REINHOLD ENVIRONMENTAL ®

2024 Reinhold/PCUG Round Table Presentation

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2024 REINHOLD/PCUG CONFERENCE

SCR System Performance Issues: The Big Four

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The Big Four

1. Plugging

2. Deactivation

3. Catalyst Selection

4. NH_3/NOx Distribution

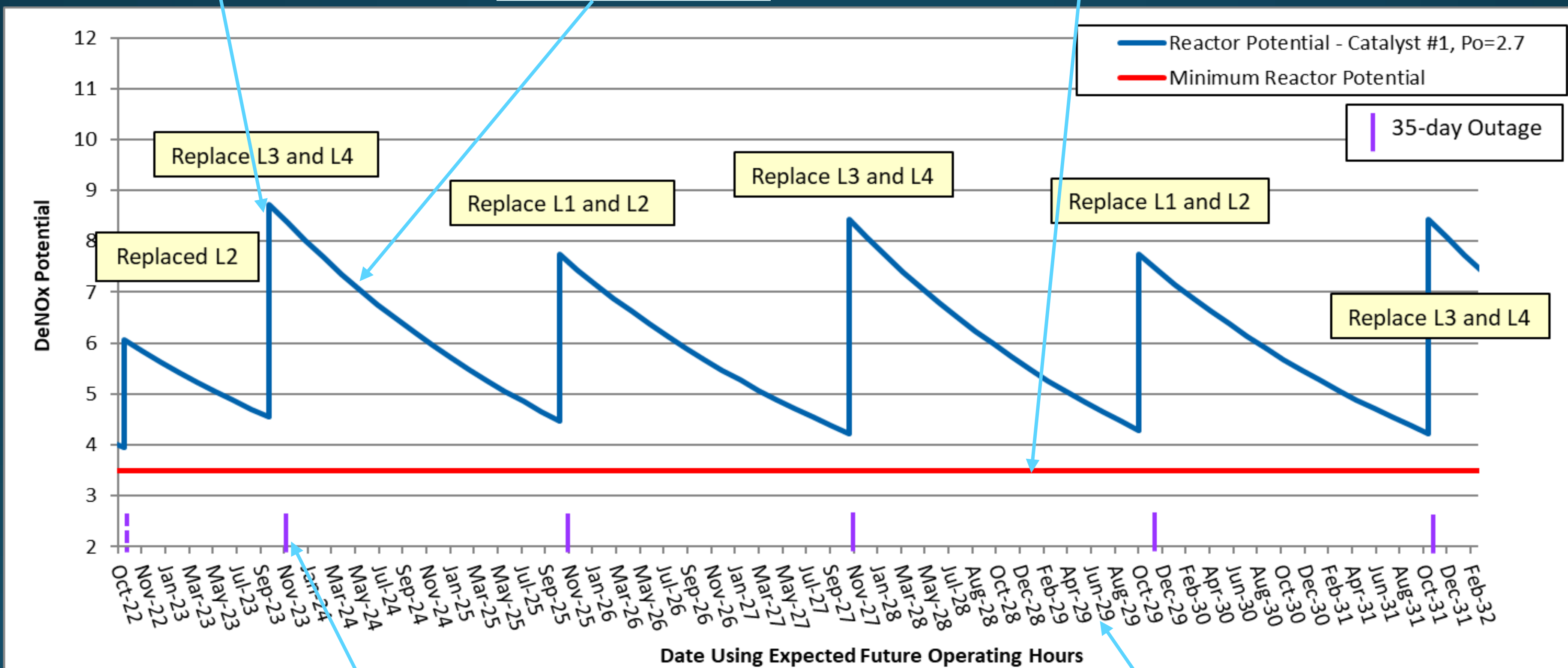
Catalyst Management Plans

What are we really looking at ?

Initial deNOx potential controls height of step; includes catalyst volume, activity, geometry (SSA), unit flow rate

Slope is controlled by deactivation and plugging

Minimum required deNOx potential is controlled by inlet and outlet NOx (deNOx), and NH_3/NOx, temperature, and flow distributions

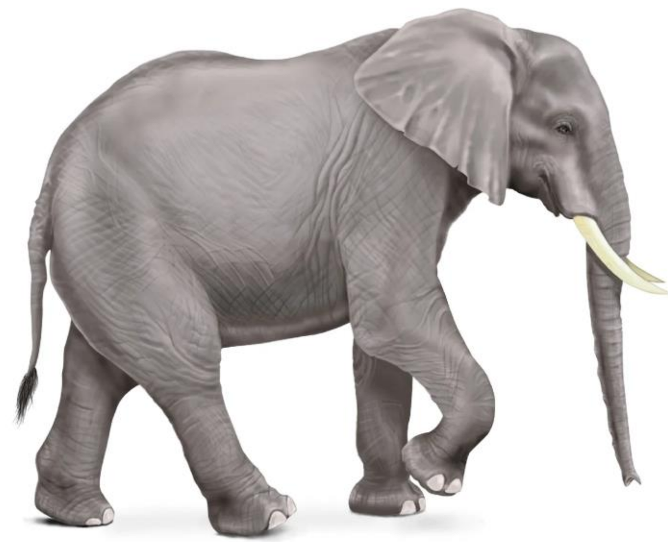


Catalyst replacement dates controlled by planned outages (hopefully)

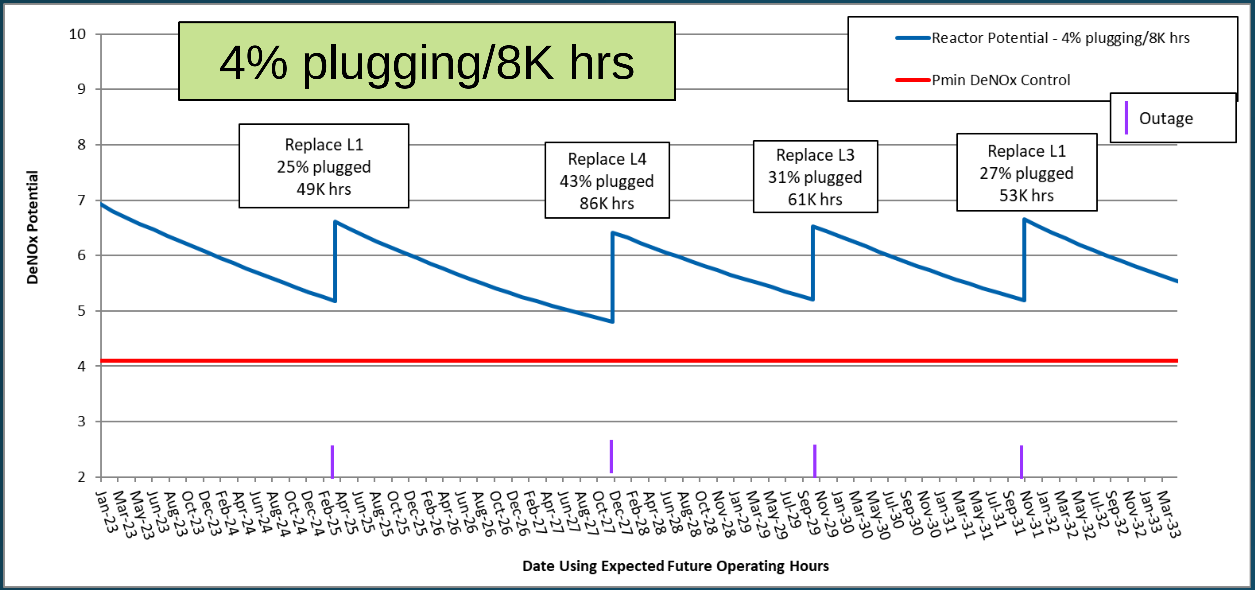
Operational hours vs. date controlled by unit utilization (hours online per calendar year – historical and predicted)

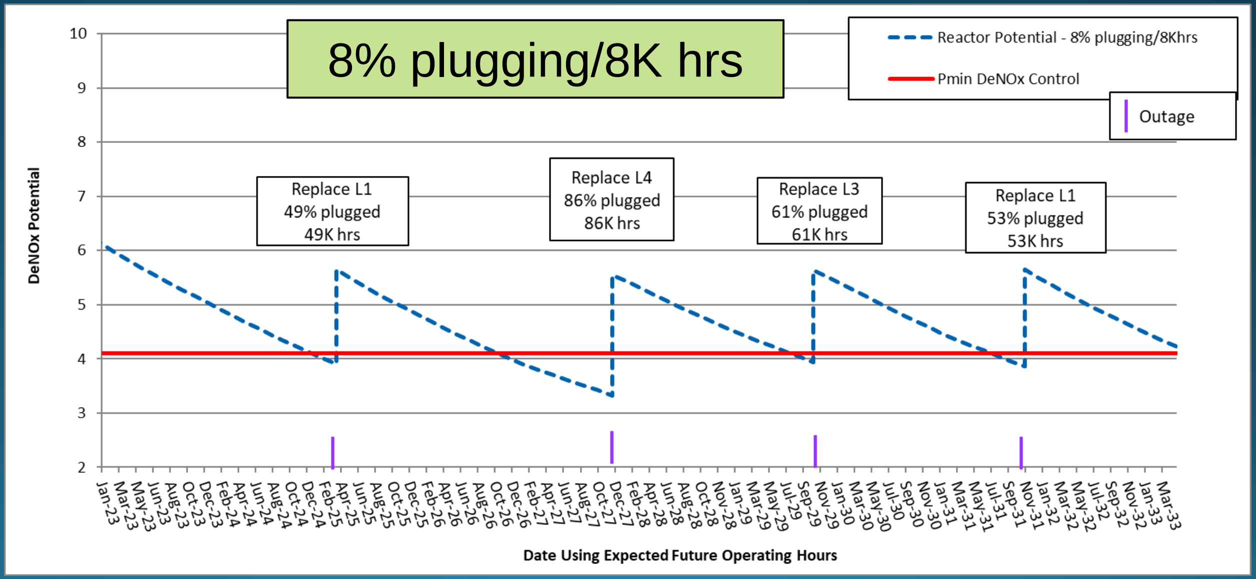
Plugging

- Plugging is generally the biggest issue that an SCR will have operationally.
- Plugging costs $$$ -huge cost in premature catalyst replacements, pressure drop, and maintenance.
- Plugging most often caused by improper flow and ash distribution or inadequate cleaning.
- Catalyst design should <u>not</u> be the first stop to correct plugging.



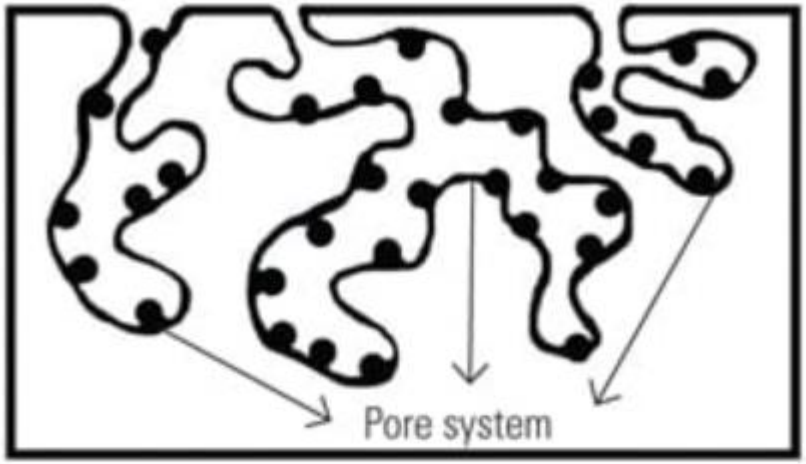
Practical Effect of Plugging on Catalyst Management



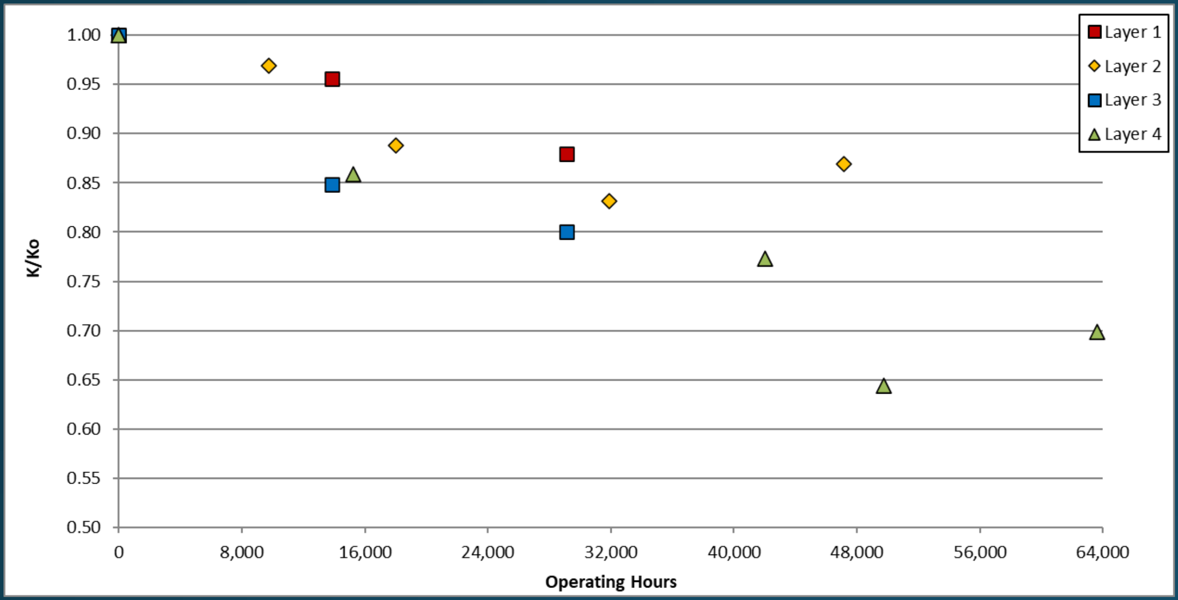


Deactivation

- Unavoidable decline in deNOx potential as a function of fuel combined with operating conditions.
- Calcium sulfate poisoning for PRB coals, arsenic poisoning for EB coals.
- Deactivation is tracked through laboratory testing and predicted for catalyst management purposes.

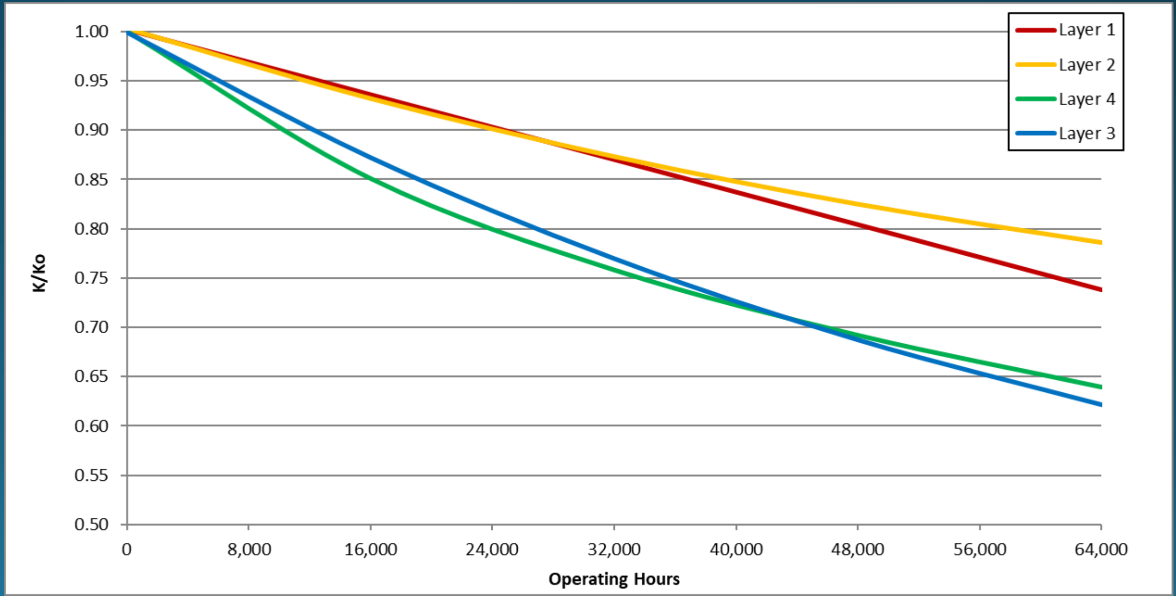


Actual deactivation data has scatter and can be difficult to interpret – hindsight is 20/20

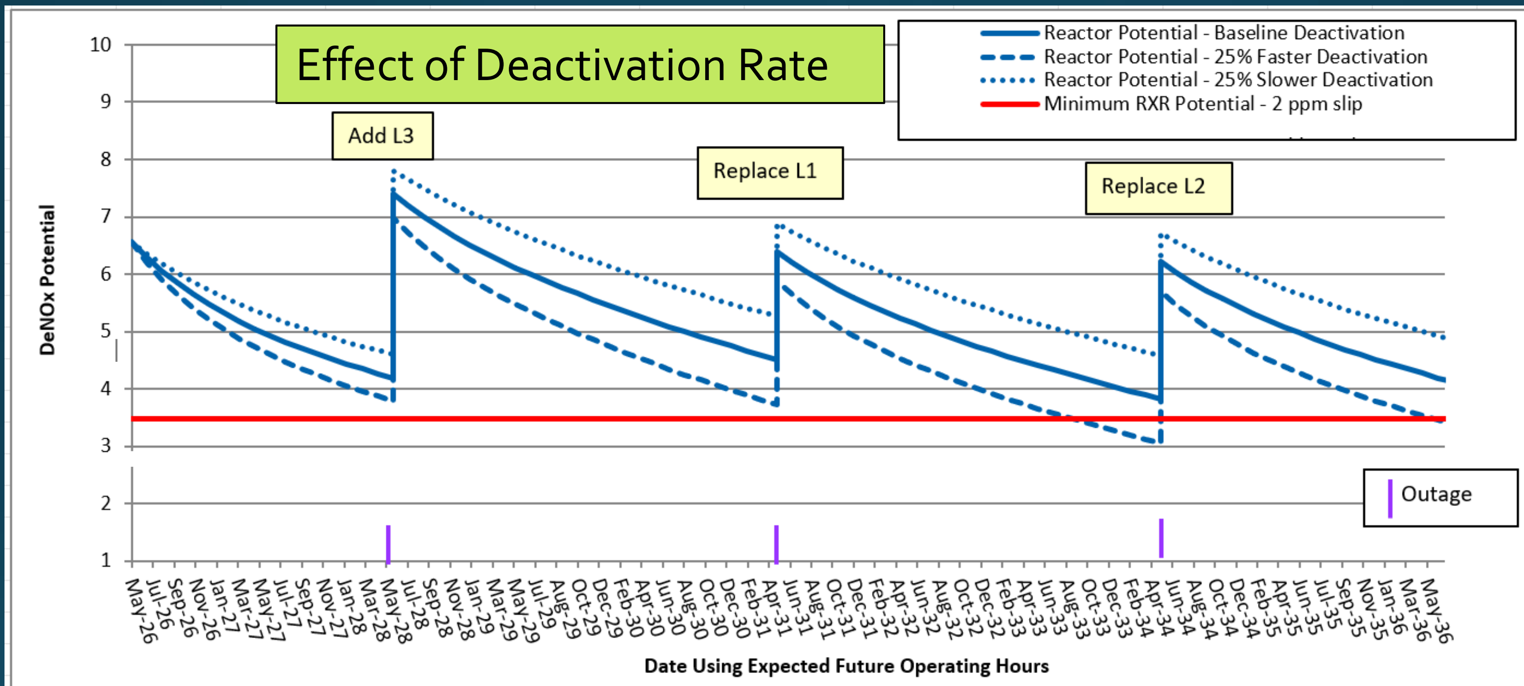


Using units with similar designs and fuels as surrogates doesn't always work.

Using historical deactivation rates for a unit isn't always applicable – things change.



Deactivation affects the slope of the deNOx potential curve, but also affects the gain in potential when replacing a layer because it affects the amount of residual potential in the replaced layer. Deactivation can strongly affect catalyst replacement demand.



Comparative K/Ko vs. Time			
Hrs	Baseline Deactivation	25% Faster Deactivation	25% Slower Deactivation
0	1.00	1.00	1.00
16,000	0.85	0.81	0.89
32,000	0.76	0.70	0.82
48,000	0.69	0.61	0.77
64,000	0.64	0.55	0.73

Catalyst Selection

Ultimately catalyst selection will determine the deNOx potential, SO_2 conversion, pressure drop and mercury oxidation. Must find a balance between these performance parameters, along with plugging potential, catalyst volume, cost.

DO NOT MISTAKE INITIAL PERFORMANCE FOR LONG TERM PERFORMANCE!

Catalyst Option	1	2	3	4	5	6
SSA (m^2/m^3)	360	404	424	539	295	351
Number of RXRs	2	2	2	2	2	2
Cat. Vol. Per RXR (m^3)	211.0	215.0	209.0	210.0	218.0	205.0
Total Cat. Vol. (m^3)	422	430	418	420	436	410
Total SA (m^2)	151,920	173,720	177,232	226,380	128,620	143,910
Ko (m/hr)	38.0	42.0	40.0	37.0	36.0	39.0
Flue Gas Flow at (wNm3/hr, 0 ^{o}C)	2,584,991	2,584,991	2,584,991	2,584,991	2,584,991	2,584,991
AV (m/s)	17.0	14.9	14.6	11.4	20.1	18.0
Po	2.23	2.82	2.74	3.24	1.79	2.17
SO2 Conv. (%)	0.45	0.55	0.40	0.35	0.30	0.40

Always a tradeoff with catalyst parameters

- Smaller pitch increases specific surface area (SSA), which increases total surface area which increases deNOx potential, but also increases SO_2 conversion, pressure drop, and potential for plugging

- Taller catalyst increases catalyst volume and total surface area, which increases deNOx potential, but also increases SO_2 conversion and pressure drop. Height changes may require changes to catalyst cleaning equipment.

- Higher deNOx activity increases deNOx potential but typically also increases SO_2 conversion.

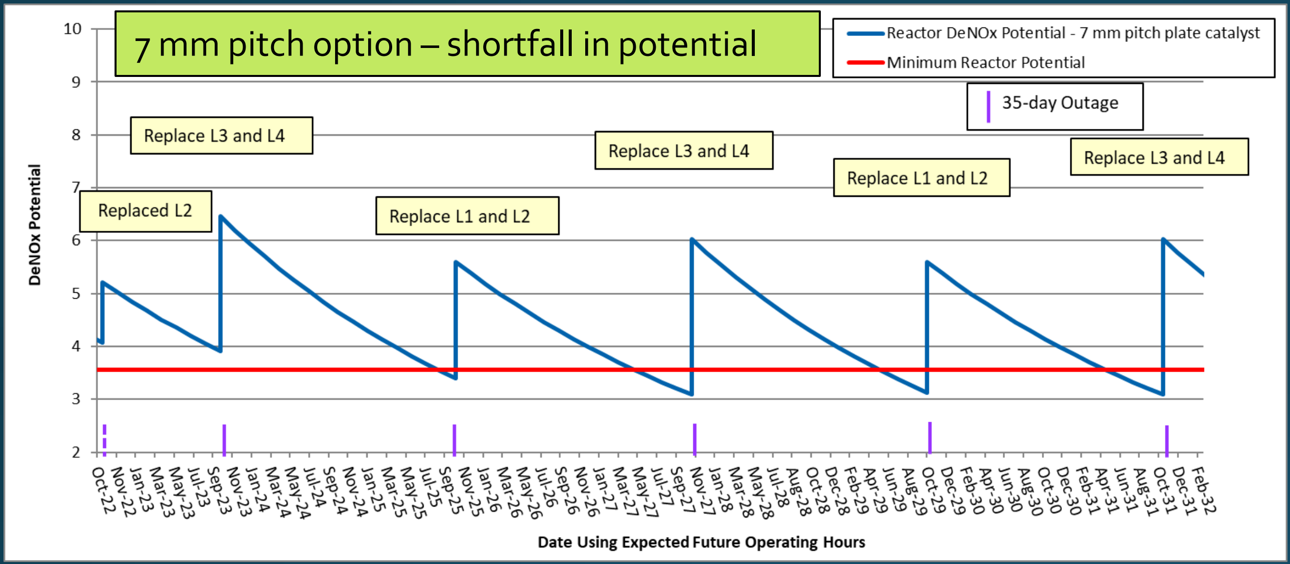
$$P_t = \text{deNOx Potential} = \frac{K_t}{AV}$$

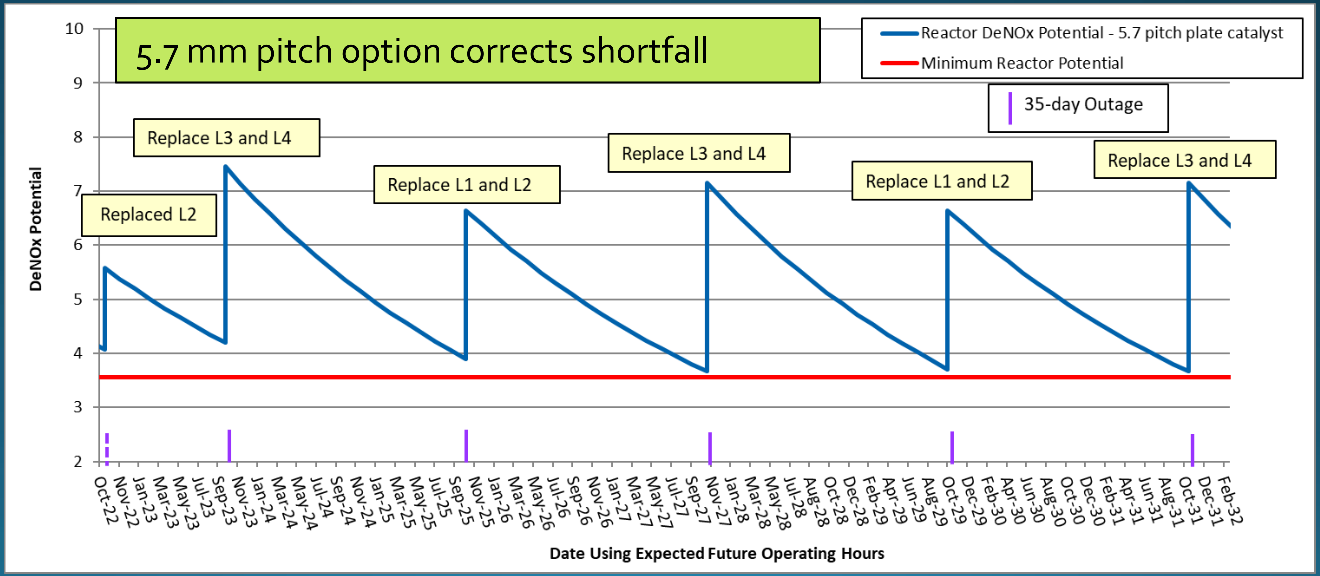
Where; P_t = layer potential at t operational hours
K_t = catalyst activity at corresponding t operational hours (m/hr)
AV = area velocity (m/hr)

$$AV = \text{Area Velocity (m/hr)} = \frac{F}{SSA * V}$$

Where; F = flue gas flow rate (m^3/hr at 0 ^{O}C, actual O_2 and moisture)
SSA = catalyst specific surface area of layer (m^2/m^3)
V = catalyst volume of layer (m^3)

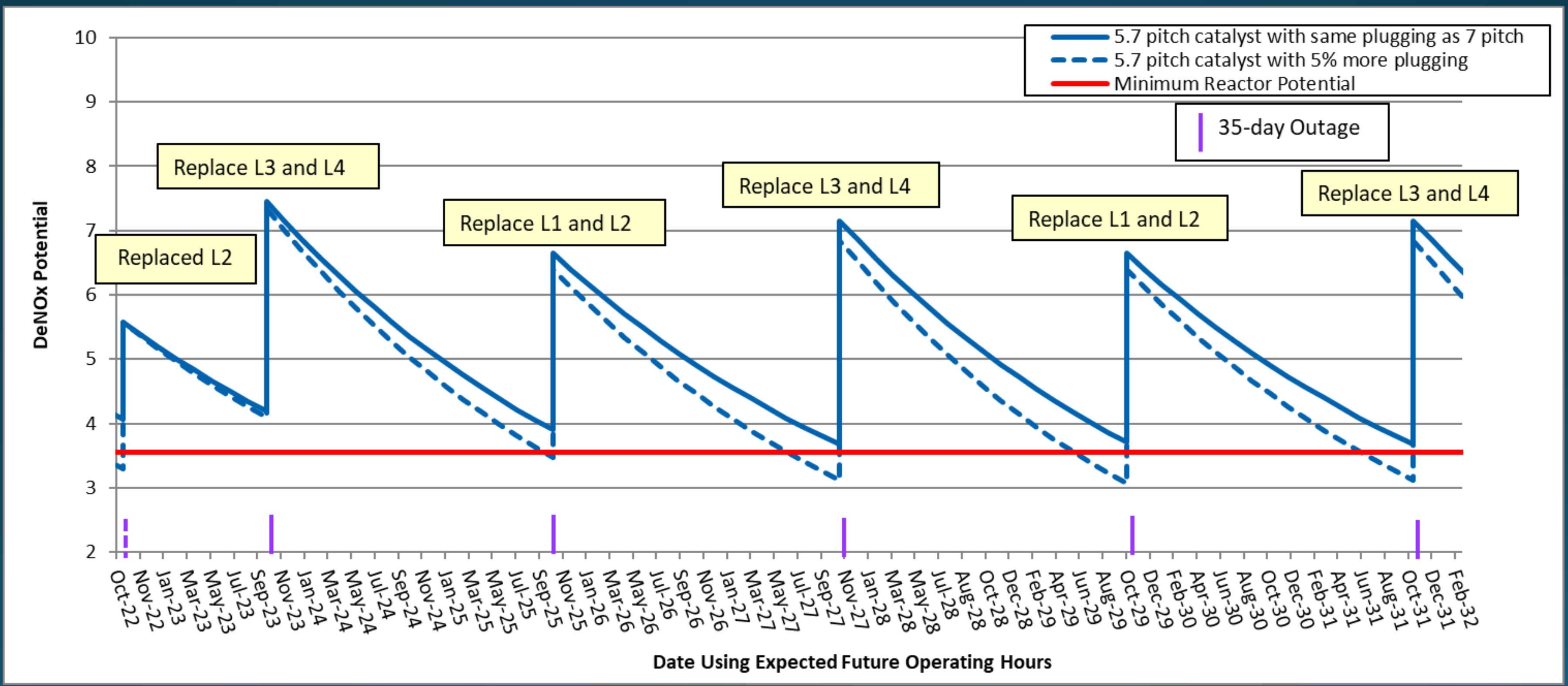
Real world catalyst selection exercise:
7 mm pitch plate vs. 5.7 mm pitch plate
all other factors equal





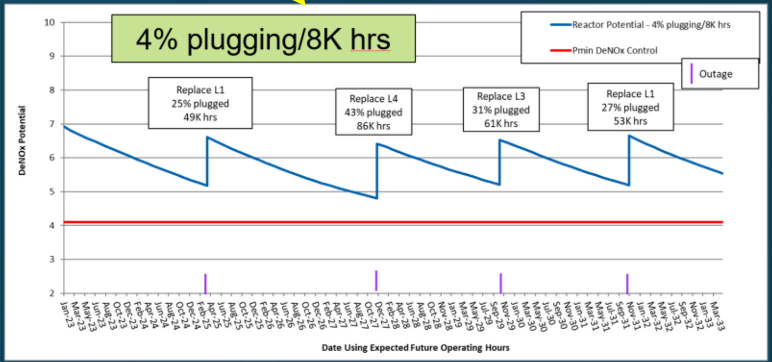
What are the tradeoffs with the smaller pitch ?
Pressure drop and potential for plugging

You give up your advantage with the smaller pitch if it increases plugging. Break-even point for example is 5% more plugging per 8K hours with the 5.7 mm pitch catalyst. In other words, if the 5.7 pitch catalyst has a plugging rate of 5% greater than the 7 pitch, then the resulting actual potential is the same as the 7 pitch option.

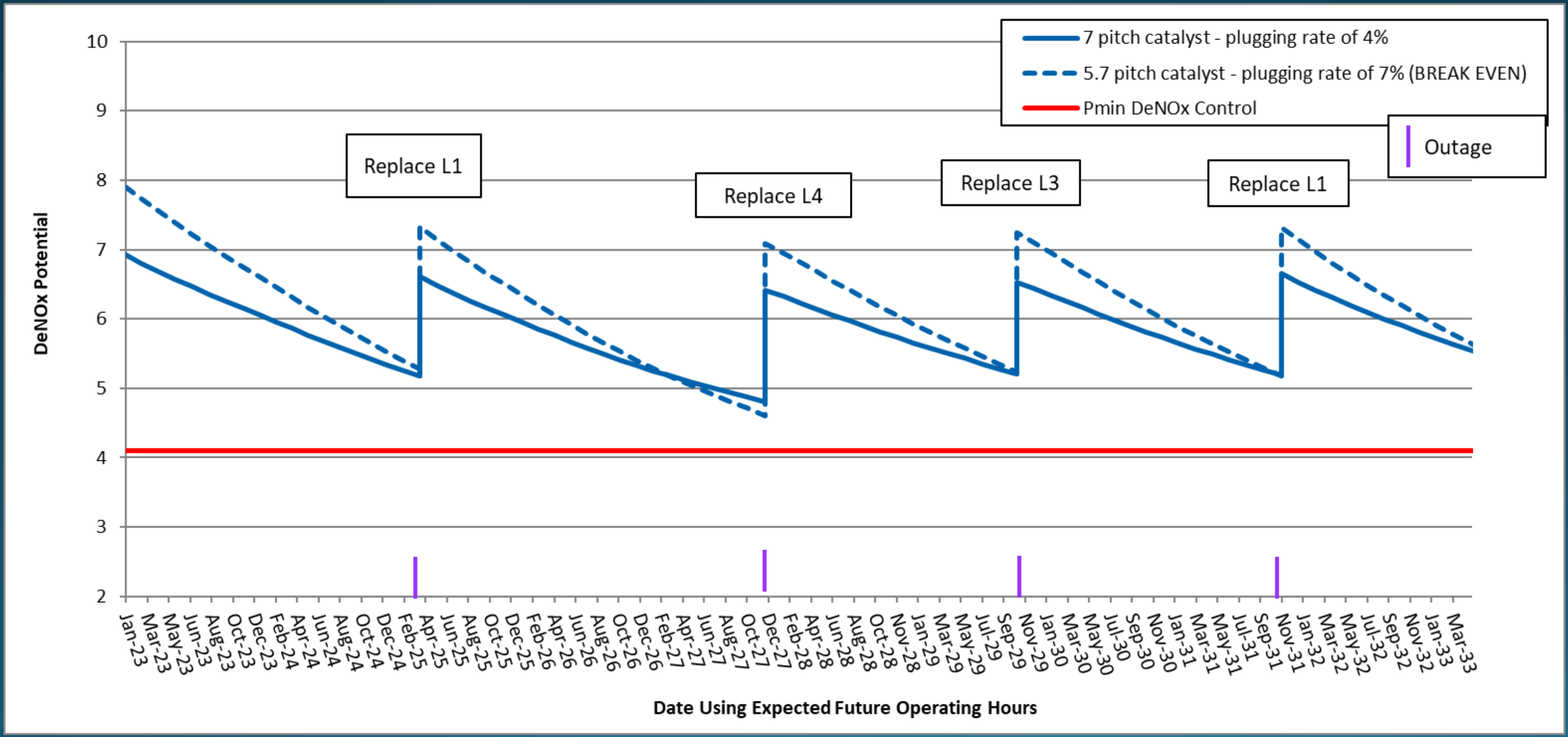


Another Example: The longer the operational time, the less increased plugging it takes to break even.

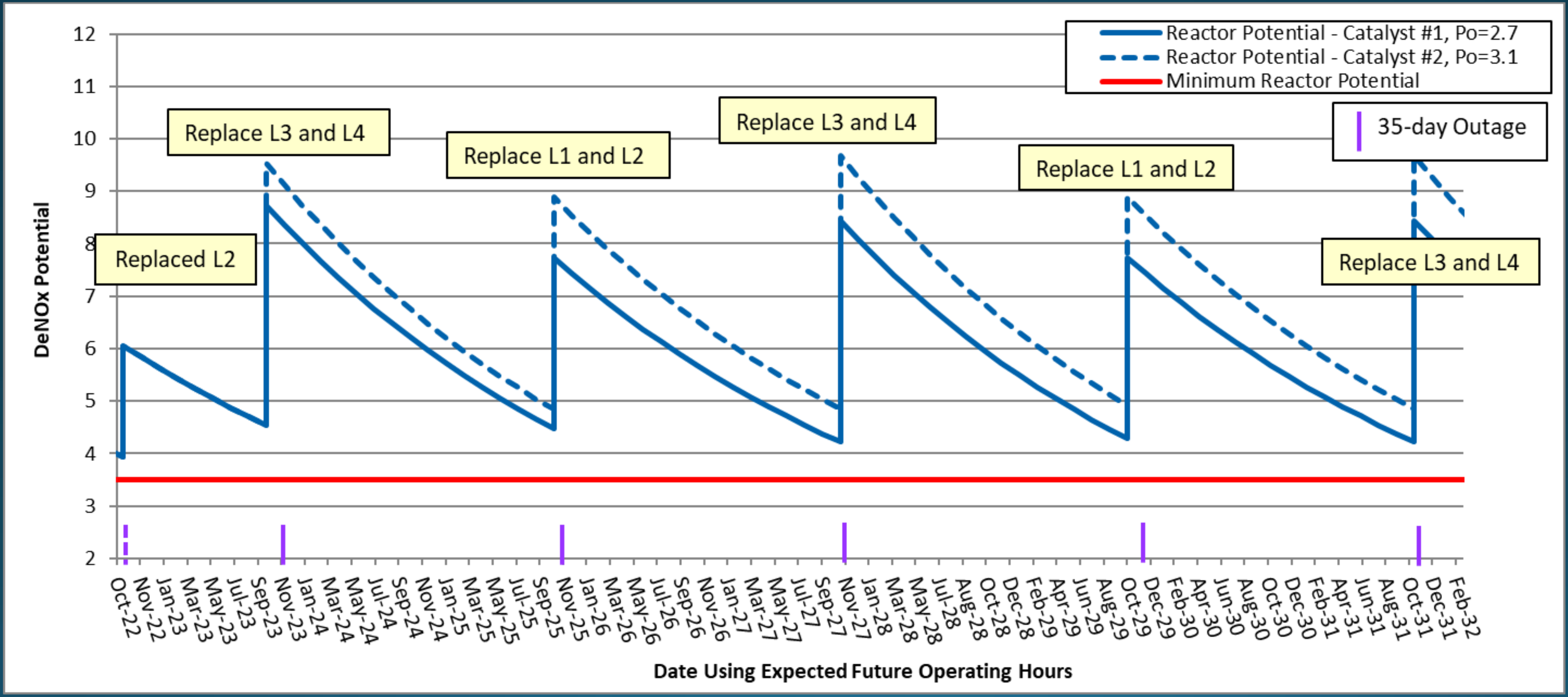
(previous example with high-hour catalyst)



In this example, if the 5.7 pitch plate increases the plugging rate by just 3%, then it is no longer advantageous

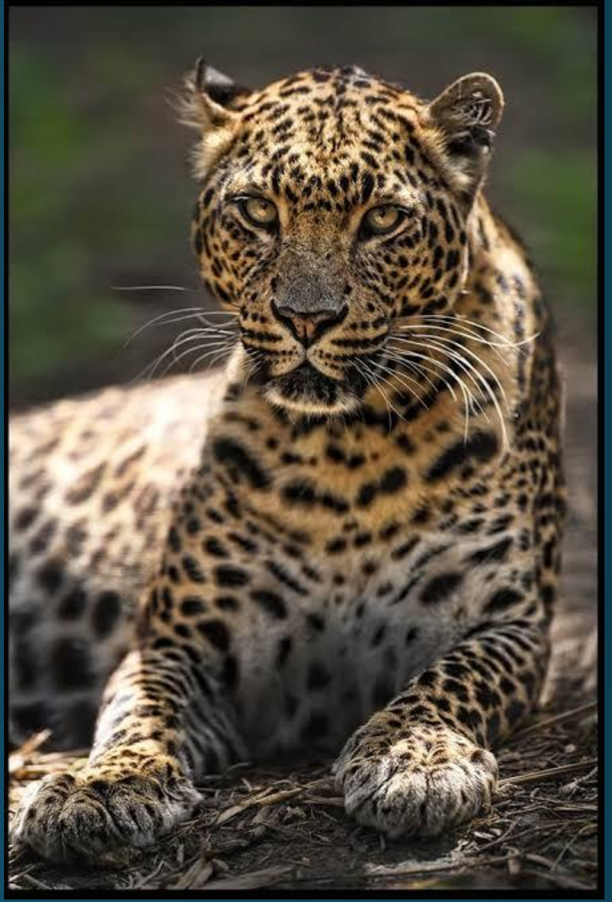


Higher deNOx potential isn't always the best choice. If you have comfortable margin with deNOx potential then focus on other benefits such as lowering pressure drop or plugging potential, lowering SO2 conversion, or increasing mercury oxidation.



NH3/NOx Distribution

Imperfect NH3/NOx distribution represents a non-ideality in the system which adversely affects deNOx performance.



The silent killer, only shows up when measured or implied from high slip when another cause can't be found.

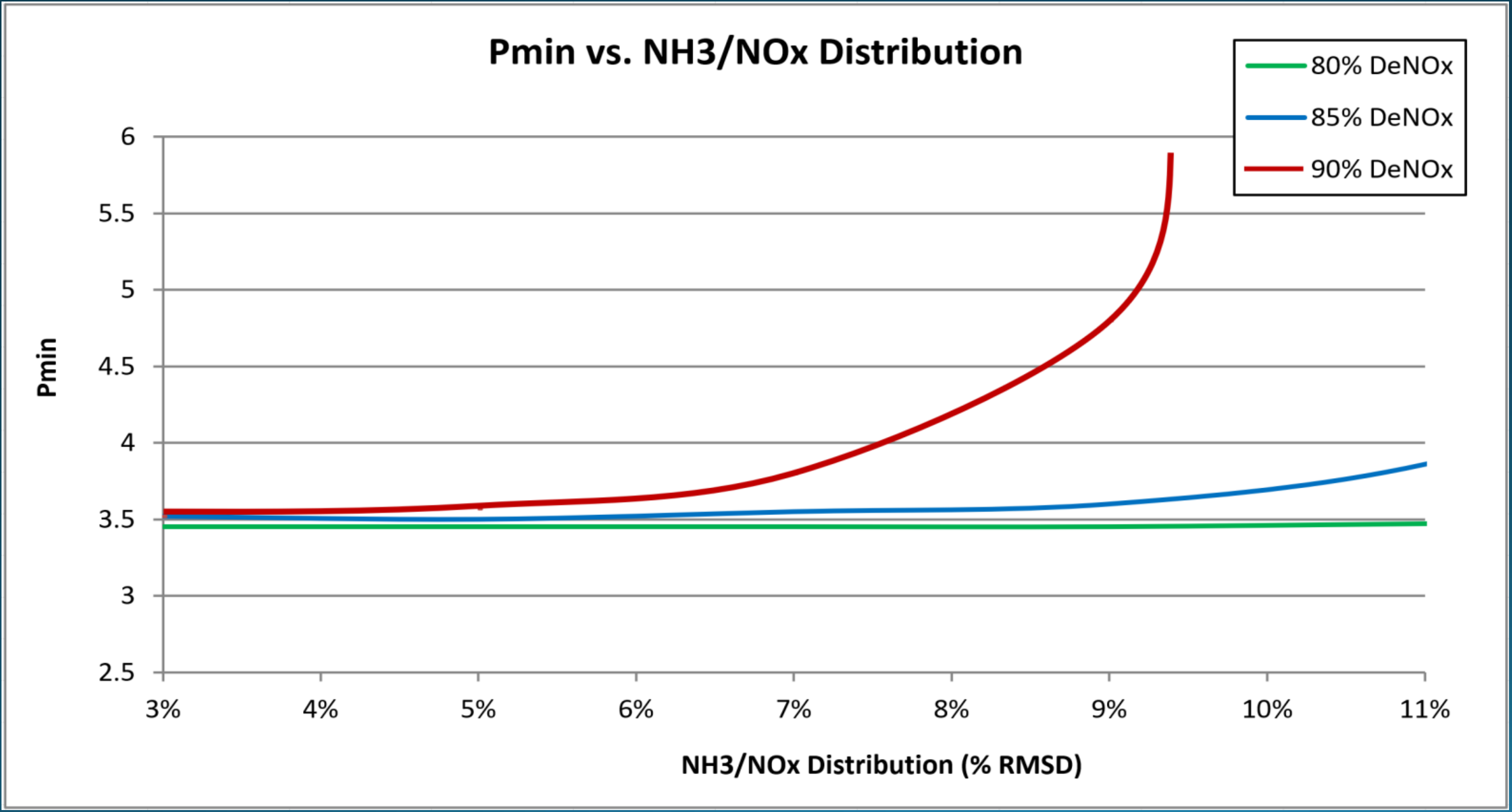
Areas of high ammonia lead to high slip, and although areas of low ammonia lead to low slip, the response is non-linear and therefore high slip areas are no offset completely by areas of low slip.

The impact of maldistribution of NH3/NOx is strongly impacted by operating parameters including inlet NOx, deNOx, and slip.

Minimum required deNOx potential vs. NH3/NOx Distribution (example)

More deNOx potential is needed to compensate for poor NH3/NOx distribution

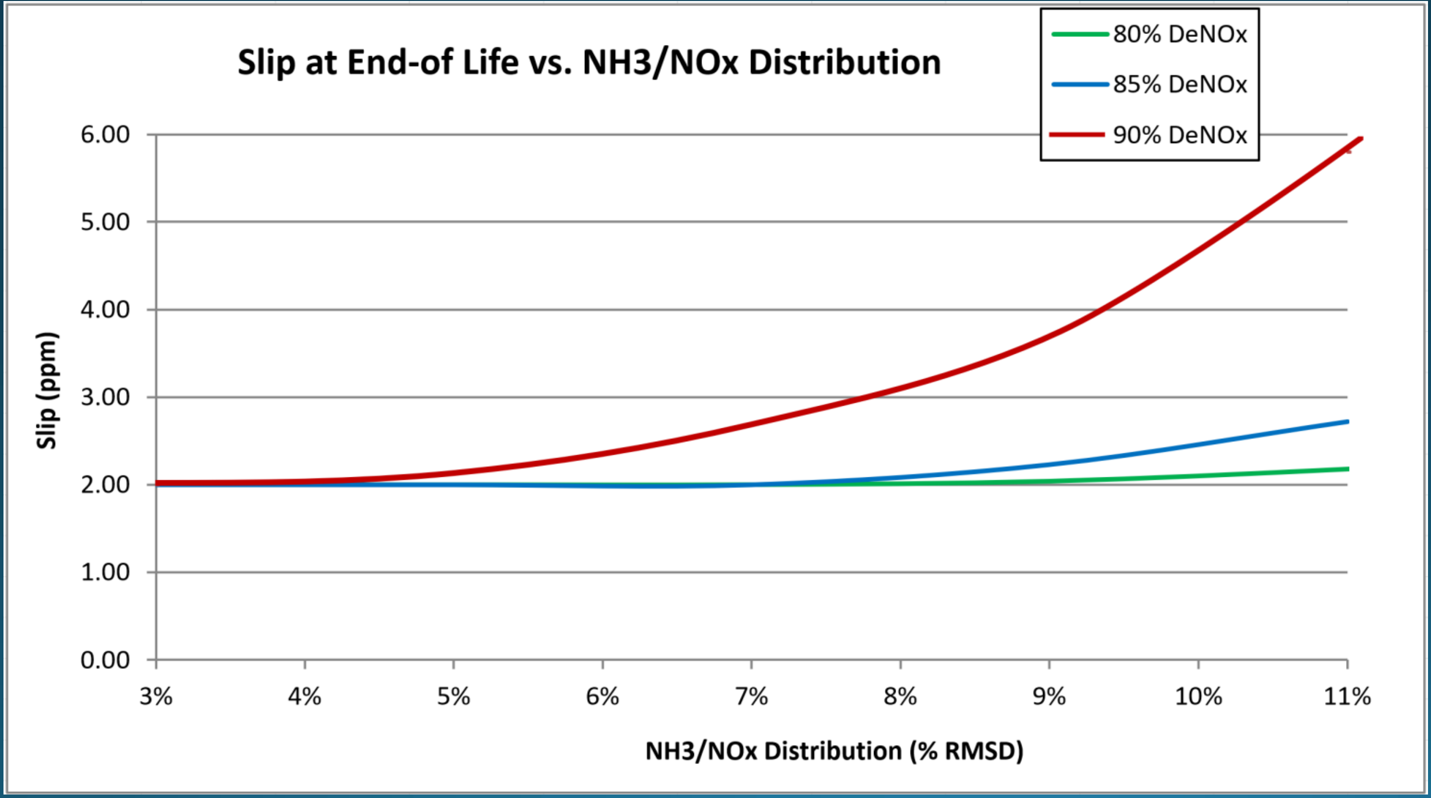
This plot is most useful during SCR design – it shows what target NH3/NOx distribution is optimal



NOx in = 300 ppm
Slip = 2 ppm

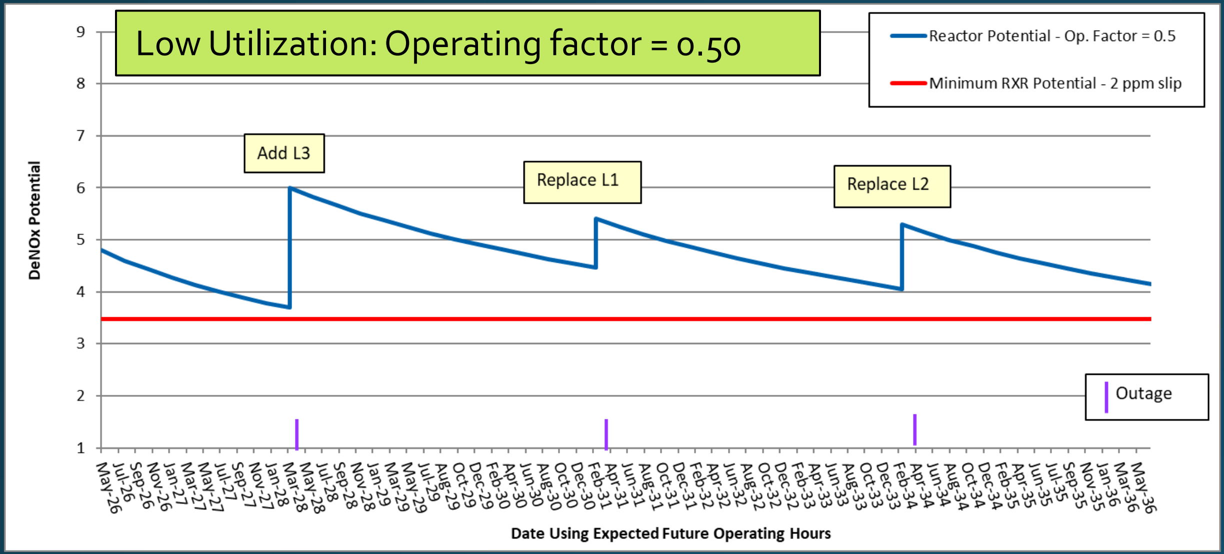
Practical effect of poor NH3/NOx distribution is higher slip

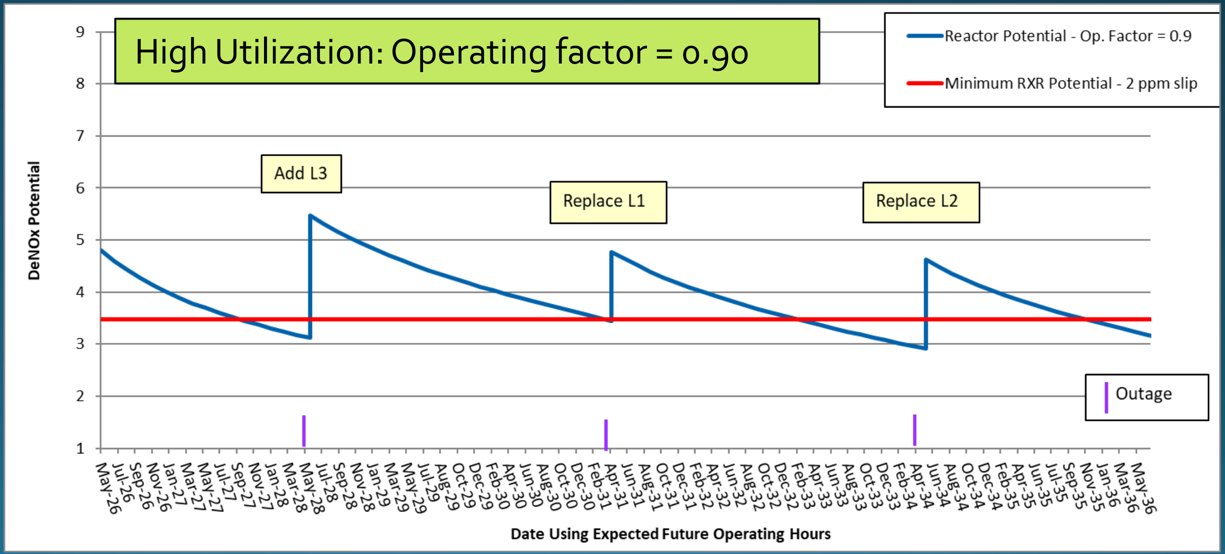
Example for slip at end of life for RXR designed for 2 ppm slip with perfect mixing.



Honorable Mention: Unit Utilization

Changes in unit utilization (hours on-line yearly) can have a dramatic effect on catalyst management.





Questions?