plate catalyst added prior to 2006 ozone season
  - Seasonal operation though 2008
  - Layer 4 replaced at the end of 2008
  - Layer 2 removed in April 2009 and replaced in October 2009



In Situ Measurement Hardware

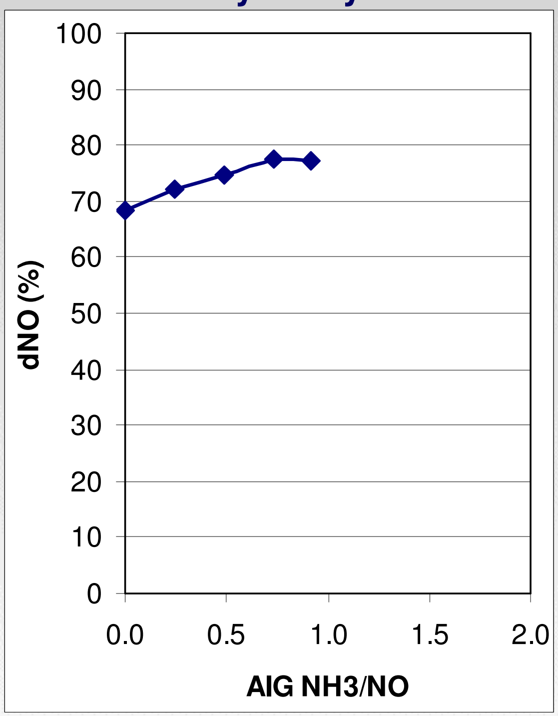
- **Stationary NEMA 4 enclosure housing multi-position sampling valves**
- **Portable "cart" housing gas analysis instrumentation and control system**



In Situ Test Protocol and Typical Test Results

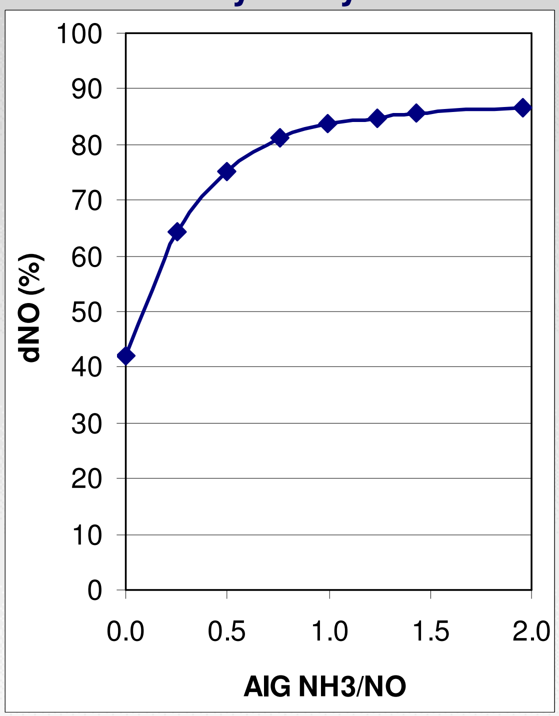
- Measure NO removal across test module without NH_3 injection
- Add NH_3 via test module AIG to point of maximum NO removal
- Calculate reactor potential from RP = -ln(1- ΔNO)

Catalyst Layer 1



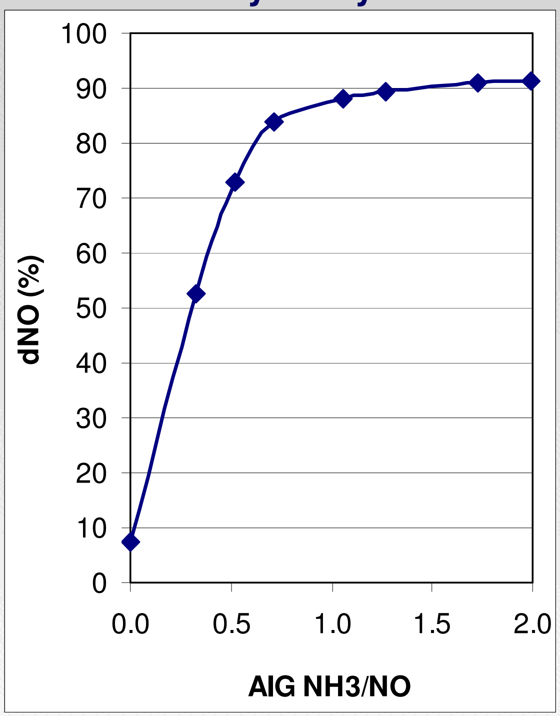
- dNO maximum = 77.3%

Catalyst Layer 2



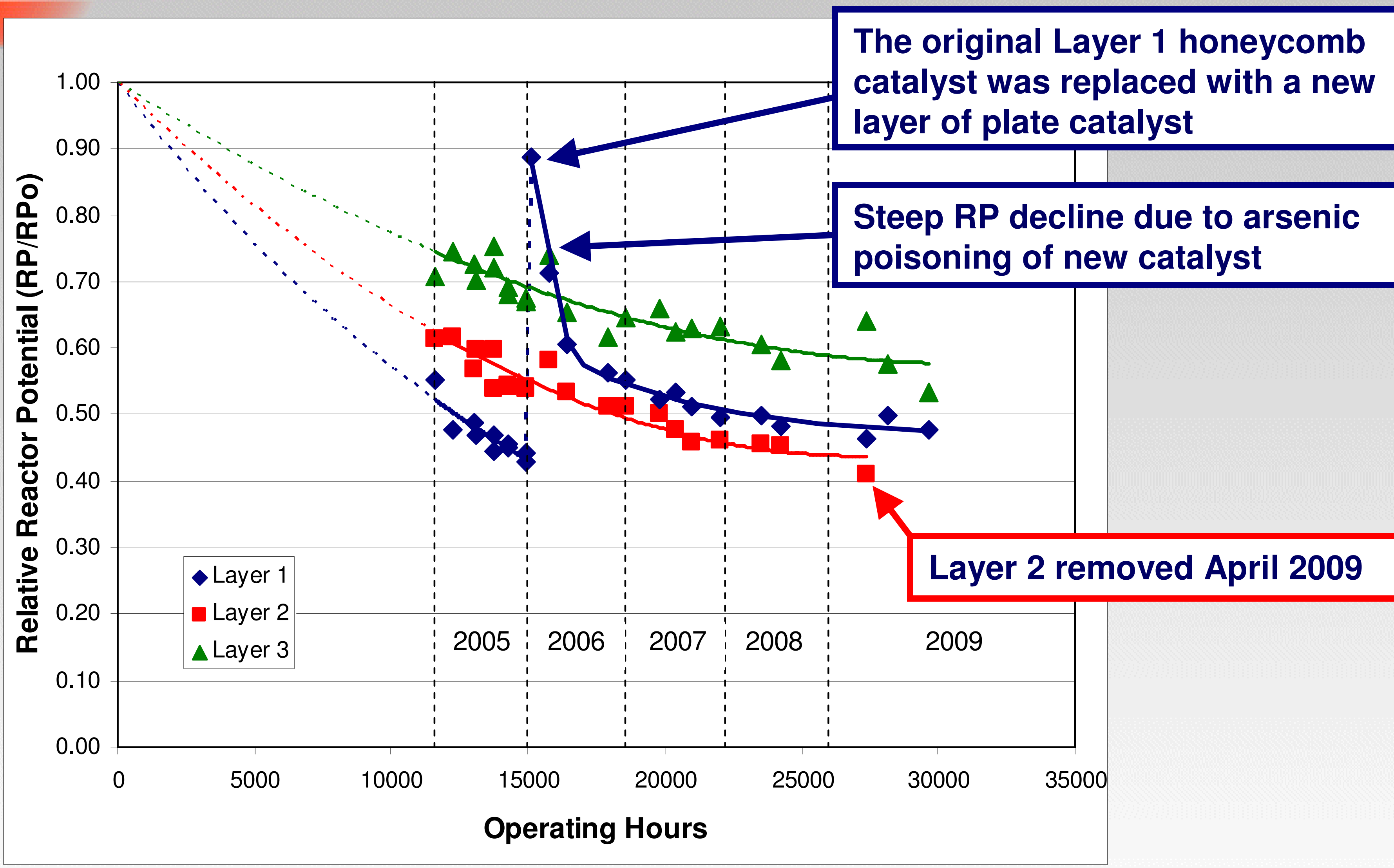
- dNO maximum = 86.6%

Catalyst Layer 3



- dNO maximum = 91.3%

Reactor Potential Results for 2005 to 2009



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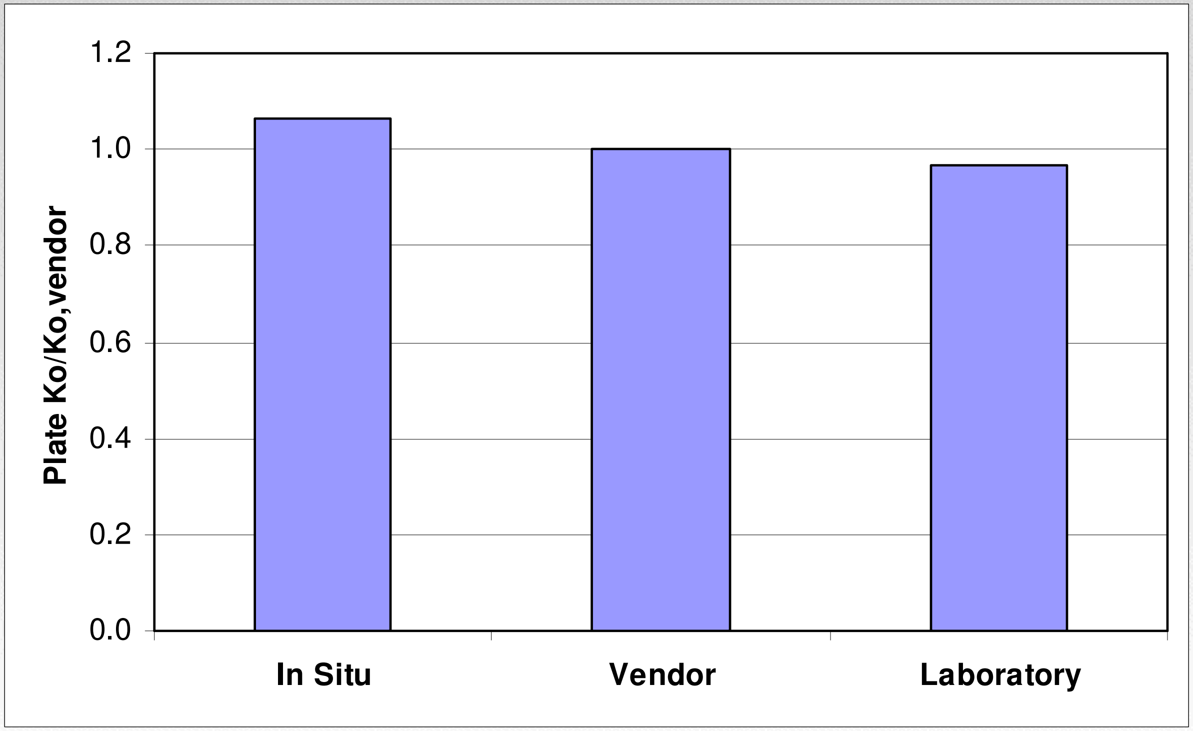
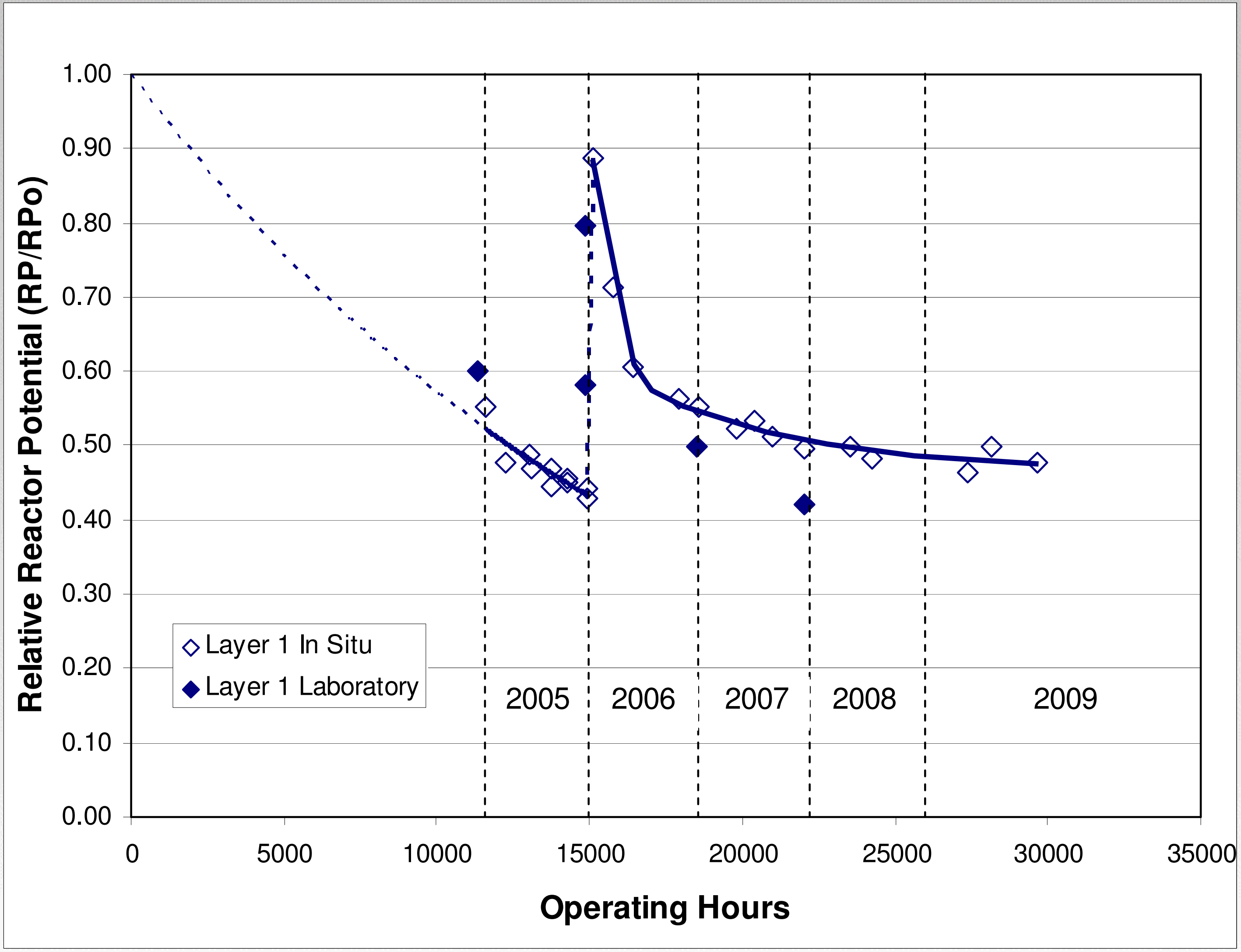
Comparison of *In Situ* and Laboratory Activities

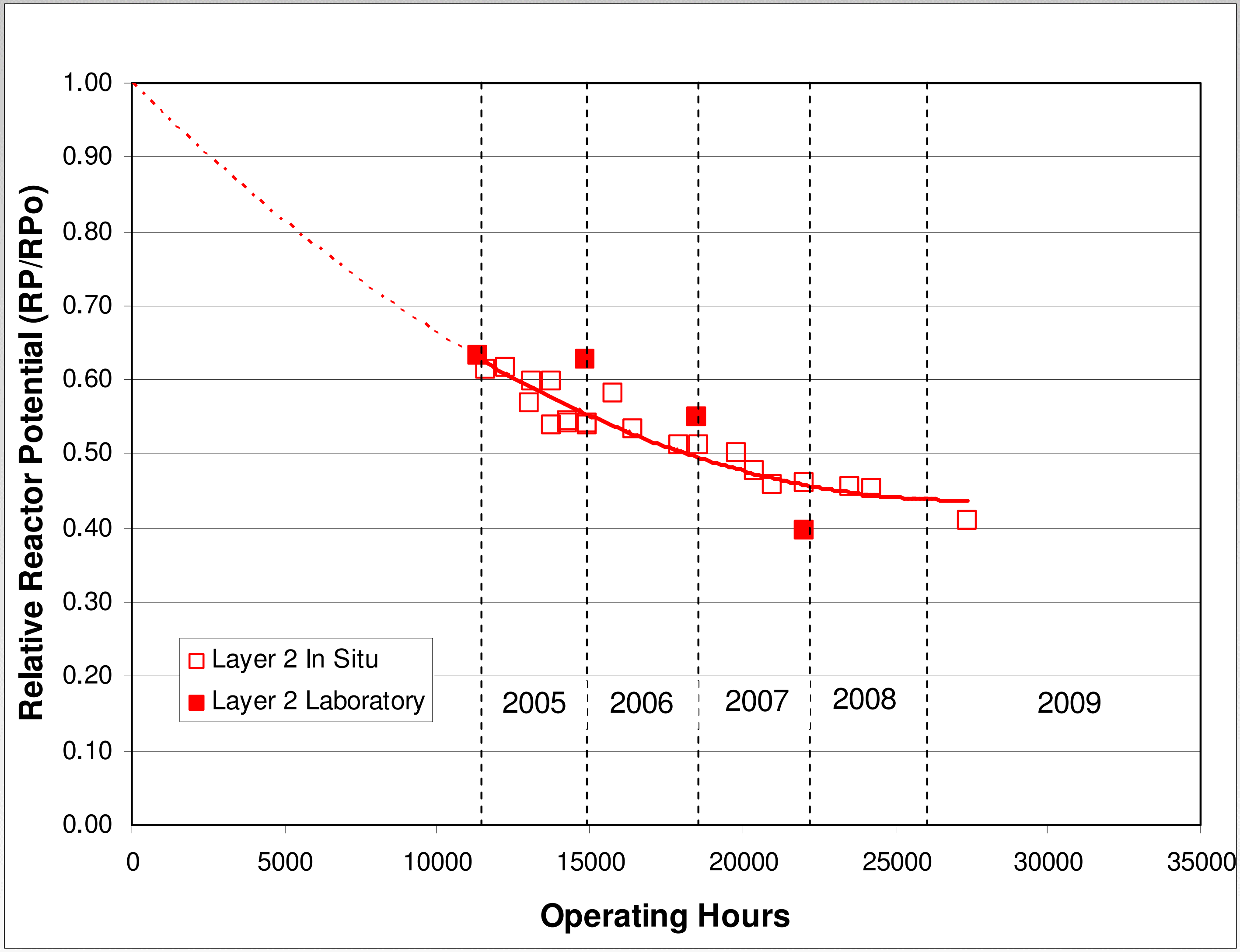
- The validity of the relationship between "*In Situ* RP" and "Lab K" was assessed by calculating K_0 for the new Layer 1 plate catalyst and comparing the value to the vendor's own value as well as a third-party laboratory measurement.
- K_0 for this material may be calculated from the first set of *in situ* RP measurements performed in 2006, where blockage was not an issue.



Comparison of RP Calculations for Layer 1



Comparison of RP Calculations for Layer 2



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Comparison of RP Calculations for Layer 3

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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 test program has shown the *In Situ* measurements can also be utilized to determine the SCR performance impacts of fuel changes or upset conditions (economizer tube leaks, etc.)
  - During the 2006 ozone season, measurements immediately showed the RP impact of having a number of the SCR sootblowers out of service for a short period of time.

- *In Situ* measurement technique can be used for real-time tracking of catalyst activity reduction and restoration when operating at low-load conditions.

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

Questions?

Knox✓ Online Catalyst Activity Test System*