Experimental Investigation of Catalyst Deactivation Below the MOT and Full Load Regeneration

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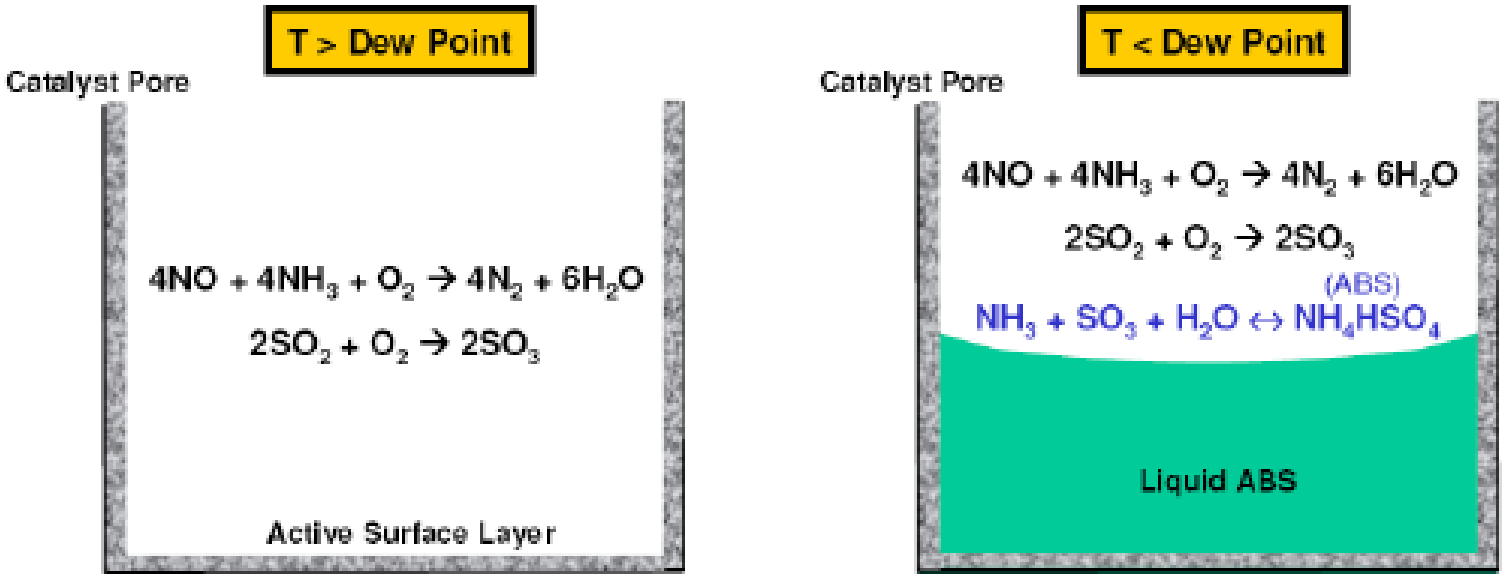
The Problem

- Alternative and renewable energy sources are forcing large coal-fired units to operate at low load more frequently and for longer time intervals
- For units without economizer bypass capability, low load requires the SCR to run at lower temperatures
- For scrubber-equipped units burning high-sulfur coal, these temperatures are often below the SCR catalyst minimum operating temperature (MOT) defined by the catalyst vendor (warranty issue)
- Operators and vendors are working together to develop procedures for safely operating below the MOT

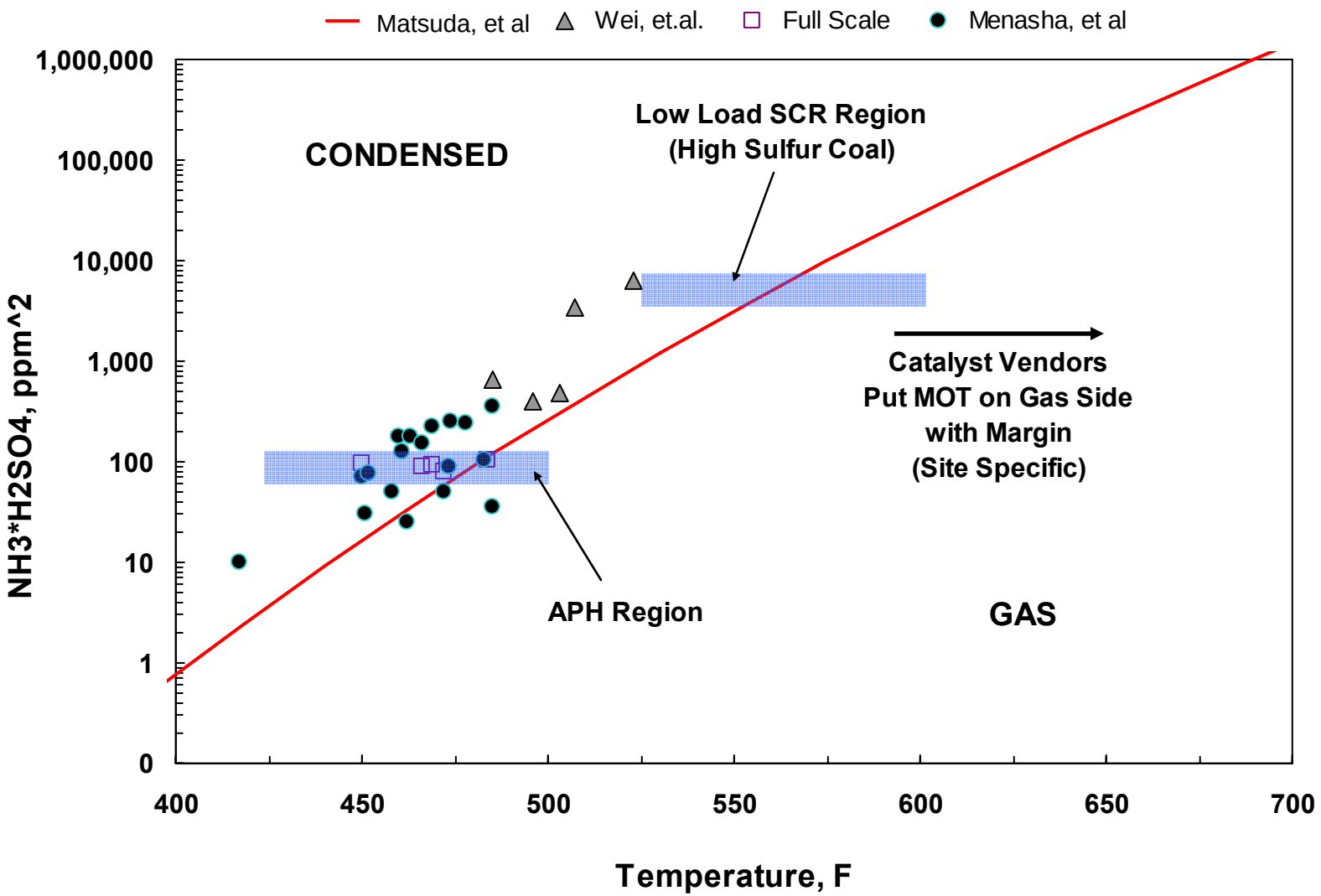
ABS Formation

SCR catalyst will deactivate at temperatures below the ABS dew point

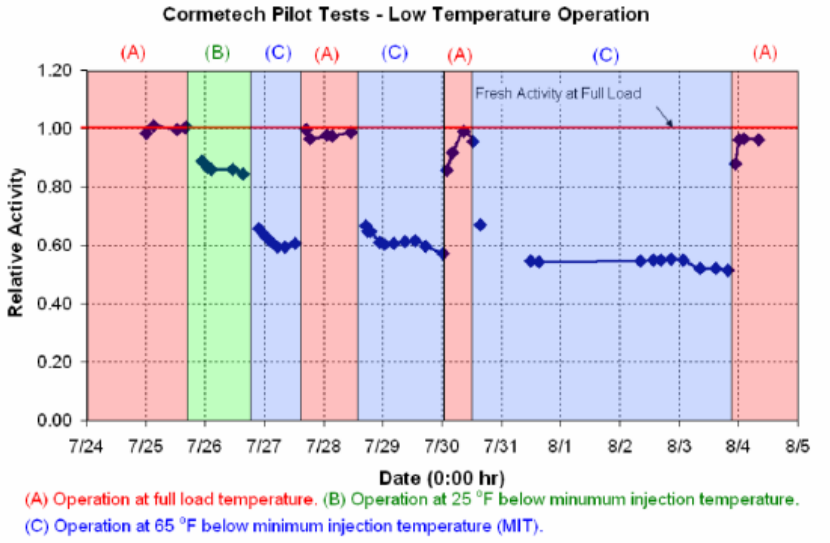


Mechanism of Pore Plugging by Liquid ABS (Bertole, 2007)

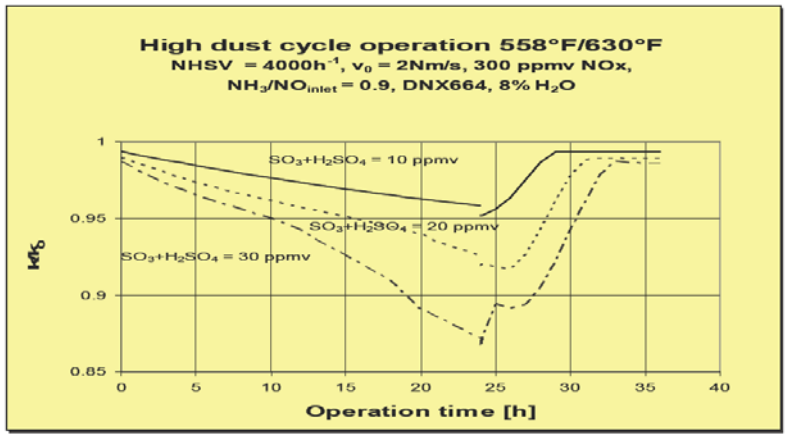
ABS Formation



Previous Studies



Cormetech (Bertole, 2007)



Haldor Topsoe (White, 2005)

- **Catalyst vendors have studied deactivation below MOT and regeneration at full load**
- **They can provide site-specific recommendations for low load operation**
- **The current 3rd party work is intended to add clarity to the MOT issues, not to serve as a substitute for catalyst vendor data or recommendations**

Practical Issues

- **ABS formation will gradually deactivate the catalyst**
- **What is the maximum time allowed at low load before SCR performance is compromised?**
  - Overnight (demand driven)
  - 3 to 5 days (demand driven)
  - 2 to 4 weeks (maintenance issue)
- **Does ABS deactivation affect just the top layer, or all layers?**
- **How does catalyst aging impact all of the above?**

Current Objectives

- **Investigate SCR catalyst deactivation/regeneration due to ABS formation/evaporation**
  - Catalyst type
  - Regeneration temperatures
  - ABS deactivation/regeneration cycling
- **Investigate impact on 1st and 2nd catalyst layers**
- **Use experimental data and FERCo process model to develop SCR performance predictions for low load scenarios**
  - Reactor potential change (flow and temperature)
  - Maximum allowable time at low load
  - Catalyst aging impacts

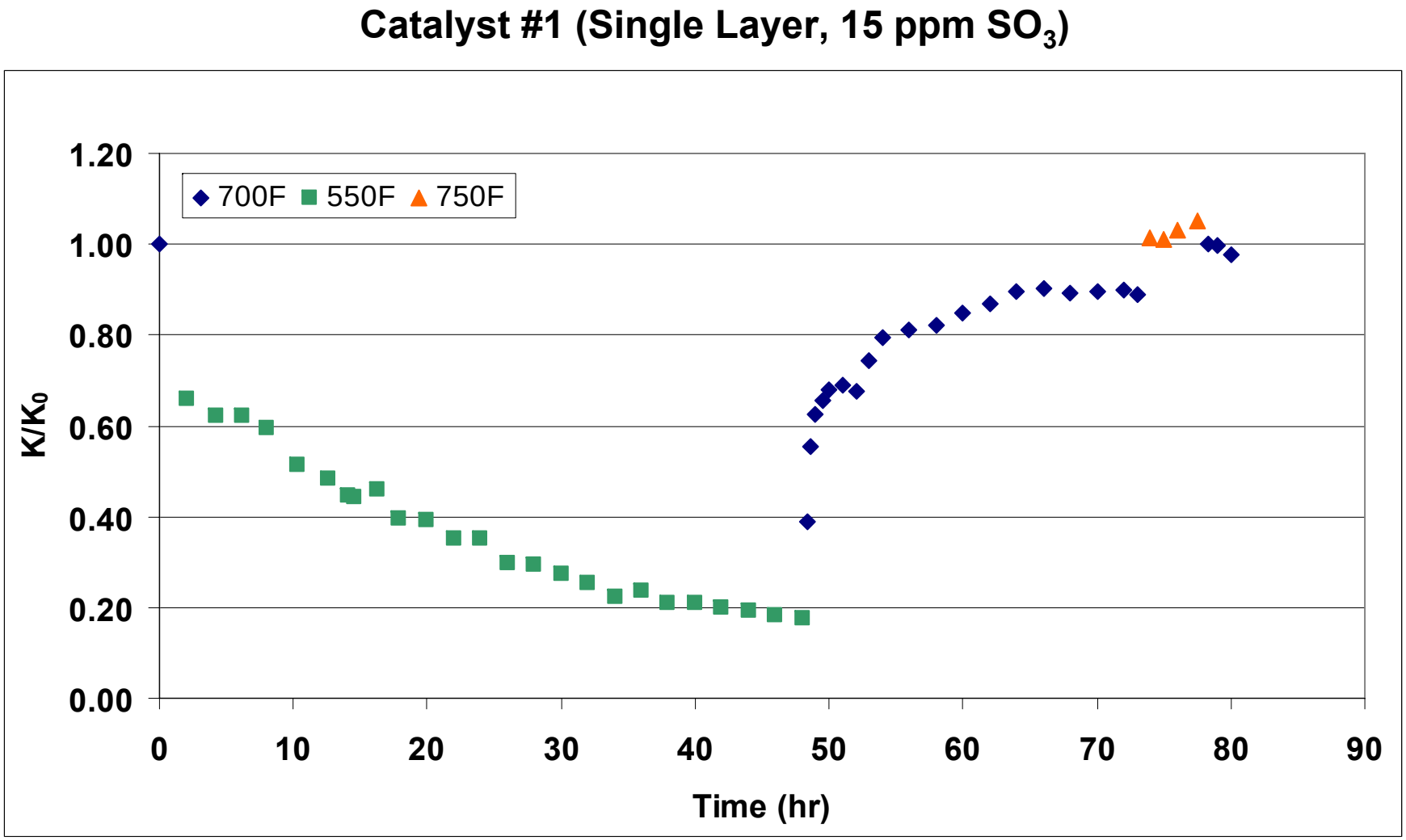
Experimental Setup

Gas-fired Combustion Tunnel
(No Flyash)

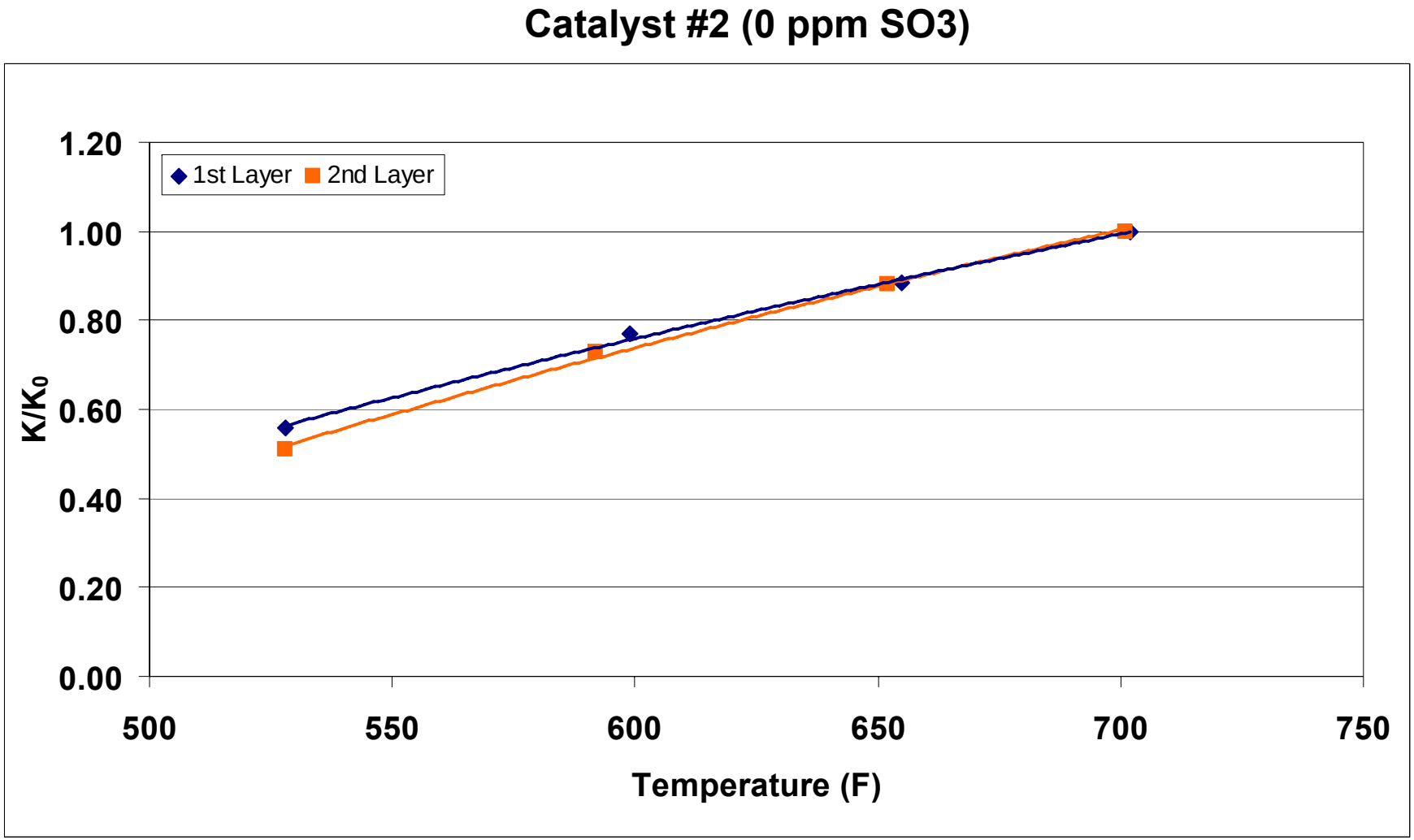
SO_3 Generator

90mm x 90mm x 2.5m Test Section
(2 x 1m catalyst layers)

Experimental Results: Proof of Concept



Experimental Results: Two Layers



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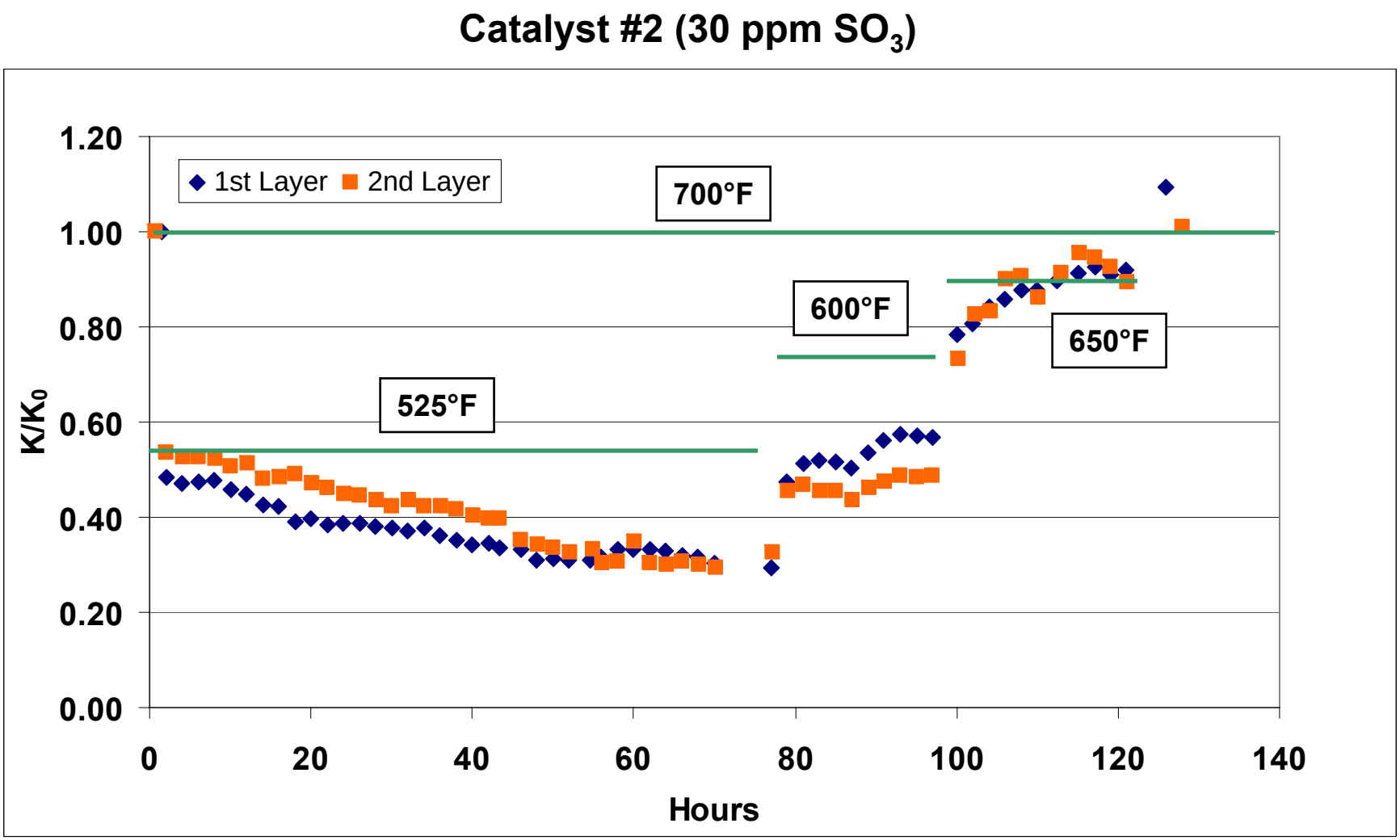

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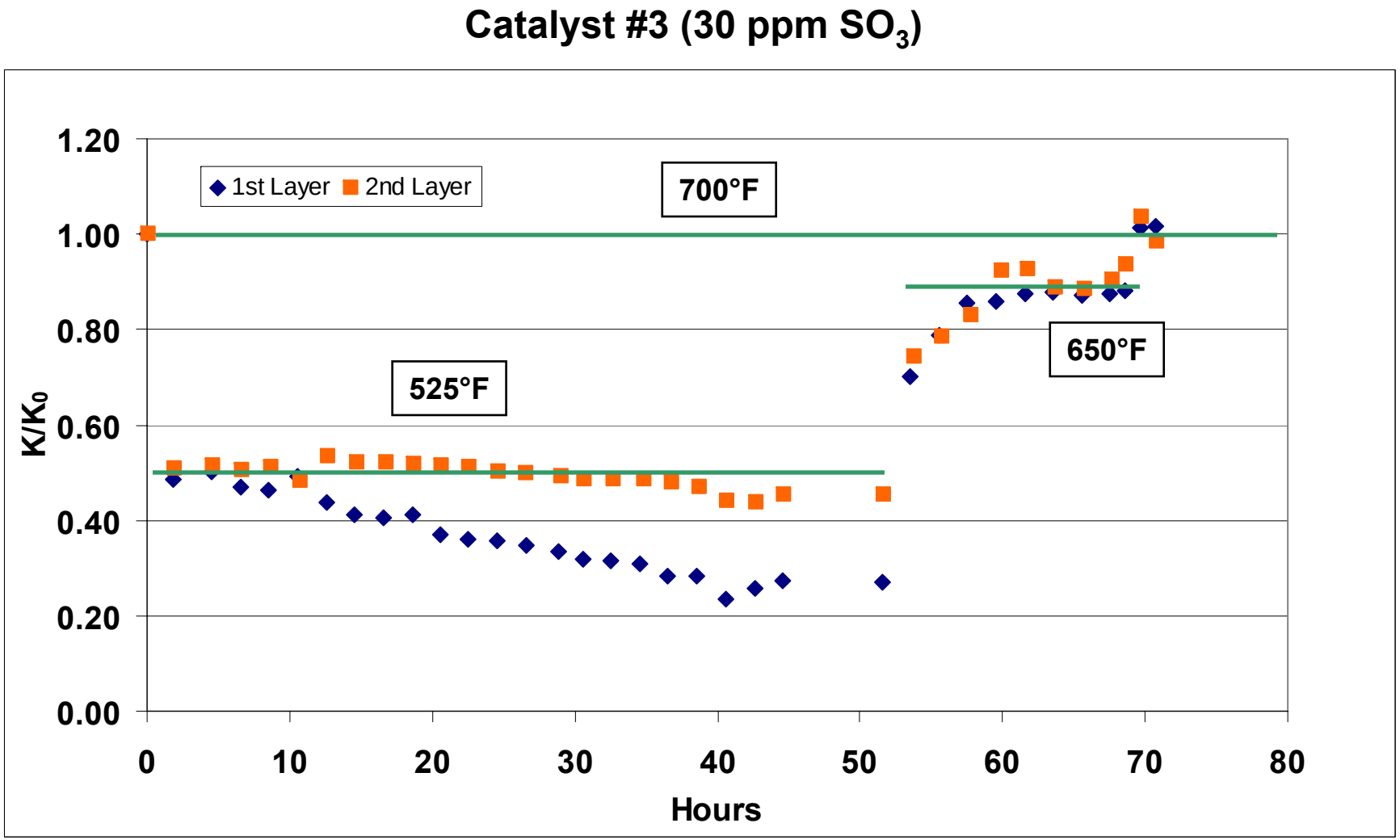
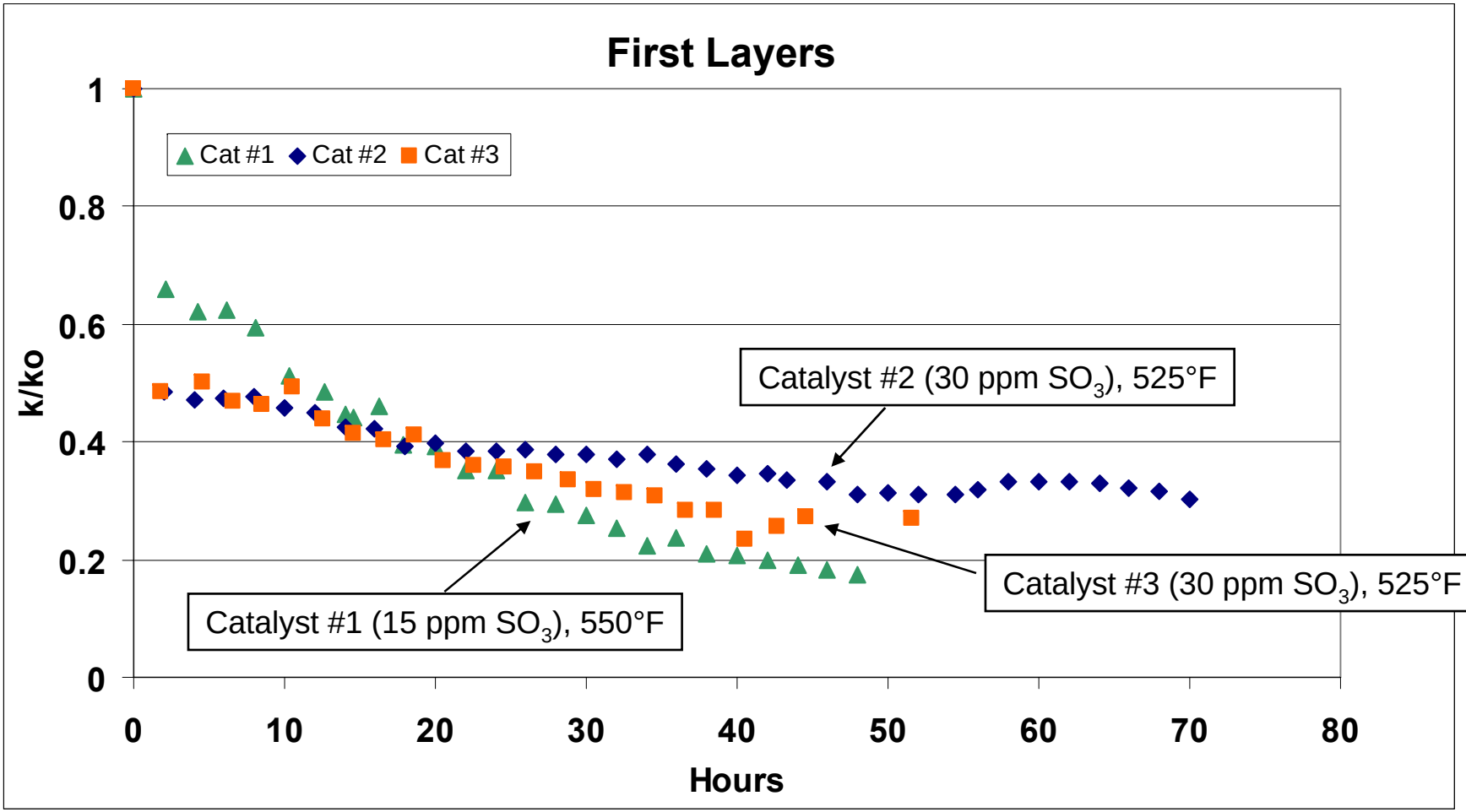
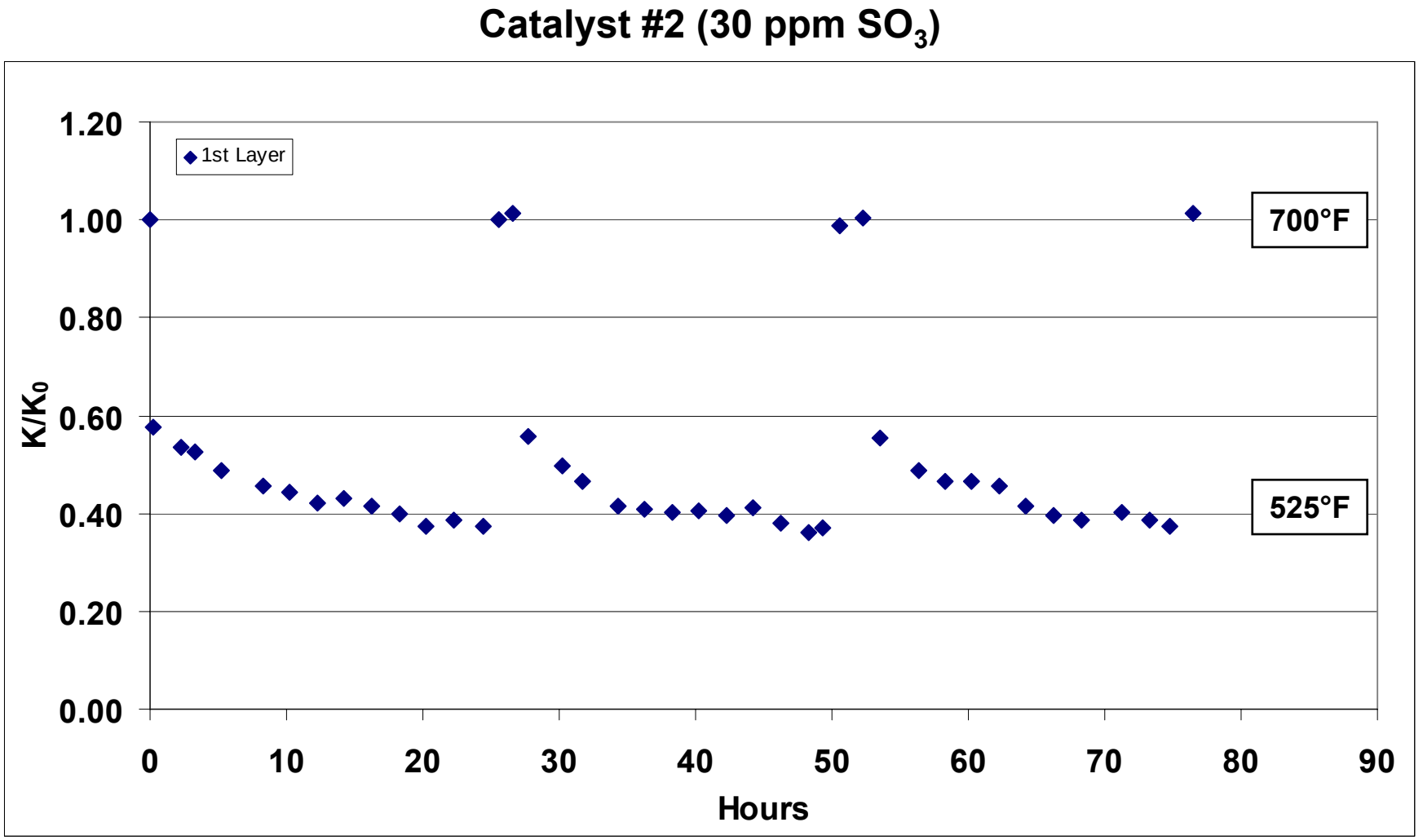


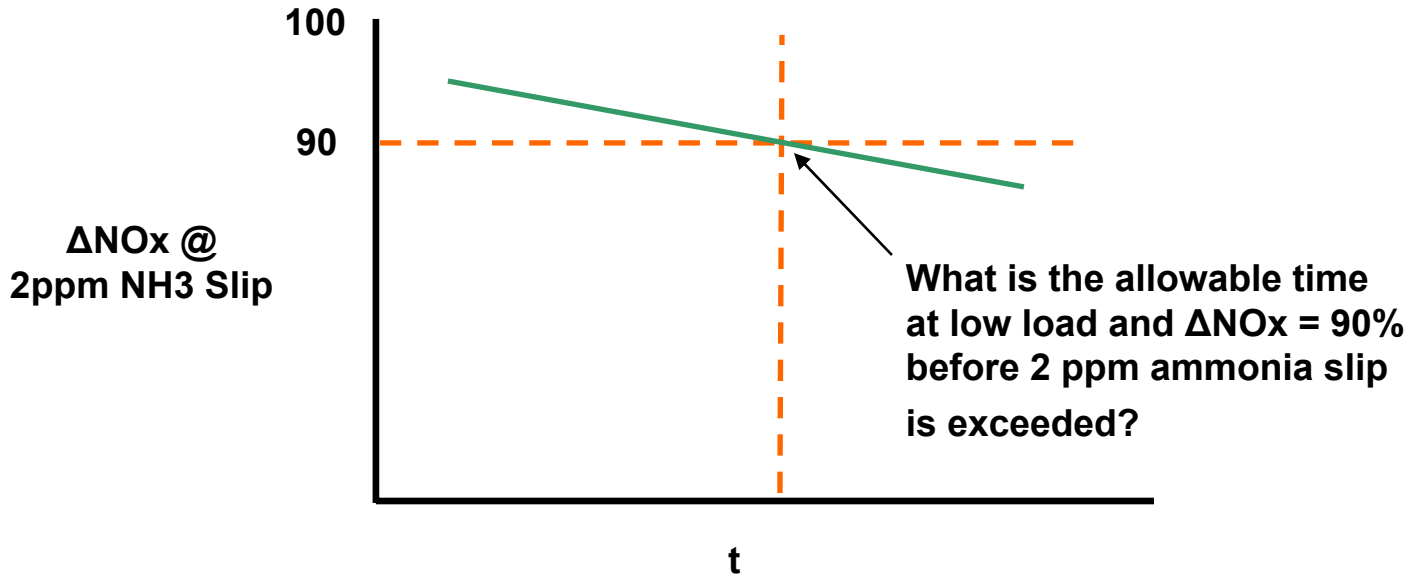
Experimental Results: Catalyst Comparison



Experimental Results: 24-hr Cycling



Impacts on SCR Performance

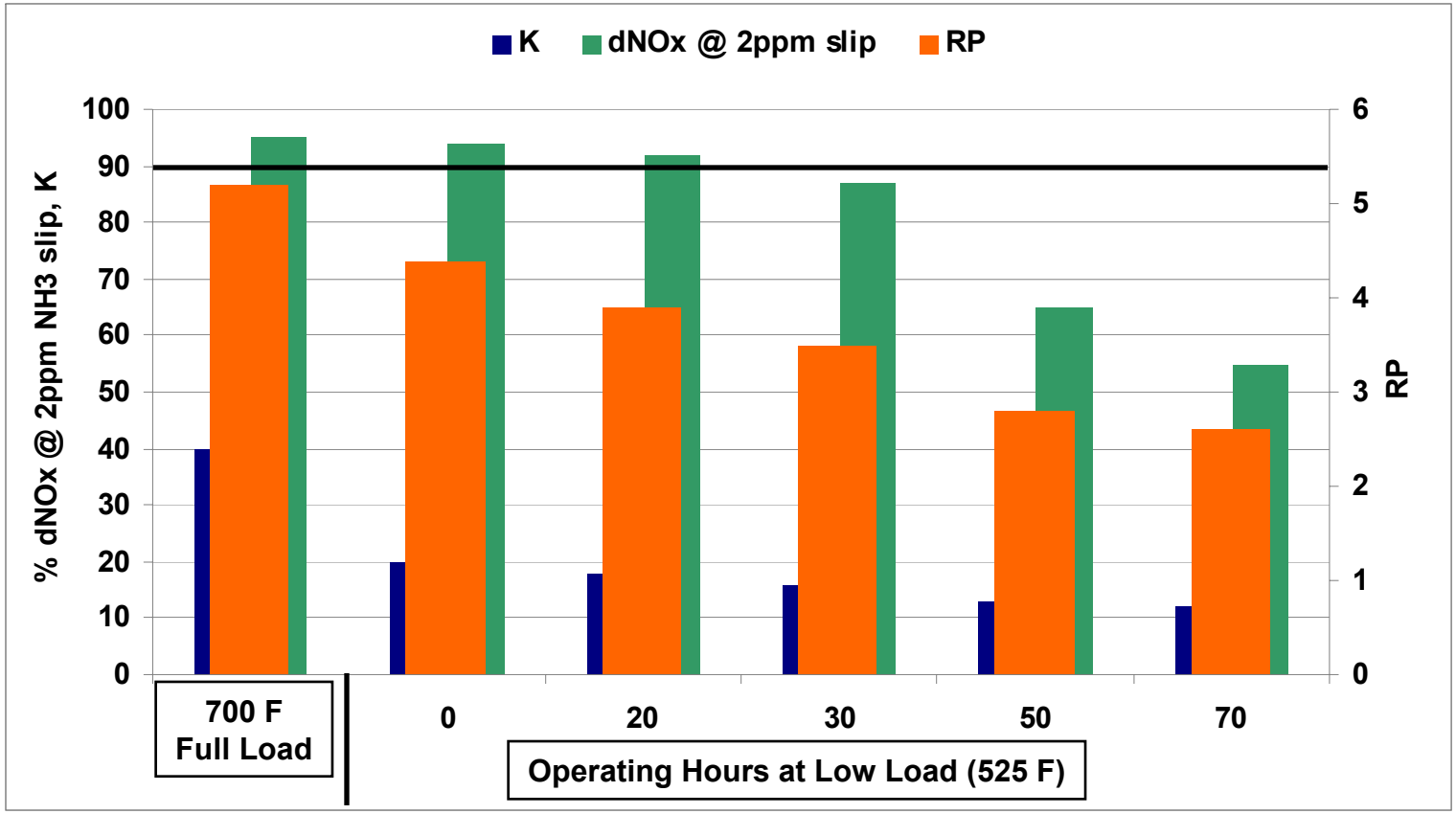


Process Model Assumptions:

- 500 MW Unit
- NO_{xi} = 0.4 lb/MMBtu
- A_v at full load = 7 m/hr
- K_0 = 40 m/hr
- Low Load: T = 525°F, Flue gas flow = 60% of full load
- Temperature and ABS deactivation rates from Catalyst #2 experimental data
- SCR Performance Goal: 90% NOx removal @ 2 ppm NH3 slip

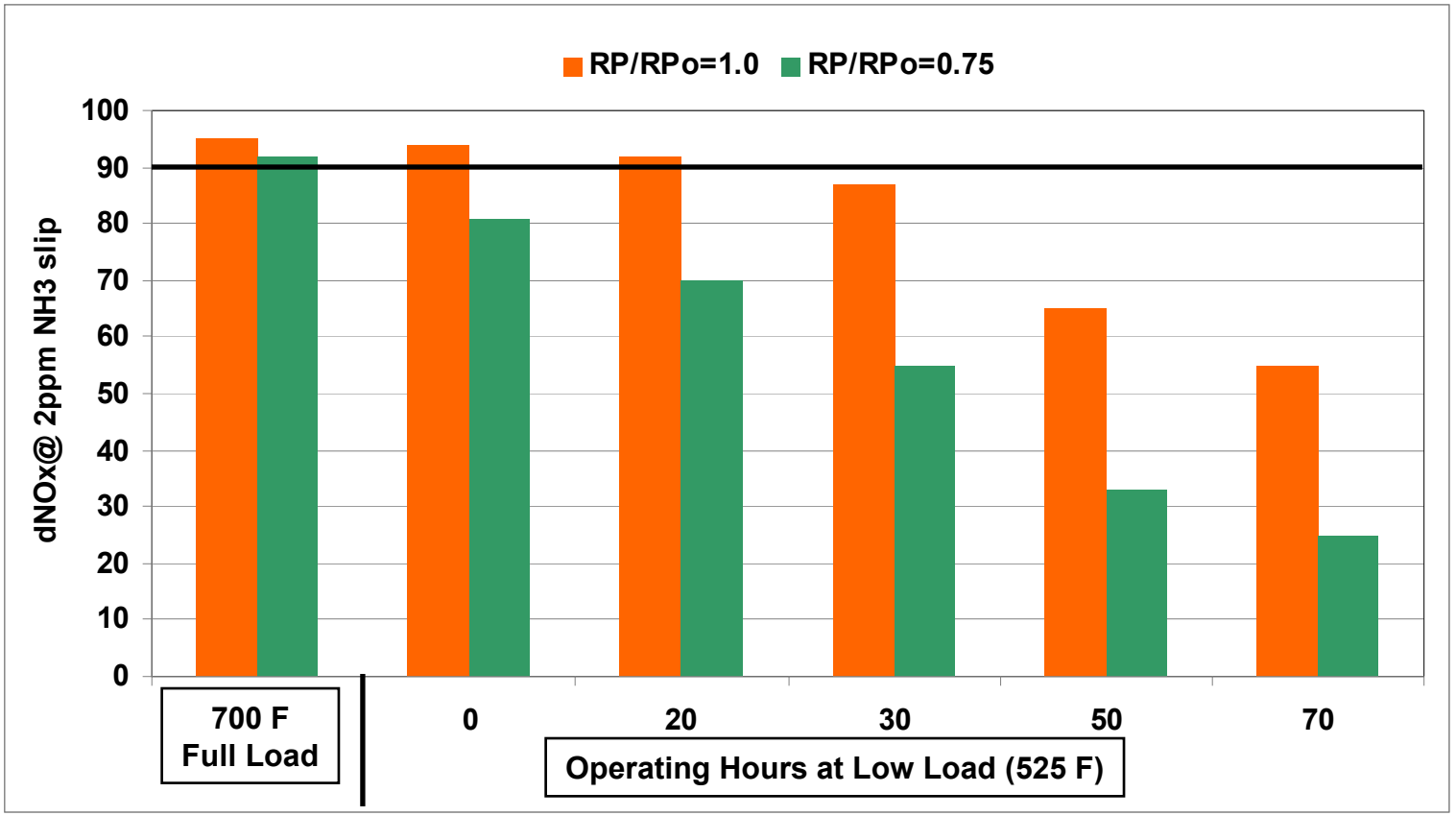
Impacts on SCR Performance

FERCo Process Model Calculations: Catalyst #2, New

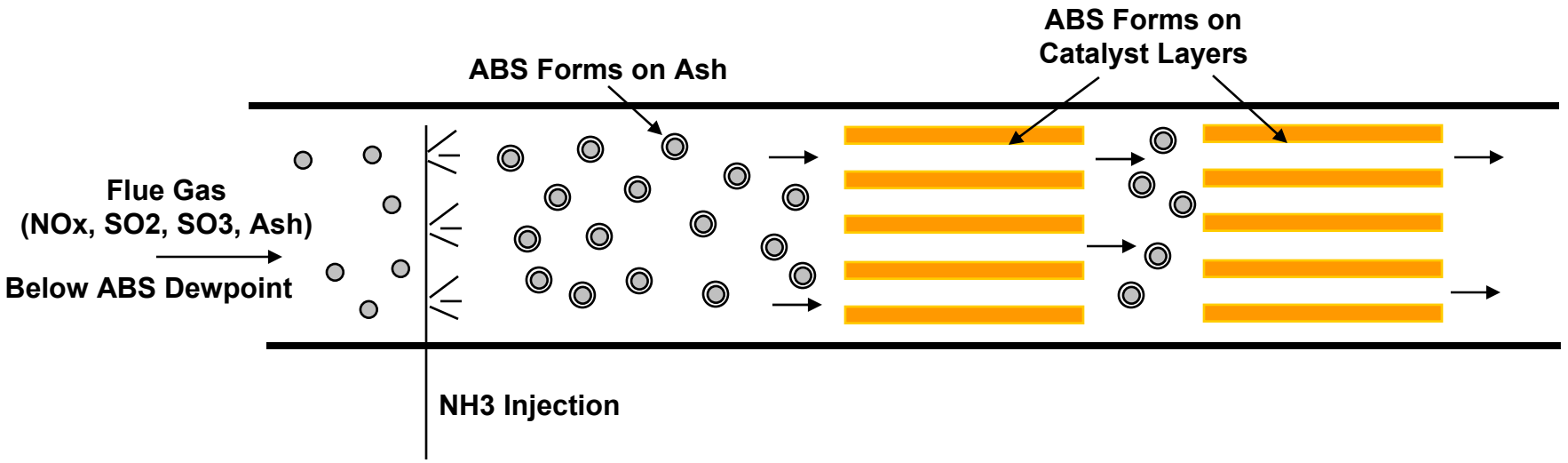


Impacts on SCR Performance

FERCo Process Model Calculations: Catalyst #2, Aged



ABS Deactivation Process: Ash Impact?



- **Ash not included in lab experiments**
- **In full-scale systems, ABS can deposit on either flyash or catalyst**
- **Catalyst surface area >> ash surface area**
  - Experimental deactivation comparable to field
- **Is ABS a vehicle for transporting very fine ash particles to pores?**

Topics for Further Consideration

- **Ash impacts**
- **Does aged catalyst respond differently to ABS formation?**
- **Allowable time at low load depends on inherent K vs temperature and ABS deactivation**
  - Does this vary with catalyst type and composition?
  - New catalyst vs regenerated?
- **Monitoring activity loss at low load to prevent high NH_3 slip (air heater plugging)**
  - Continuous ammonia monitoring
  - In situ catalyst activity monitoring (FERCo's KnoxCheck™)

Conclusions

- Different catalyst types have different ABS deactivation rates and different 2nd layer behavior
- Moving from full load to low load (700°F to 525°F) can result in a net loss of RP – even before ABS deactivation begins (lower catalyst activity due to decreased temperature counteracts lower flue gas flow)
- For new catalyst, operation at low load below the ABS dewpoint for overnight periods (8-12 hours) and then regenerating at full load does not appear to threaten SCR performance

Conclusions (continued)

- For new catalyst, operation at low load below the ABS dewpoint for more than 24 hours may threaten NH_3 slip target
- The time allowance will steadily decrease as the catalyst ages
- Consult your catalyst vendor for site specific recommendations

Questions?