SCR Catalyst Management Strategies – Modeling and Experience

James E. Staudt
Andover Technology Partners
Anthony J. Engelmeyer
Orlando Utilities Commission

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Is Catalyst Management Rocket Science?

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Catalyst Management Objectives

- Minimize Catalyst Costs
- Minimize Outage Duration and Frequency
- Control Ammonia Slip
- Minimize Pressure Drop
- Optimize NOx Reduction

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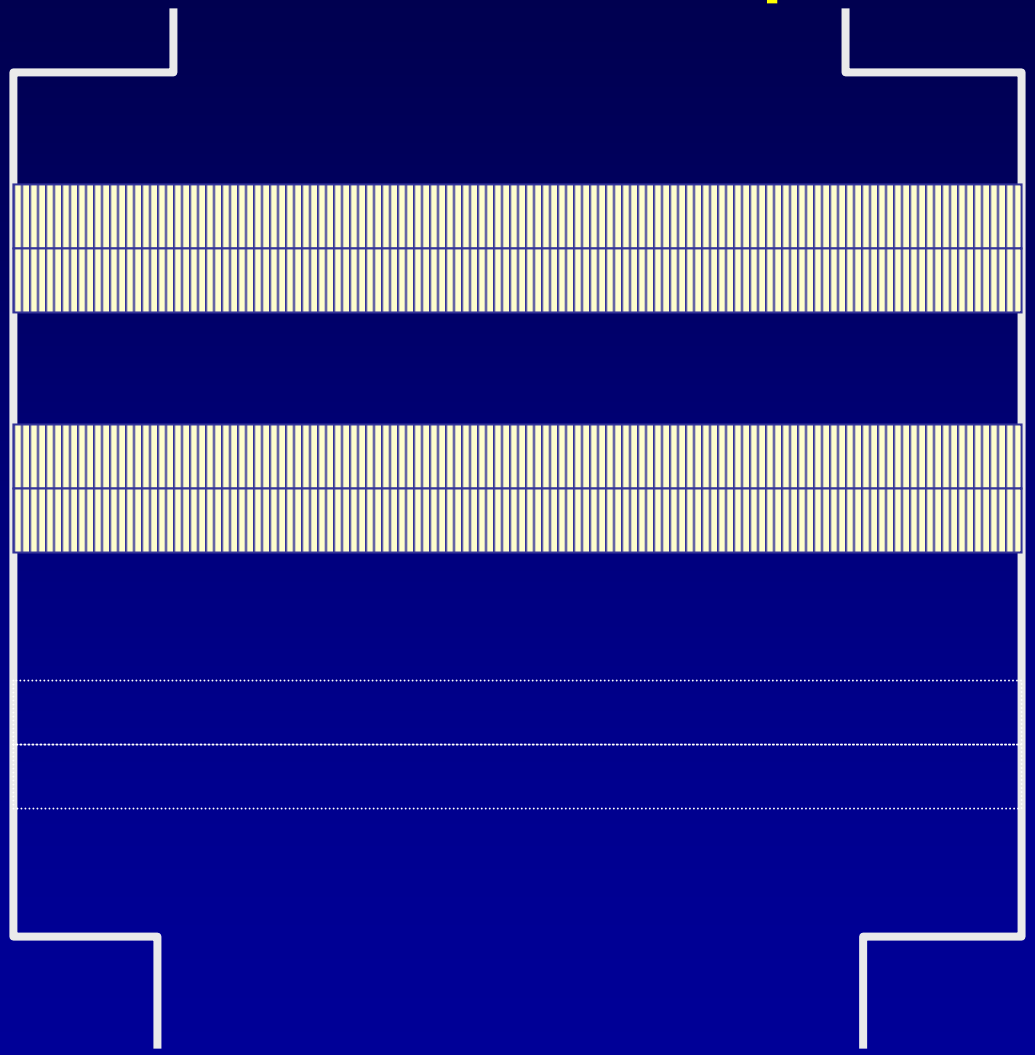
- Control Ammonia Slip
- Minimize Pressure Drop
- Optimize NOx Reduction
- Minimize Facility Operating Costs and Maximize Generation Revenue

Approaches to Catalyst Management

- Add and Replace
  - Add new catalyst to fill reactor
  - Replace catalyst with new or regenerated catalyst
- Continuous Regeneration
  - Remove layer for regeneration and add regenerated catalyst to empty layer
  - At least one layer is empty at any time

Add and Replace



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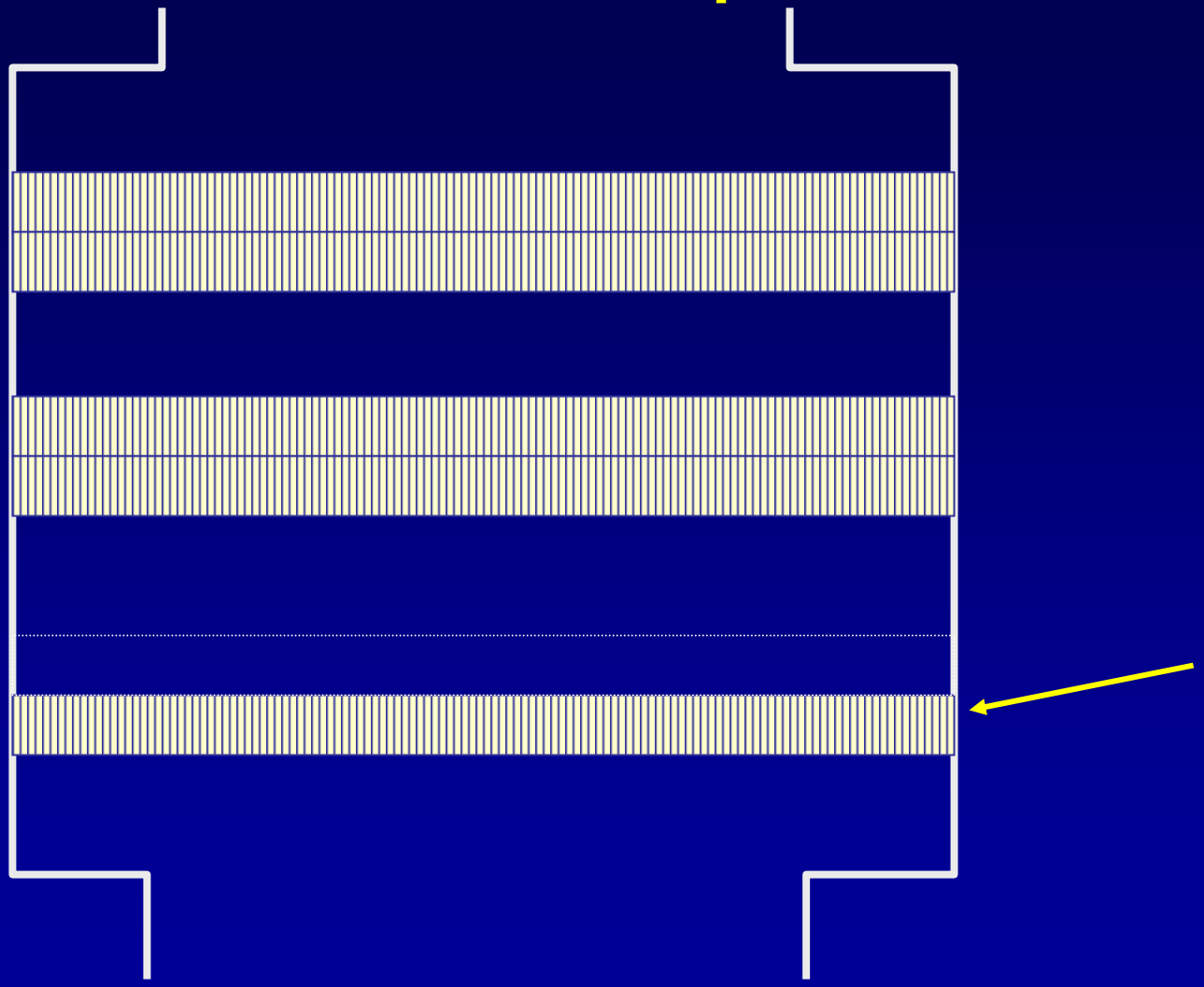

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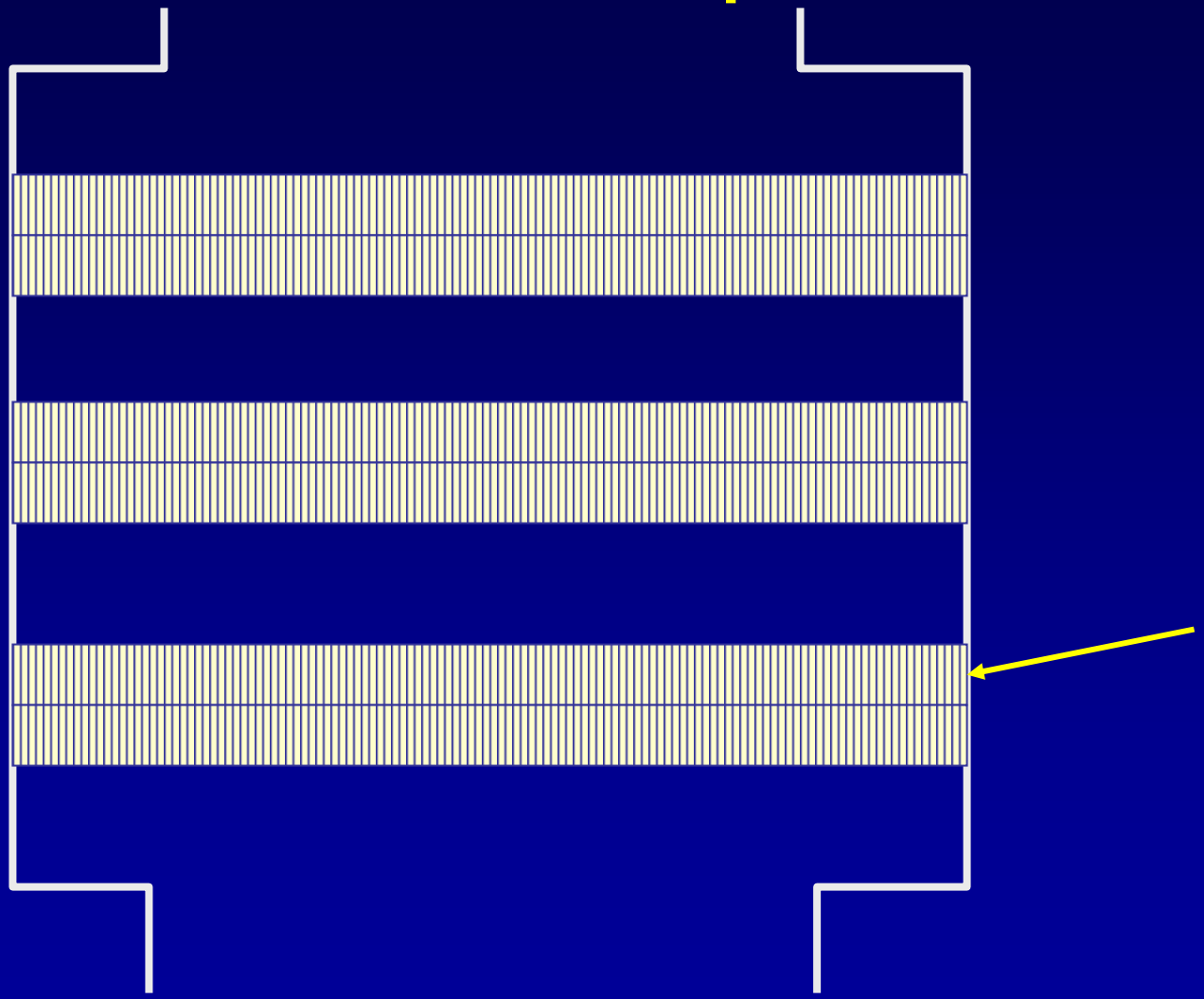

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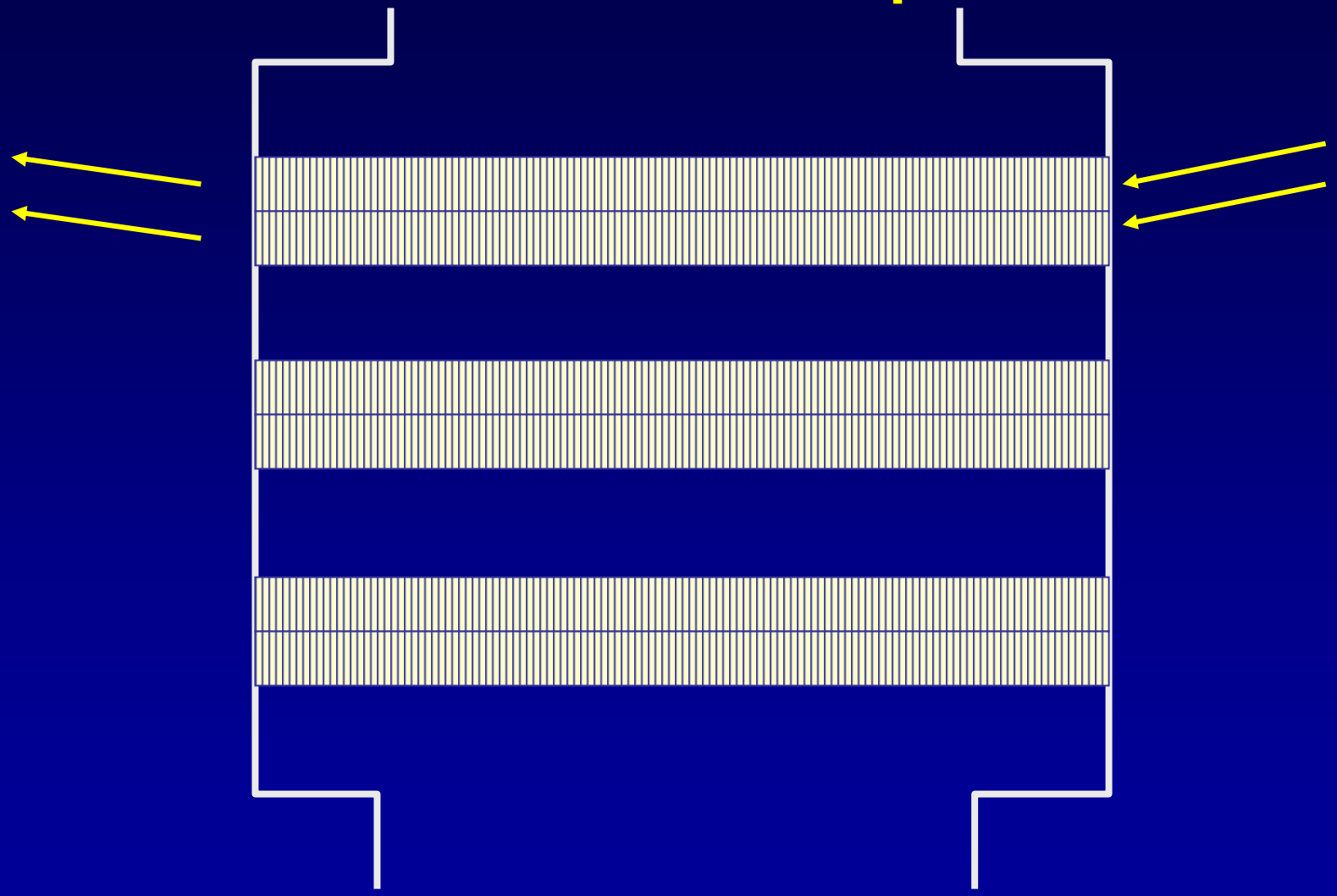

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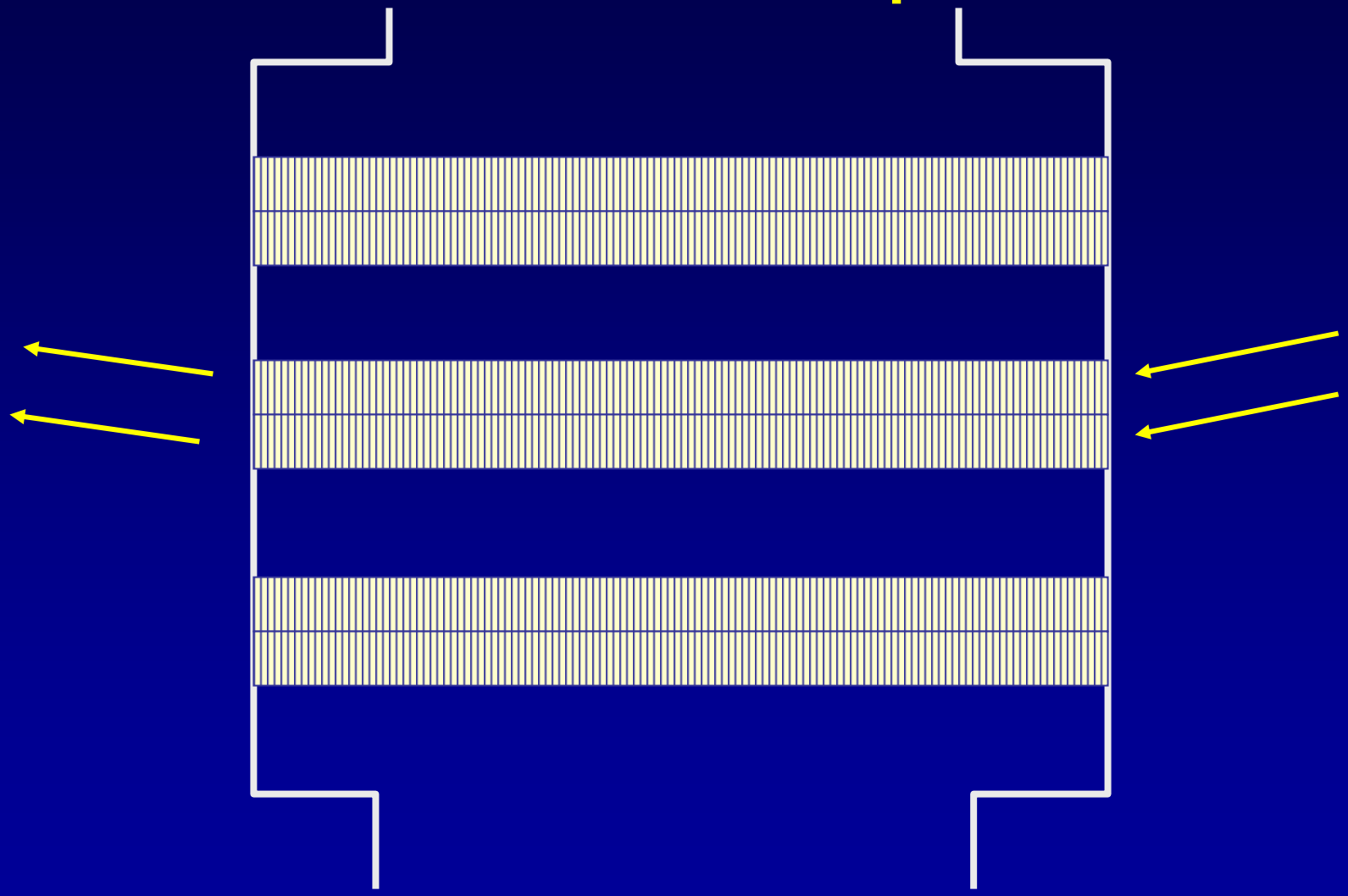

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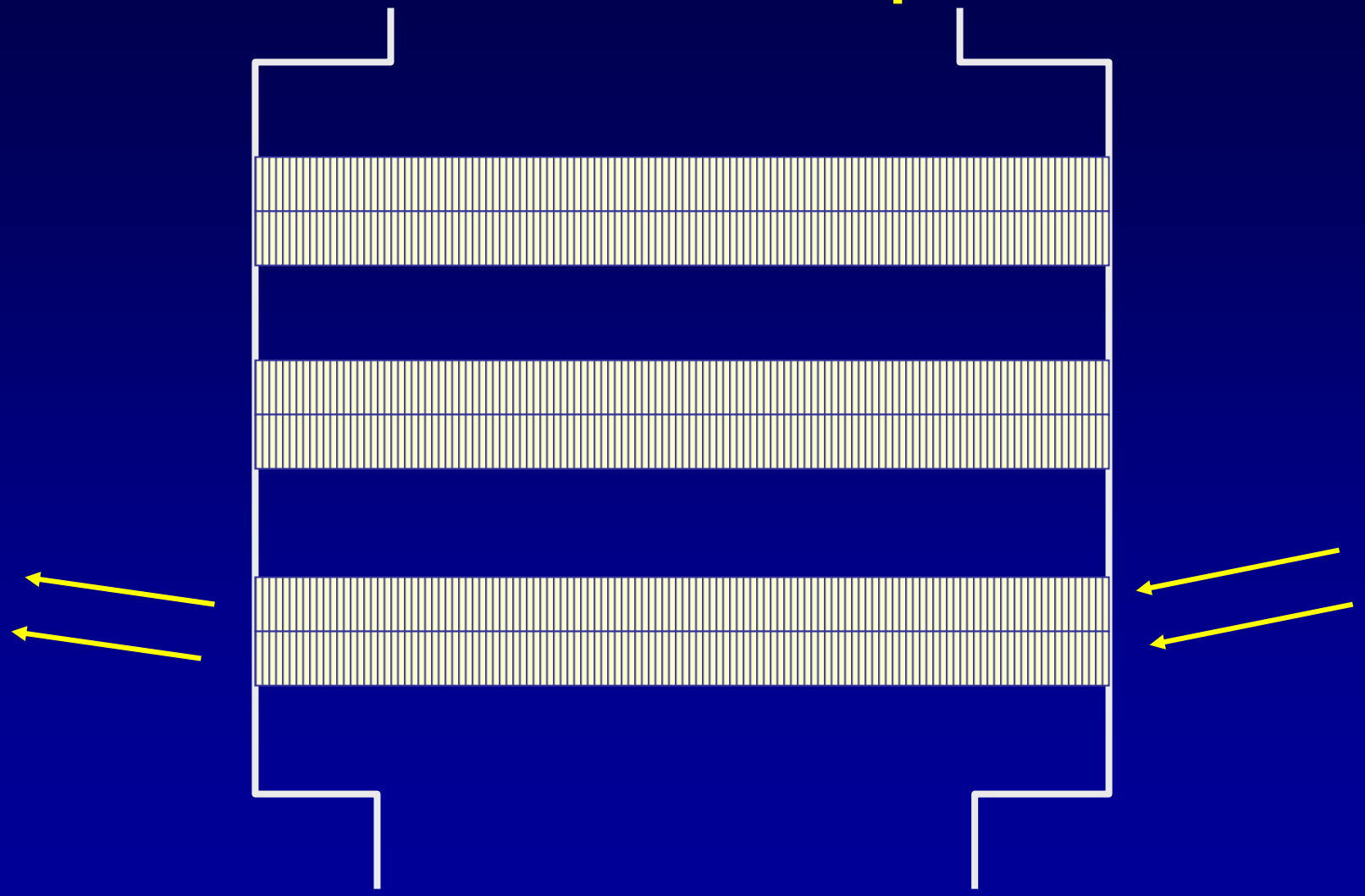
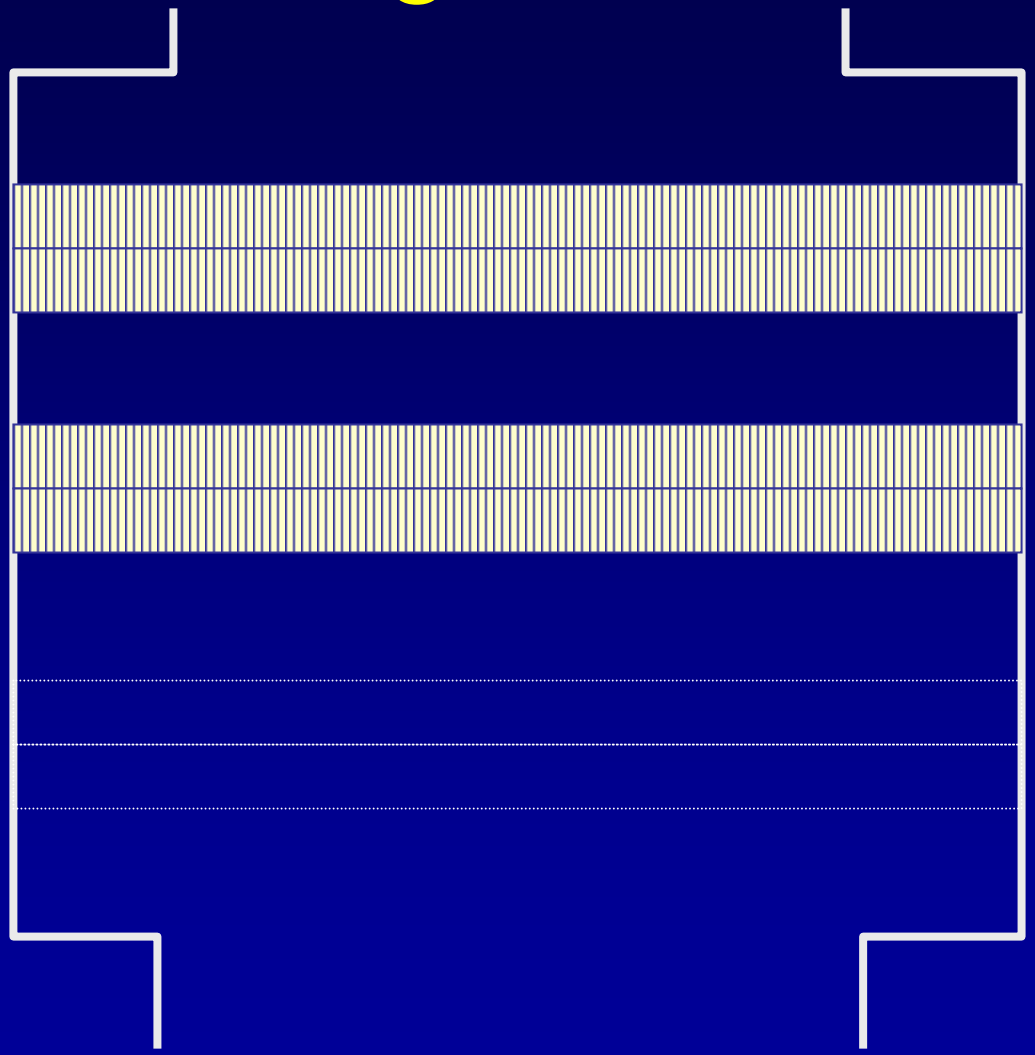


Regeneration



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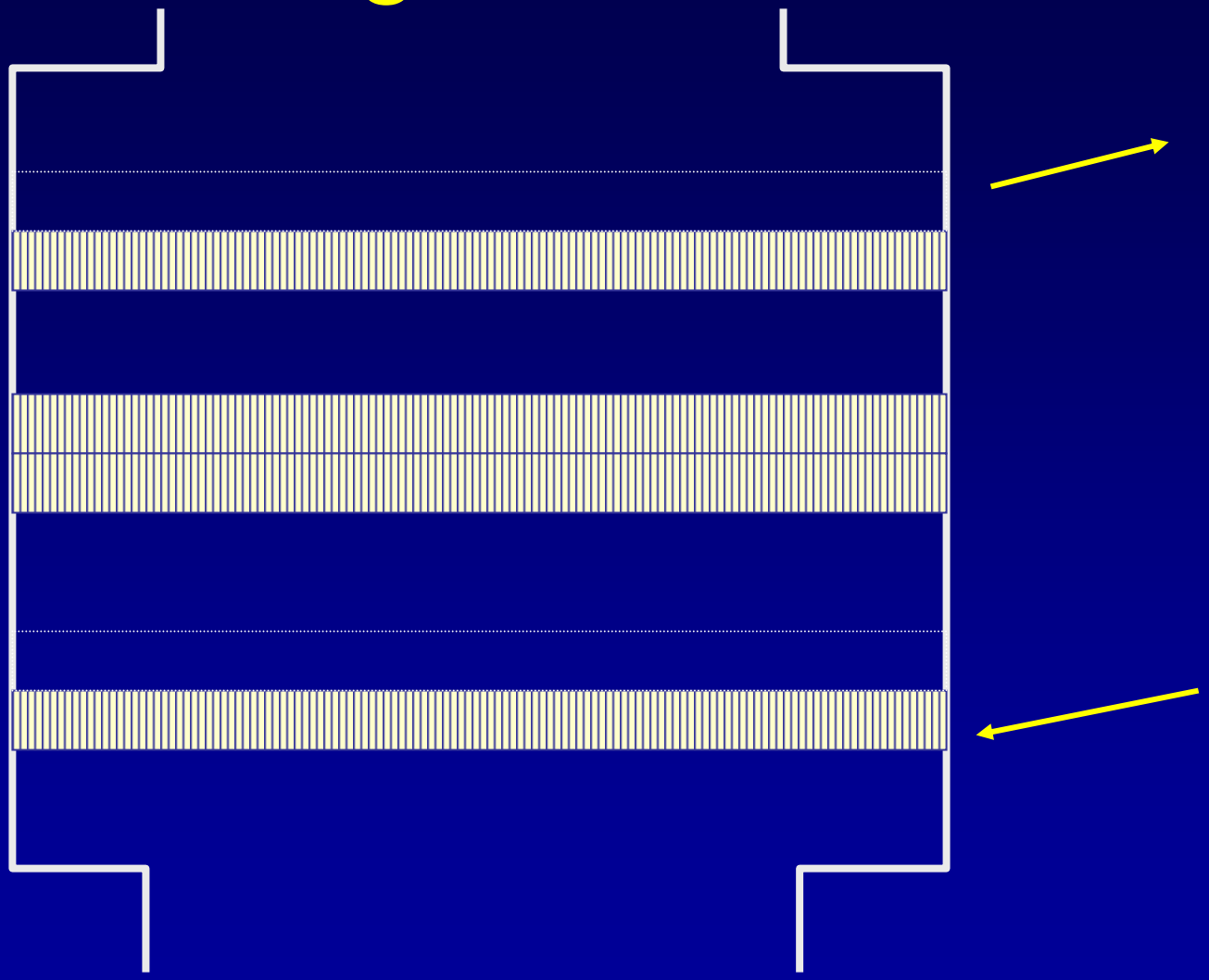

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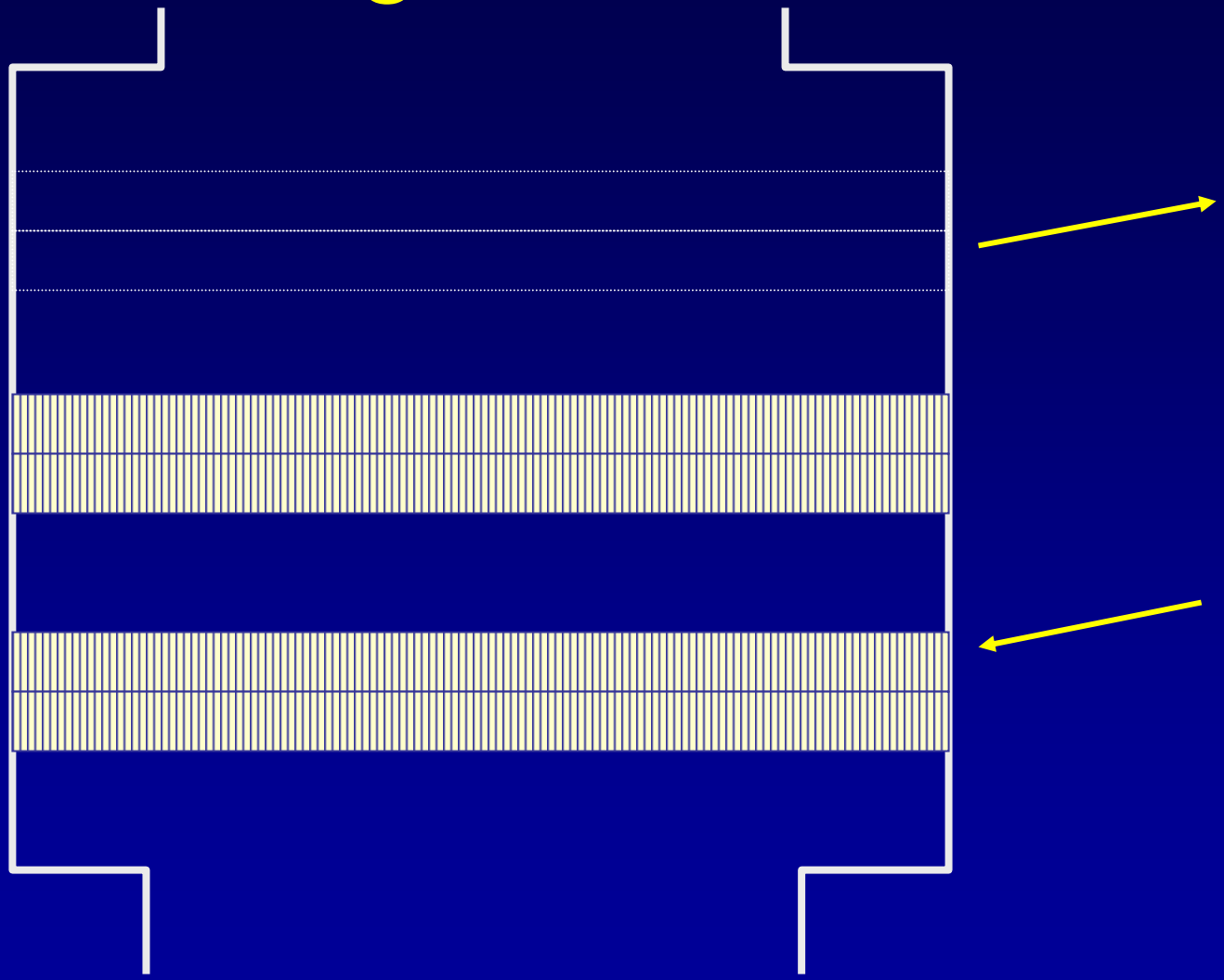

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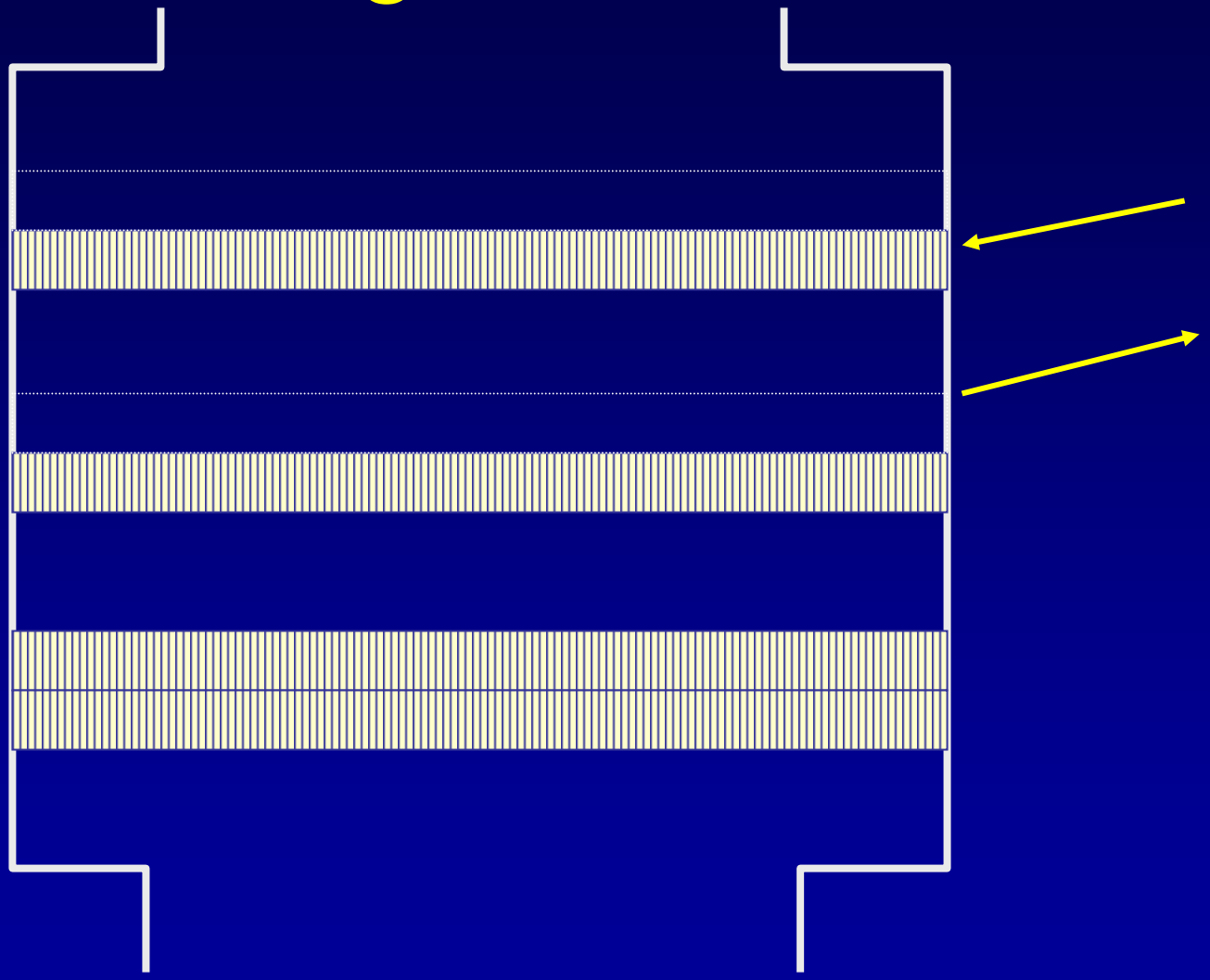

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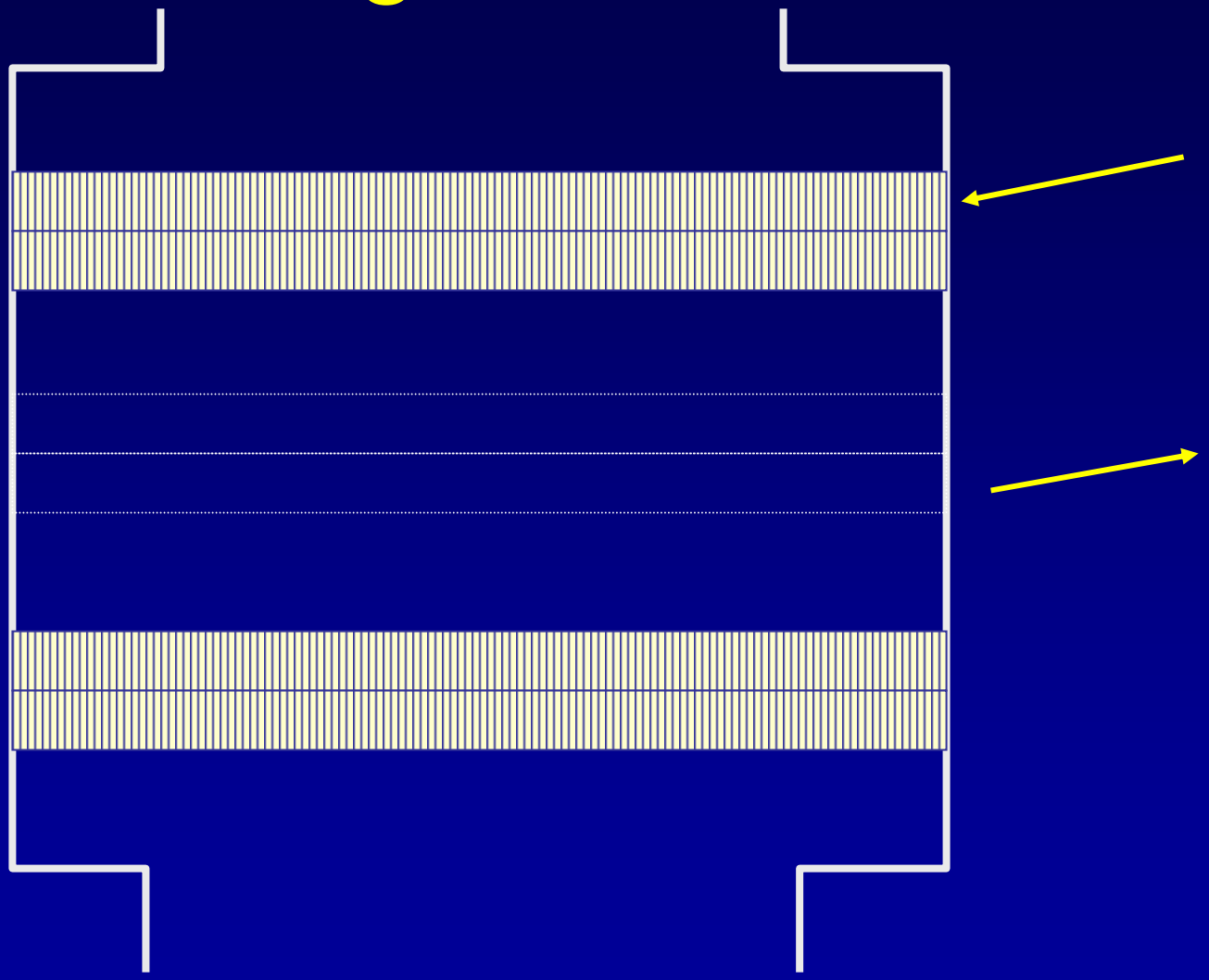

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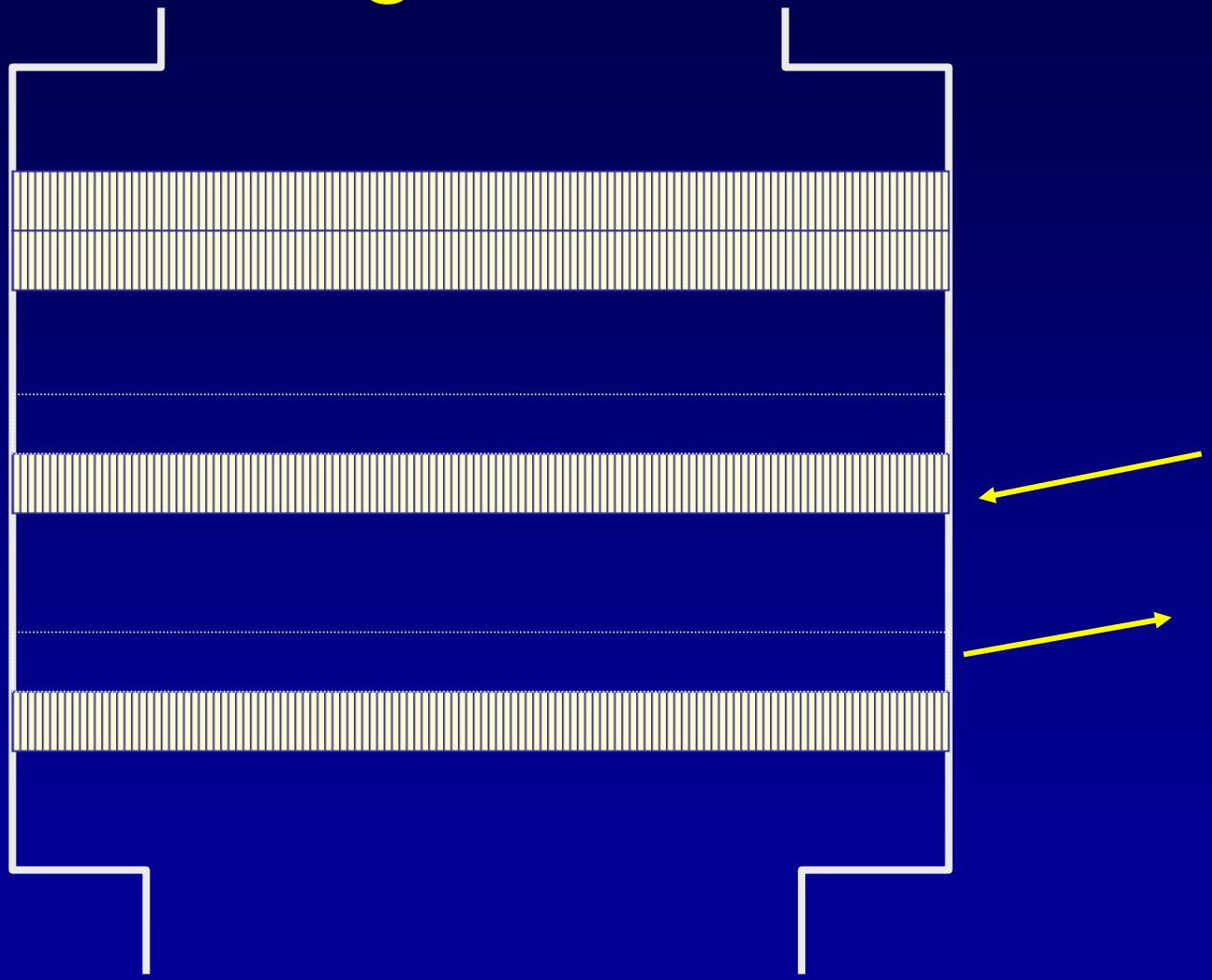

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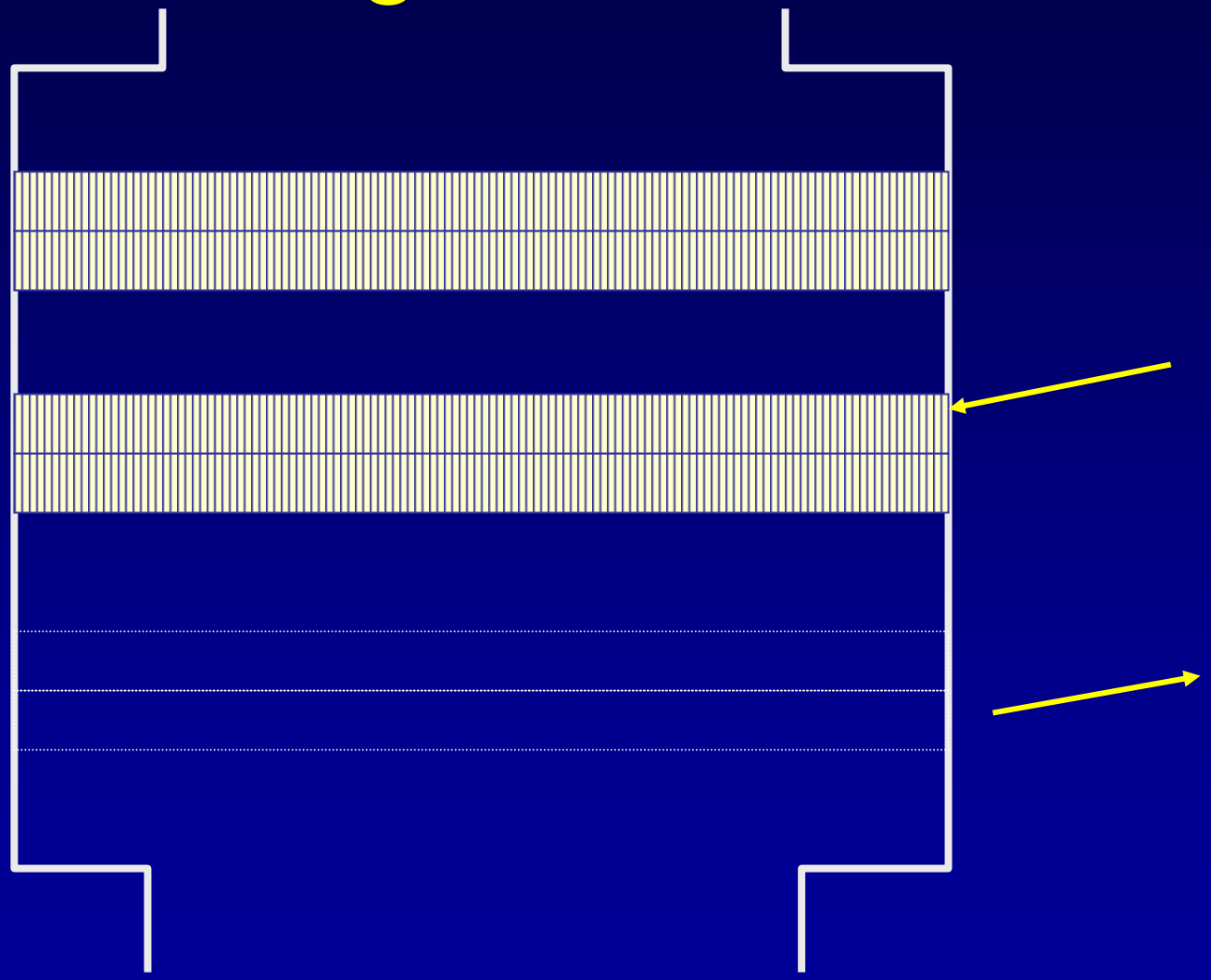

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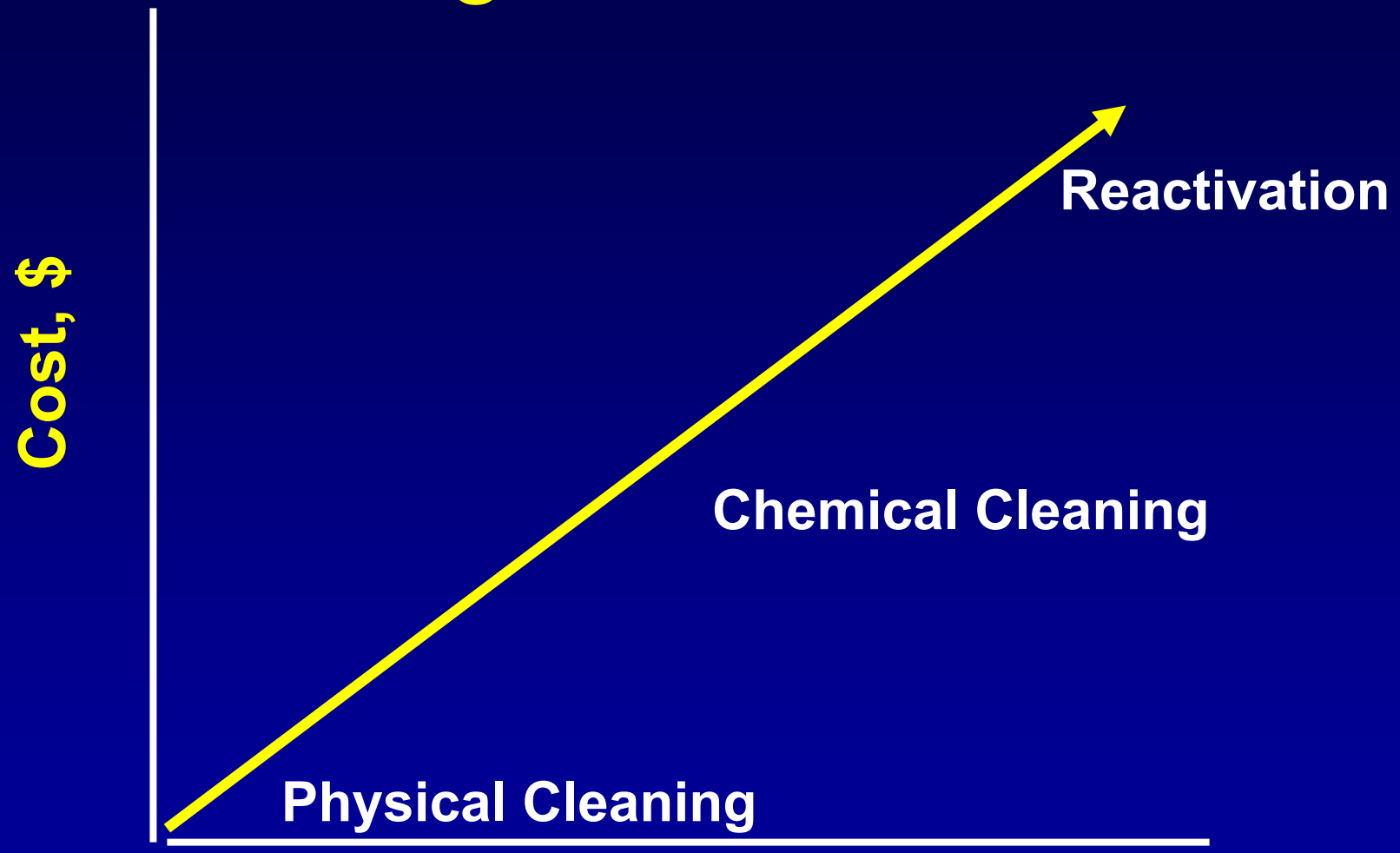


Regeneration Caveats

- Reactivated Catalyst May Not Behave Exactly Like Original Catalyst
  - Deactivation rates may differ
  - SO_2 to SO_3 oxidation rates may differ
  - Limited experience has been good
- Regeneration cannot correct physical damage (erosion, cracking, etc.)
  - Likely to eventually need new catalyst

Catalyst Management – Lots to Consider

Catalyst usage

Outage frequency and length

New or regenerate?

Catalyst Management – Lots to Consider

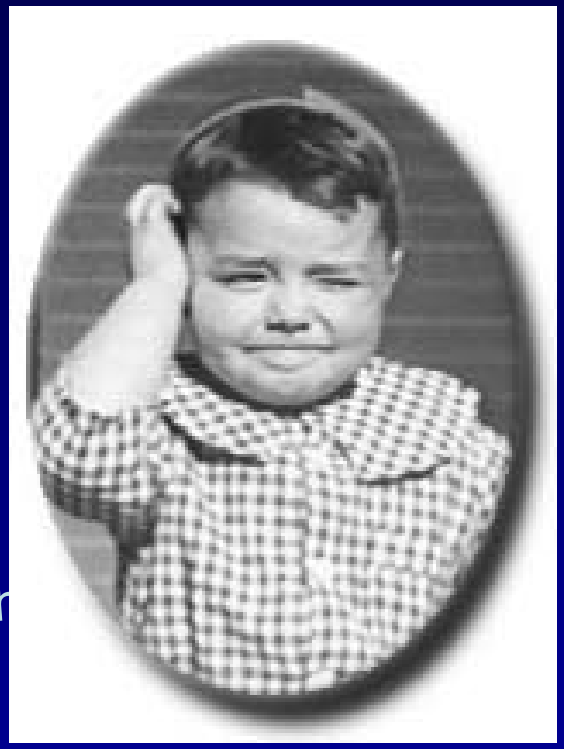
Present value of future costs?

Catalyst usage

What if we change catalyst suppliers?

Outage frequency and length

What if regenerated catalyst deactivates in a different way th original catalyst?



New or regenerate?

Ammonia Slip

What if deactivation rates change?

What if we increase NOx reduction?

Add Half Level or Whole?

Pressure drop and parasitic load

Can we go longer between outages?

What if we increase or decrease inlet NOx Level?

Effect of ammonia distribution.

Advantages of an In-House Analysis Tool

- Can quickly and easily reassess options to evaluate potential cost-saving or performance-enhancing solutions
- Less dependent upon catalyst vendors and regeneration service providers
  - A more knowledgeable buyer of products/services
  - Treat catalyst as a “commodity”
- Also a troubleshooting and optimization tool
  - NOx reduction and ammonia slip trade-offs
  - Effects of AIG distribution

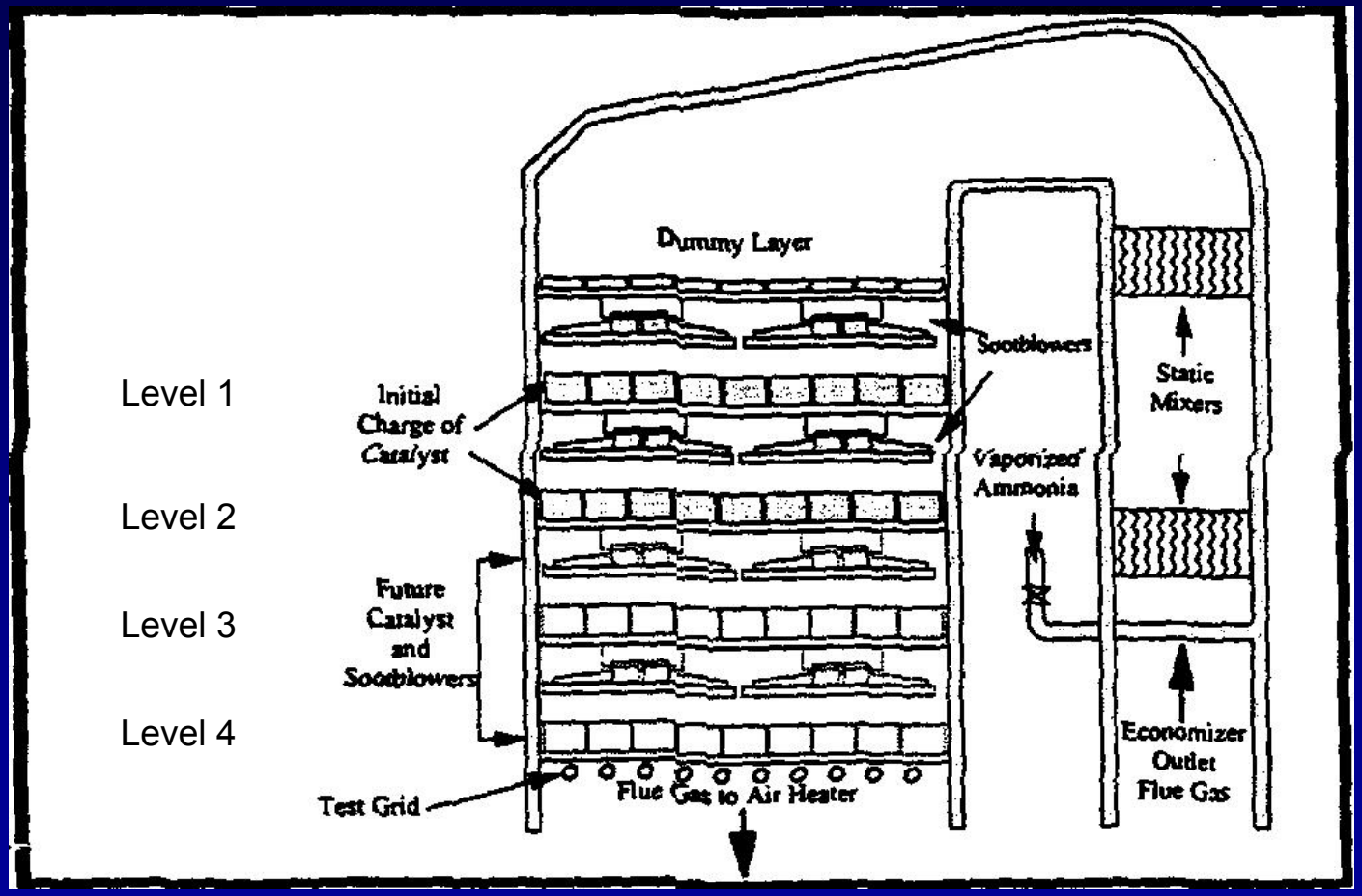
CAT MANAGER™

- Catalyst management software
  - Excel-based for Windows PC's
- Licensed by several utilities and SCR technology suppliers
- Flexible, can model a wide range of situations
  - Any catalyst
  - Add and Replace/Regenerate
  - Regeneration (ver 2.0)

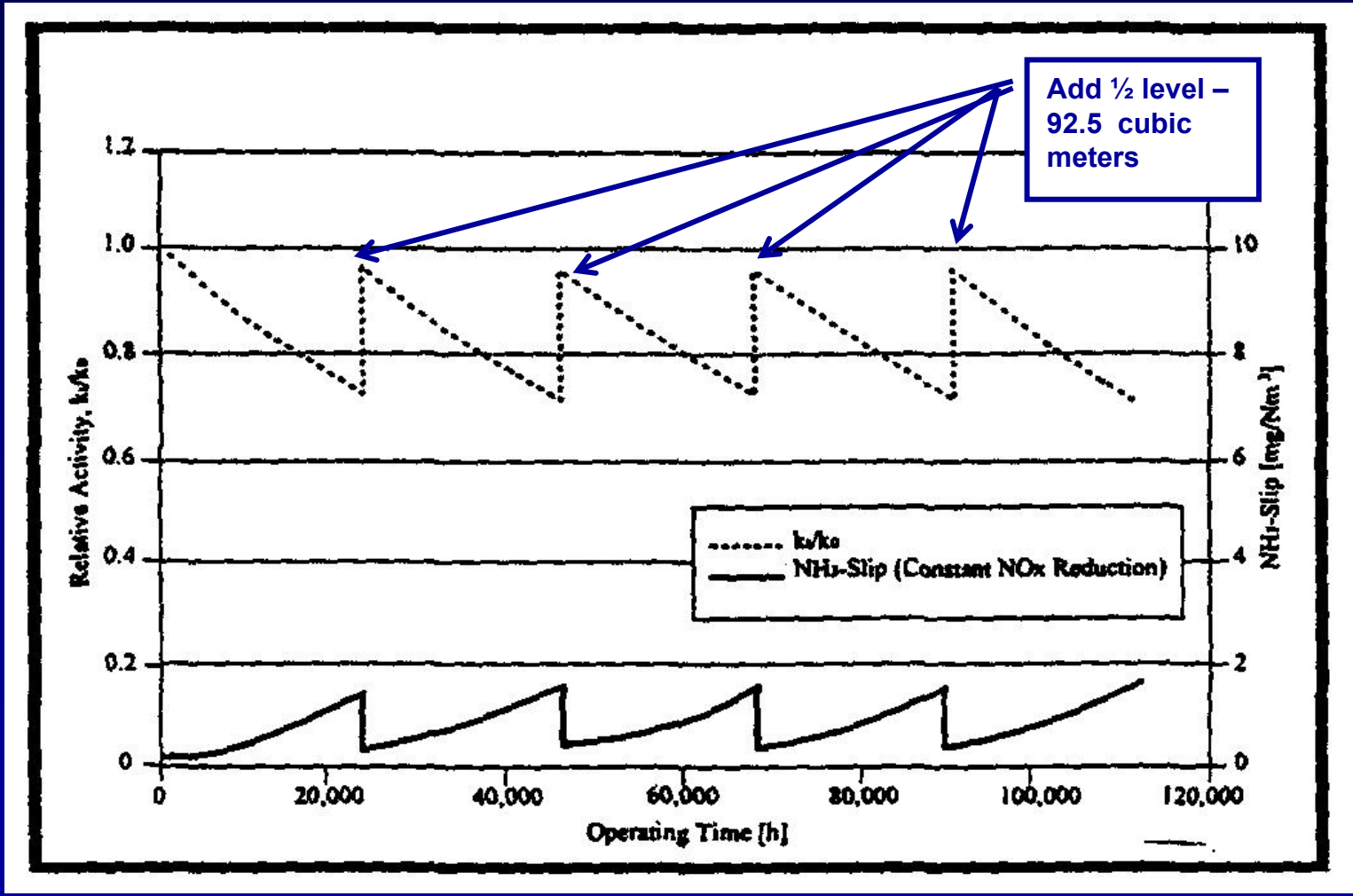
OUC

- SCR installed on new unit
  - 2+2 reactor with 2 layers per level
- Commenced operation 1996
  - About 8000 hrs per year operation
  - ~48% reduction, 2 ppm maximum slip with 3 year catalyst interval was initially planned
- Annual catalyst activity tests
- Experienced more rapid catalyst deactivation than expected
  - CaO in coal lower than expected, yielding high arsenic concentration and deactivation
- Needed to revise catalyst management plan

OUC SCR


Level 1
Level 2
Level 3
Level 4
Dummy Layer
Initial Charge of Catalyst
Future Catalyst and Sootblowers
Sootblowers
Vaporized Ammonia
Static Mixers
Economizer Outlet Flue Gas
Test Grid
Flue Gas to Air Heater

OUC Original Plan



Catalyst Additions

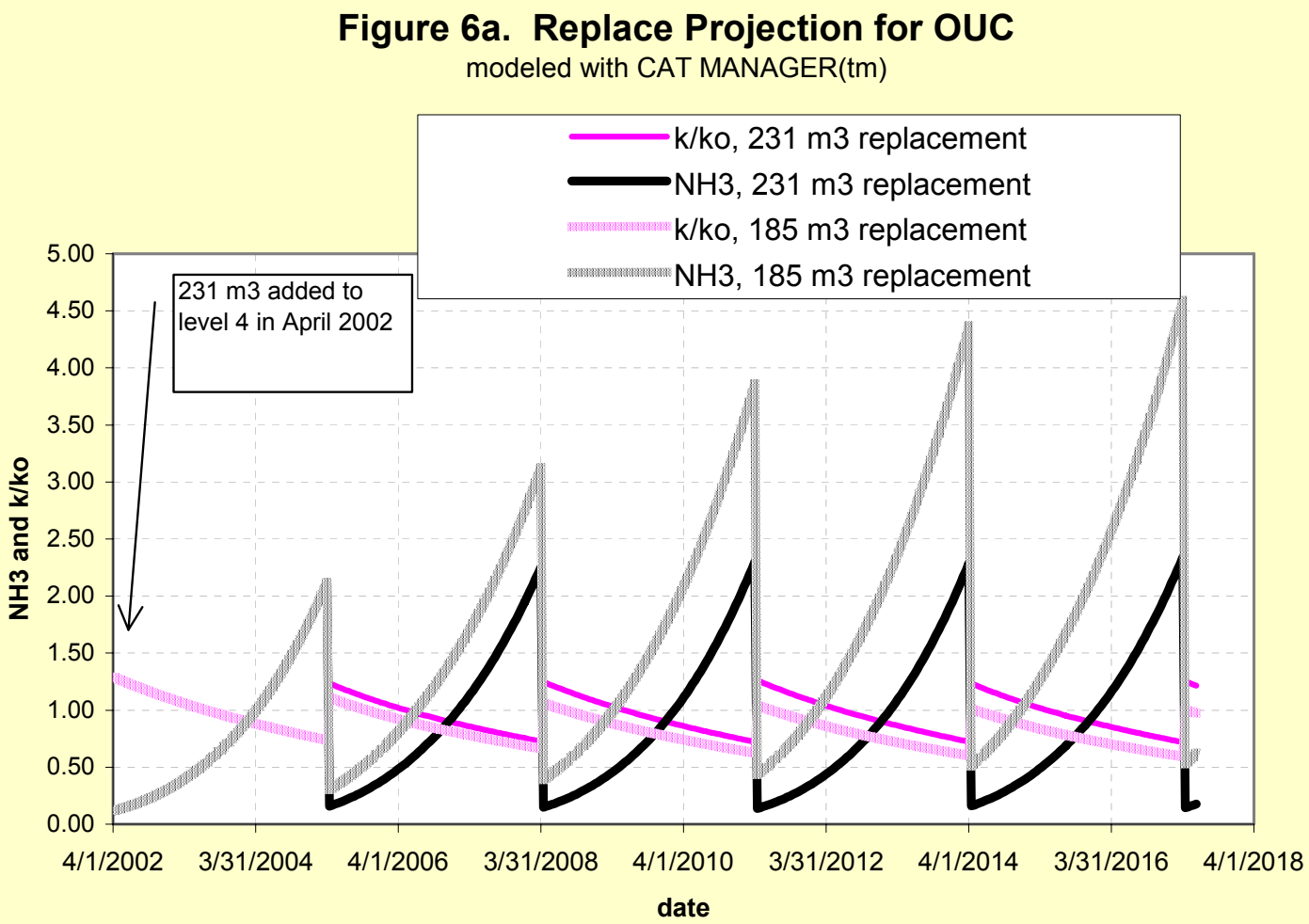
	Expected	Actual
1999	92.5 m3	185 m3
2002	92.5 m3	231 m3

- All four layers are full at this time
- Revised allowable slip to 4 ppm
  - Enables 3-year interval on replacement
- Revised catalyst plan determined by OUC and catalyst manufacturer

Going forward

- OUC evaluating various scenarios
  - Replace existing layers with new catalyst
  - Regeneration of existing catalyst
- CAT MANAGER™ ver 2.0 enables OUC to perform their own analysis of these various approaches
  - OUC purchased license to CAT MANAGER™ in 2002

Projection of Replacement



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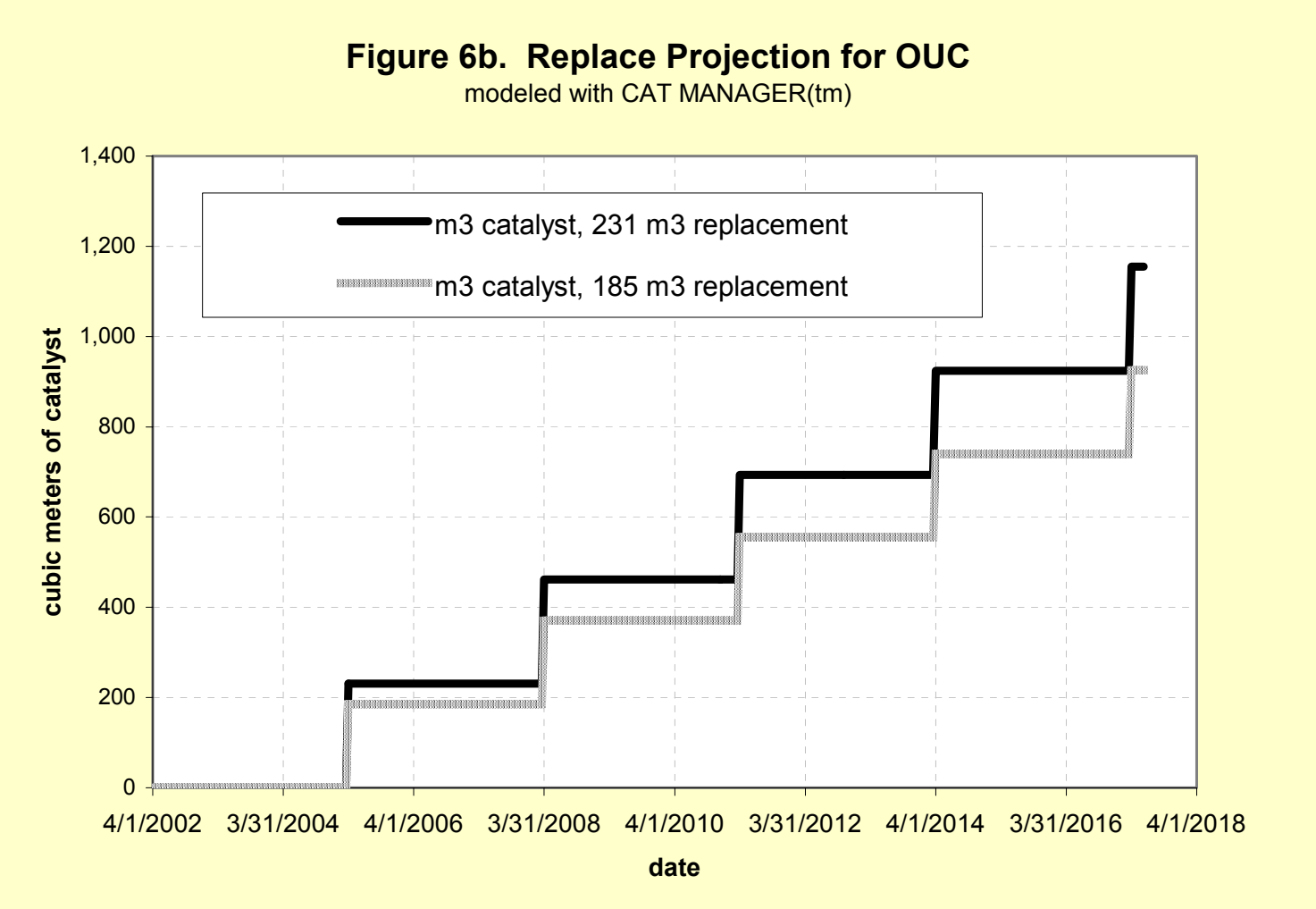
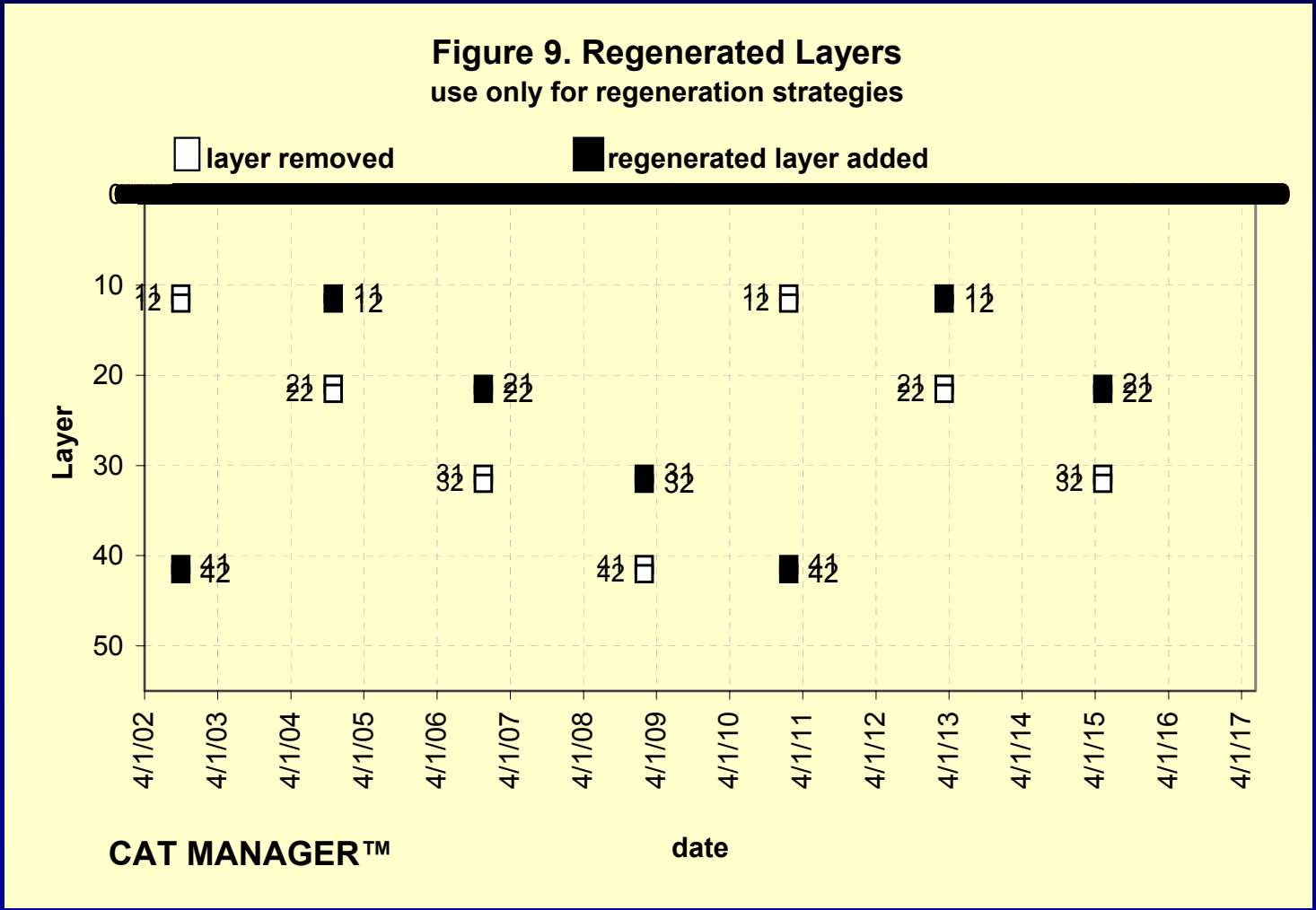


Regeneration Schedule



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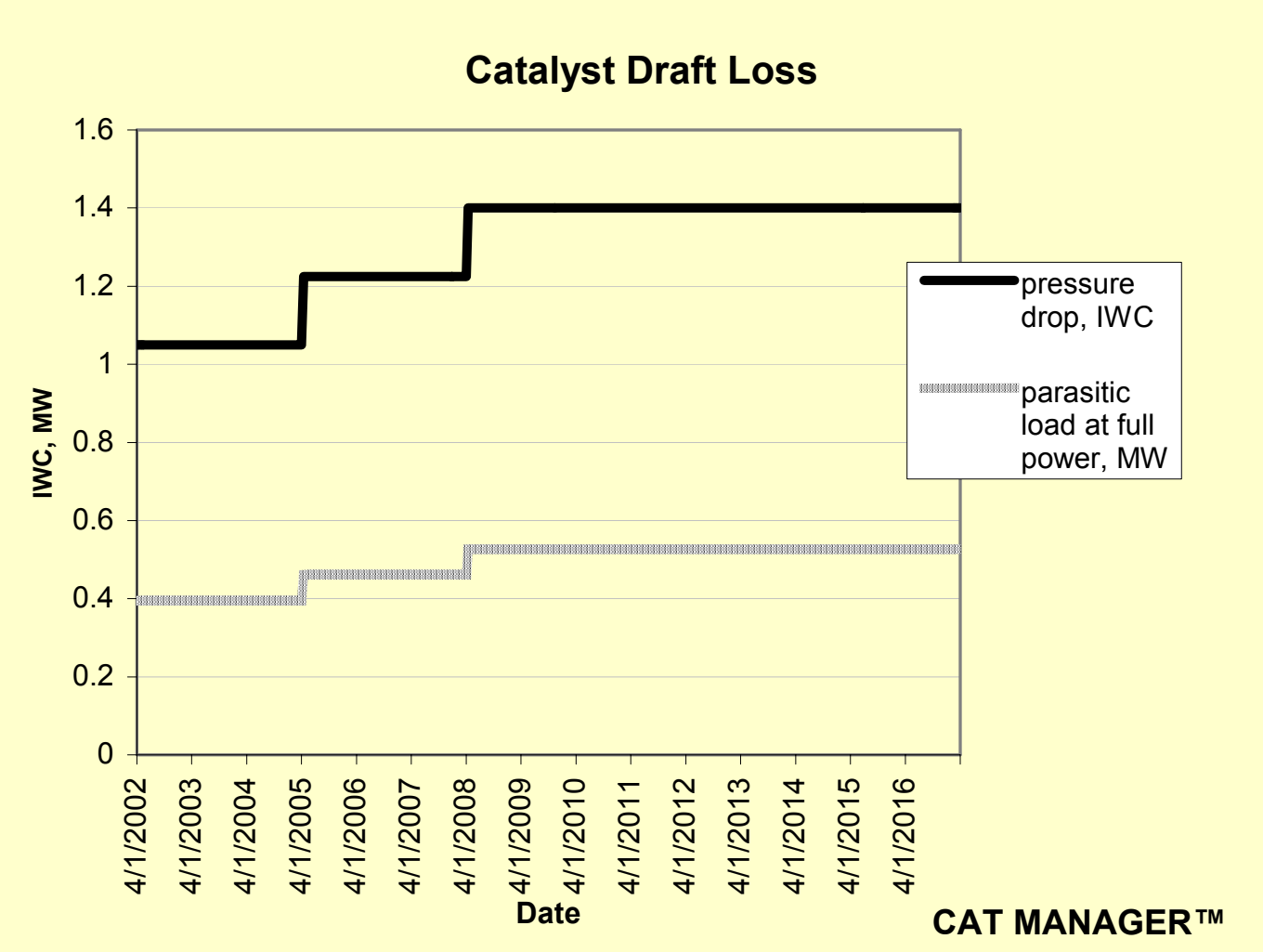
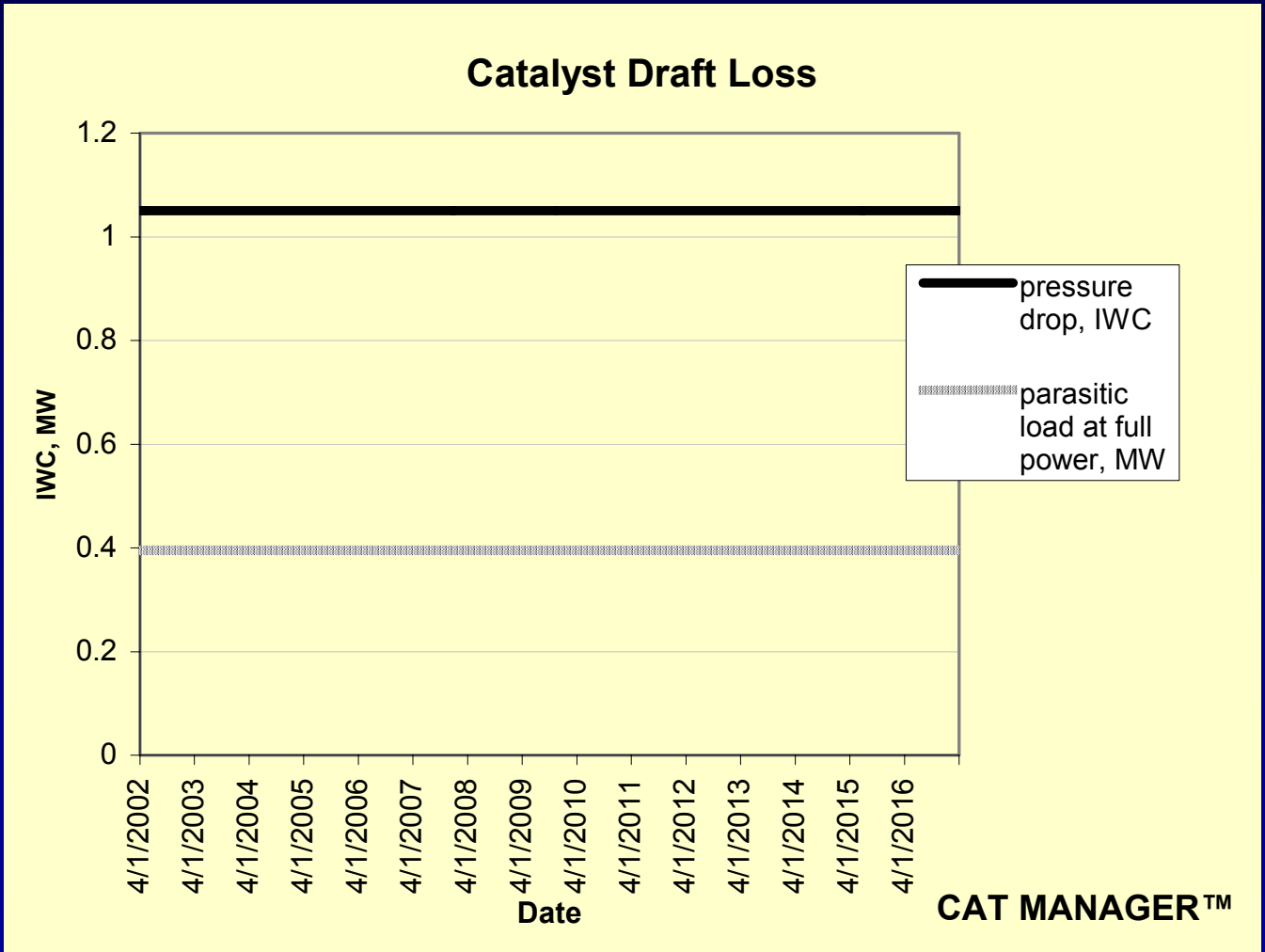
Draft Loss for Add and Replace



Draft Loss for Regeneration



Additional Outputs Available

- Cash Flow Projections by Year
- Present Value Analysis
- Add/Replace projections by level and amount
- Pressure Drop and Parasitic Power and Value of Parasitic Power
- Projected activity of individual layers

OUC 15 Year Analysis - Summary

	Per event	Catalyst	Outages
3-yr Replace	185 m3	925 m3	5
3-yr Replace*	231 m3	1155 m3	5
Regen (100%)	92.5 m3	1017.5 m3	11
Regen (100%)	185 m3	1295 m3	7
Regen (95%)	185 m3	1480 m3	8

* Could go longer than 3 years and stay under 4 ppm slip

Conclusions – OUC catalyst

- 3-year replacement interval and 4 ppm slip appear possible with less than 231 cubic meters replacement
- Regeneration may be an economical alternative to meet performance objectives
  - Somewhat more frequent outages
  - Somewhat lower pressure drop
  - Depends on cost to regenerate and costs of outages

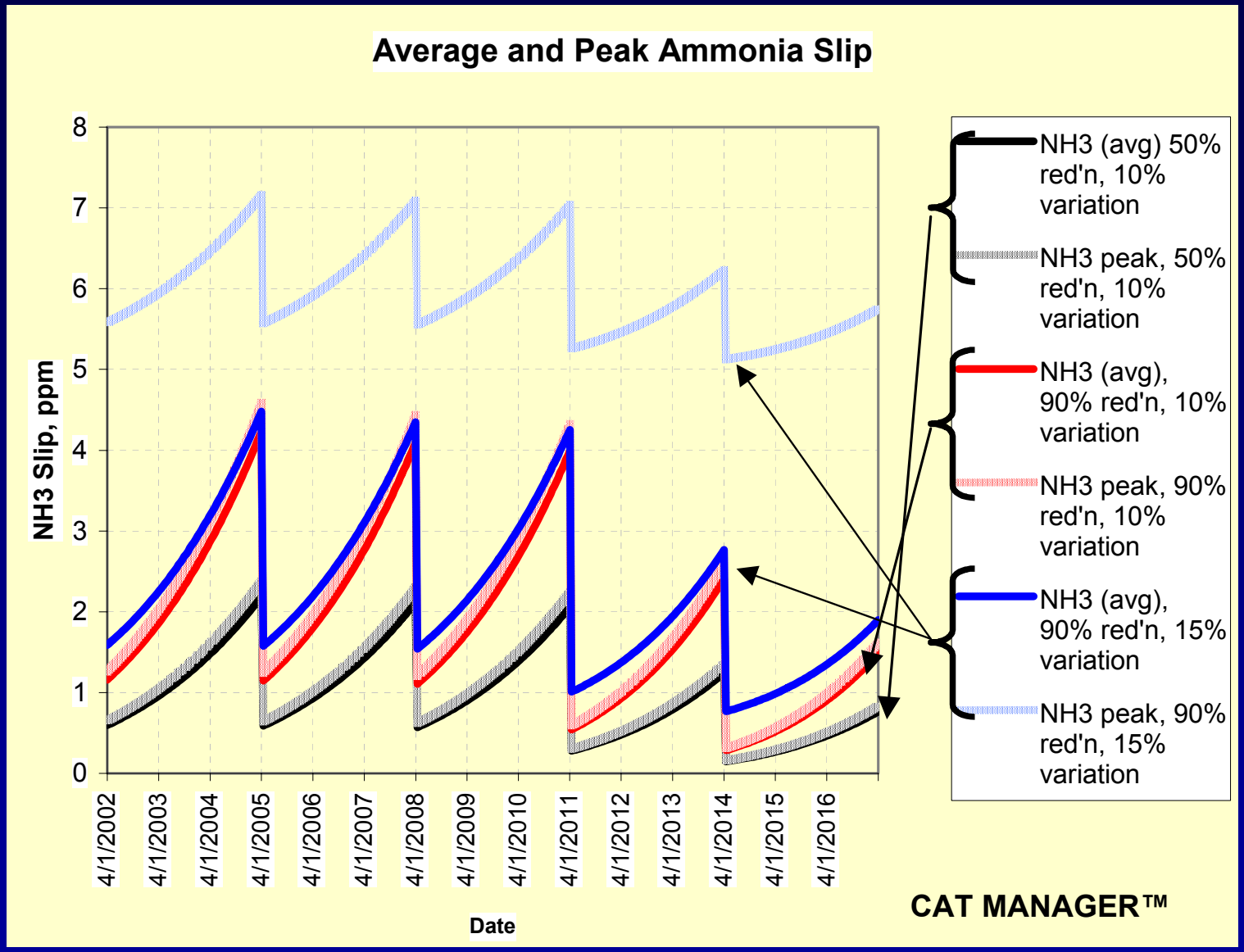
Conclusions – CAT MANAGER™

- Modeling of SCR performance, including ammonia, showed reasonably good accuracy
- Provides useful tool for screening catalyst management strategy alternatives
- Complements program of regular catalyst testing/monitoring.
  - Testing provides input for update and verification of deactivation models

Ammonia Distribution and Ammonia Slip for High Removal SCRs

- Unrelated to OUC, but an important issue for many attendees here
- Looked at similar reactor (3+1), but lower deactivation rates typical for dry-bottom boiler with low gaseous arsenic levels
- Looked at effects of
  - Increasing NOx reduction
  - Worsening of ammonia distribution

Increasing NOx Reduction



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General Conclusions

- Catalyst management plan should consider more than just catalyst usage and outages
  - Optimize plan to minimize costs and maximize revenues of plant
- Reassess plan regularly for changes in catalyst performance, operational changes, and new management approaches
  - An interactive tool is very helpful!

General Conclusions

- Regeneration may be an economical alternative to meet performance objectives vis-à-vis add-and-replace
  - Somewhat more frequent outages
  - Somewhat lower pressure drop
  - Depends on cost to regenerate and costs of outages

General Conclusions

- Extra vigilance is needed for high NOx reduction systems
  - Especially sensitive to NH3:NOx distribution
  - Peak ammonia slip may be much greater than average slip if distribution is poor
- Catalyst Management is important, but with the right tools it's not Rocket Science

Thank You!

- Come by the Poster
- Web site has more info
  - Technical papers/presentations
    - NOx and Mercury control
  - How to order CAT MANAGER™
  - To contact me:
    - **staudt@AndoverTechnology.com**