

REINHOLD ENVIRONMENTAL Ltd.



2016 NO_x-Combustion-CCR Round Table Presentation

February 1 & 2, 2016, in Orlando, FL / Hosted by OUC

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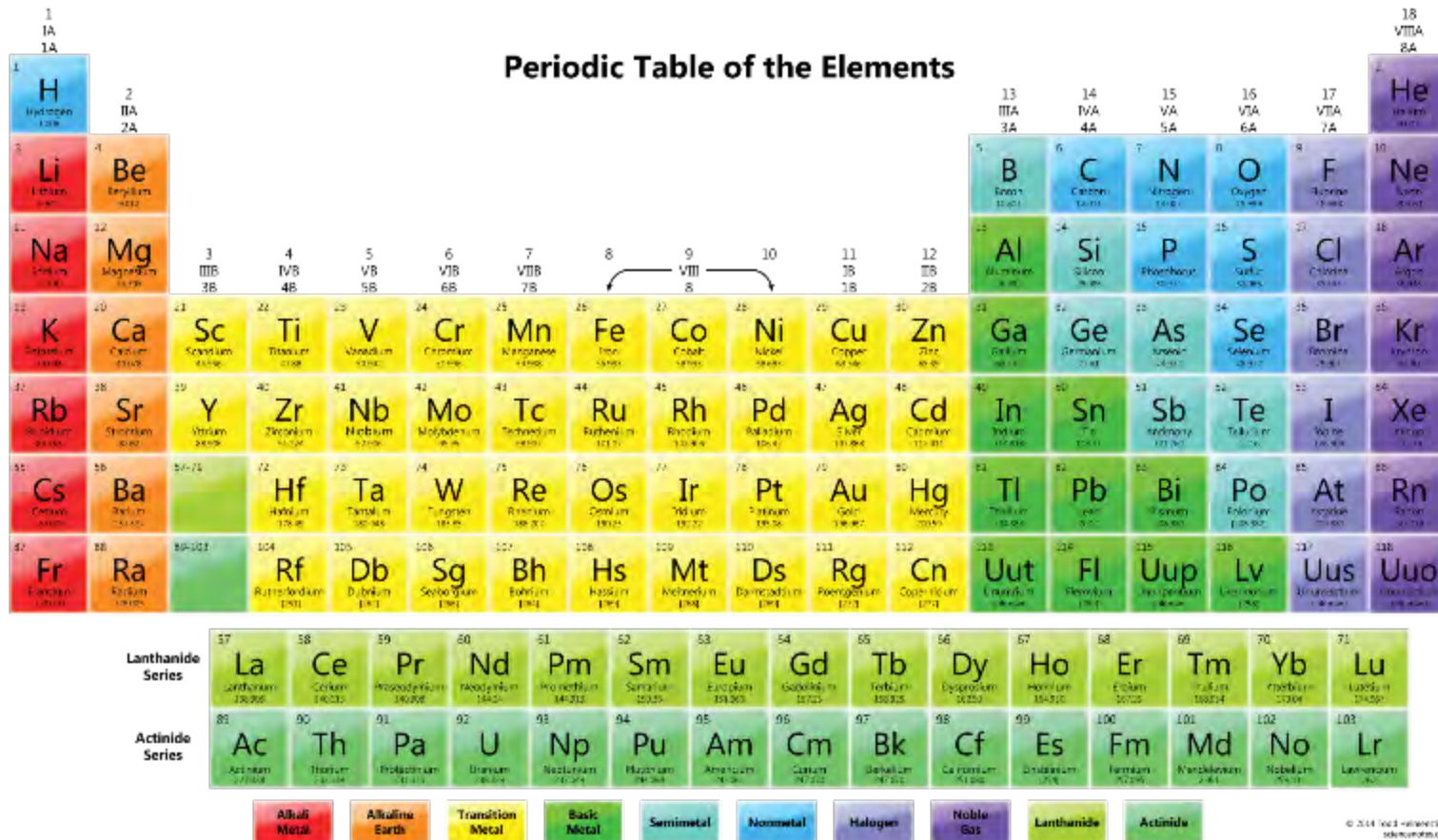


SCR Catalyst Regeneration Overview of the “Process”

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February 1st, 2016

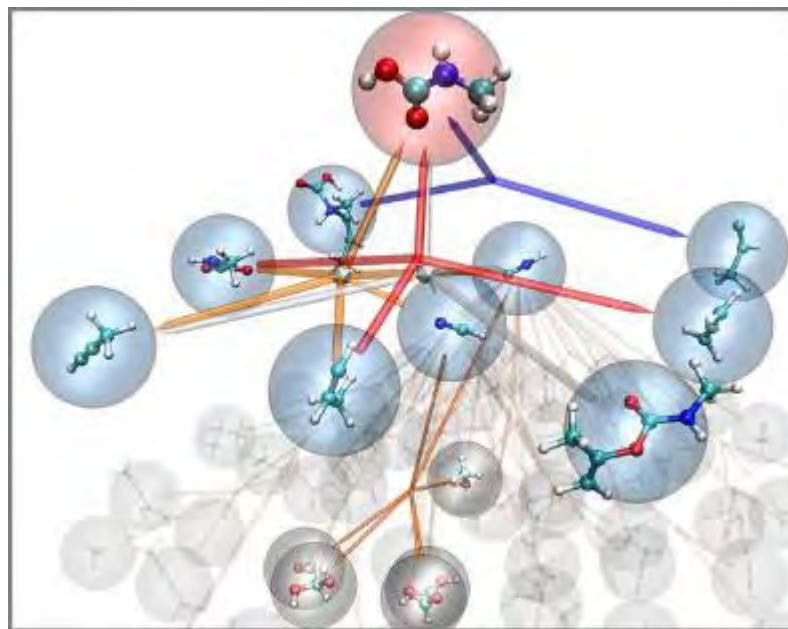
The "Process"

Today we are **NOT** going to talk about



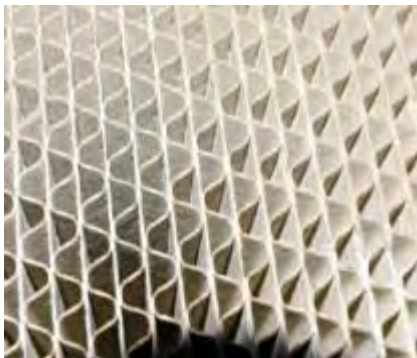
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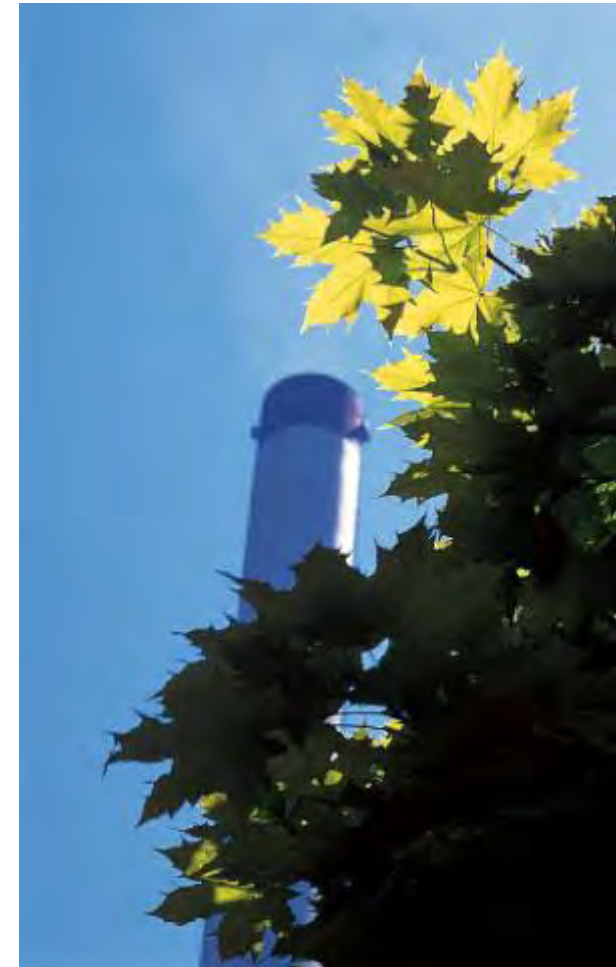
Today we **ARE** going to talk about “The Process”
to maximize your valuable Asset?

SCR Catalyst



Agenda

- **Proper catalyst selection**
- **SCR – The circle of life**
- **Should my catalyst be regenerated?**
- **Economics of catalyst selection**
- **Economics of proper SCR management**



Proper Catalyst Selection

- **Know your requirements**
- **Know your risk tolerance**
- **Know your costs**



Design Conditions

Ranges (Current & Future)

- Fuel
- Load

Operating conditions

- Ammonia to NO_x Molar Ratio
- Flue Gas Velocity
- Flue Gas Temperature
- Inlet NO_x , SO_2 , SO_3 and H_2O



Performance requirements

- NO_x removal
- SO₂ conversion
- Performance life
- Mechanical life
- Pressure drop
- Allowable ammonia slip
- Mercury oxidation

Outage schedule

- Minor
- Major



RFQ Information

Catalyst geometrical requirements

- Maximum catalyst height
- Maximum catalyst weight
- Location of lifting devices

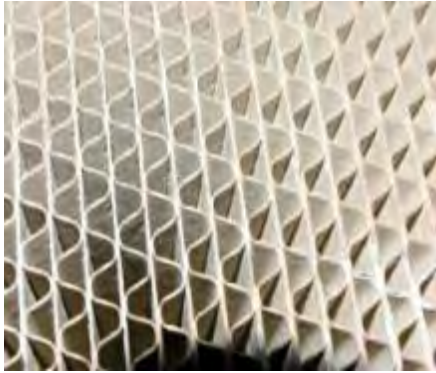
Liquidated damages

Evaluation factors

Historical catalyst test and inspection results



SCR Catalyst Choices



Corrugated



Honeycomb



Plate



Catalyst Pitch

- 5.7 to 9.4 mm

Catalyst Length

- 800 to 1,400 mm

Catalyst Formulation

- Maximum DeNO_x potential
- Minimum SO₂ conversion
- Maximum mercury oxidation
- Maximum Life



Increasing Catalyst Pitch?

Positive Affects

- Pressure drop
- Pluggage resistance
- SO₂ conversion

Negative Affects

- NO_x removal
- Catalyst life
- Mercury oxidation

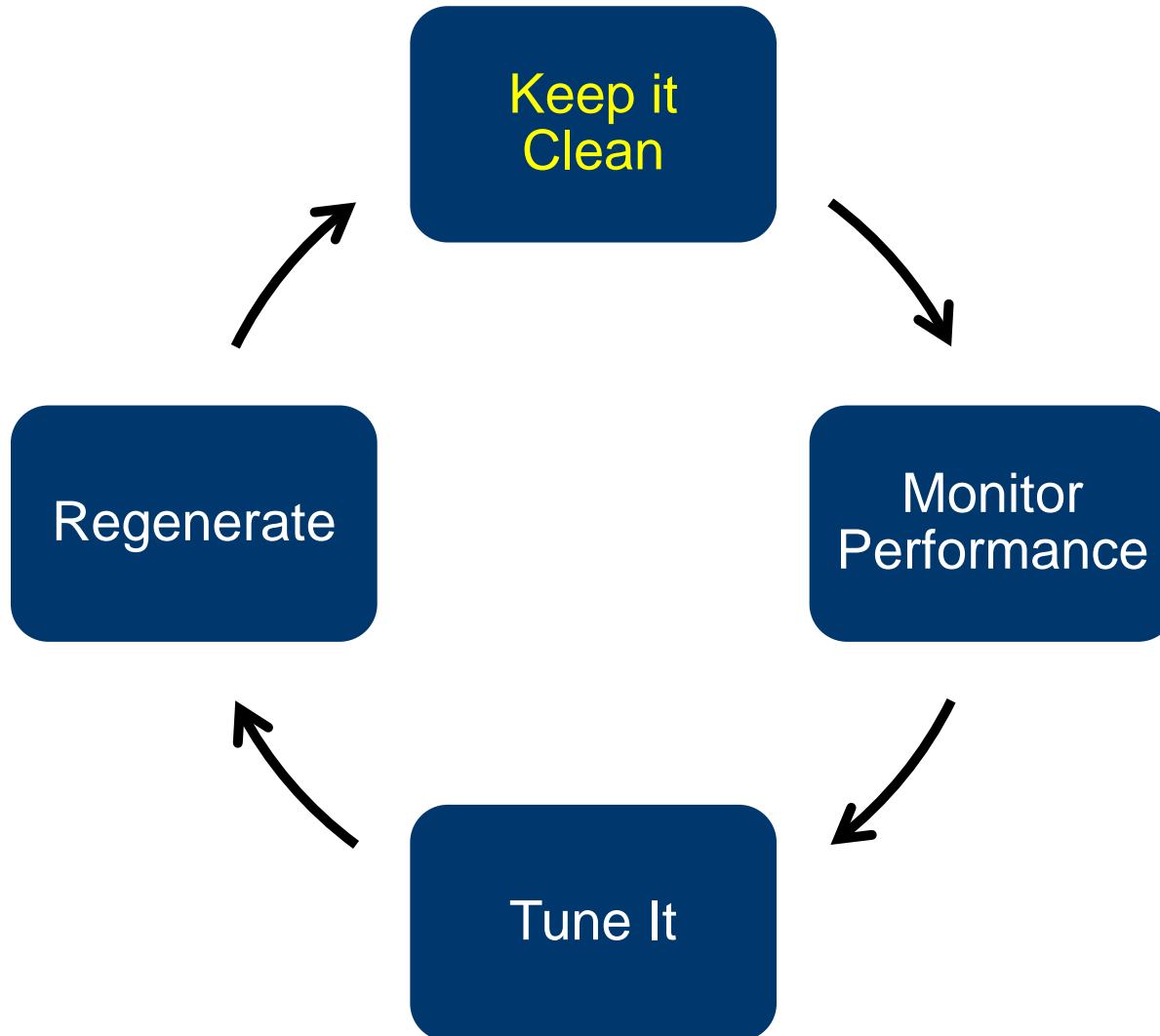


Catalyst Selection - Summary

1. Know your requirements
2. Provide reasonable design parameters
3. Provide available historical data
4. Catalyst selection
 - Smallest pitch that will not plug
 - Tallest catalyst your system can tolerate
 - Can be layer specific
 - Can be location specific (i.e. near boiler wall)



SCR – The Circle of Life



Keep it Clean

Filter

- LPA screens
- Catalyst screens



On-line cleaning

- Soot blowers
- Acoustical cleaners
- Ash sweepers



Keep it Clean

Off-line in-situ cleaning

- Standard vacuuming below screens
- Vibrating
- Ice blasting

Design changes based on flow modeling

- Baffles
- Turning vanes
- Static mixer



Keep it Clean - Summary

Pluggage is the root cause of most SCR issues

Be aggressive in pluggage prevention

- Proper catalyst selection
- Aggressive on-line cleaning and filtration
- Proper maintenance

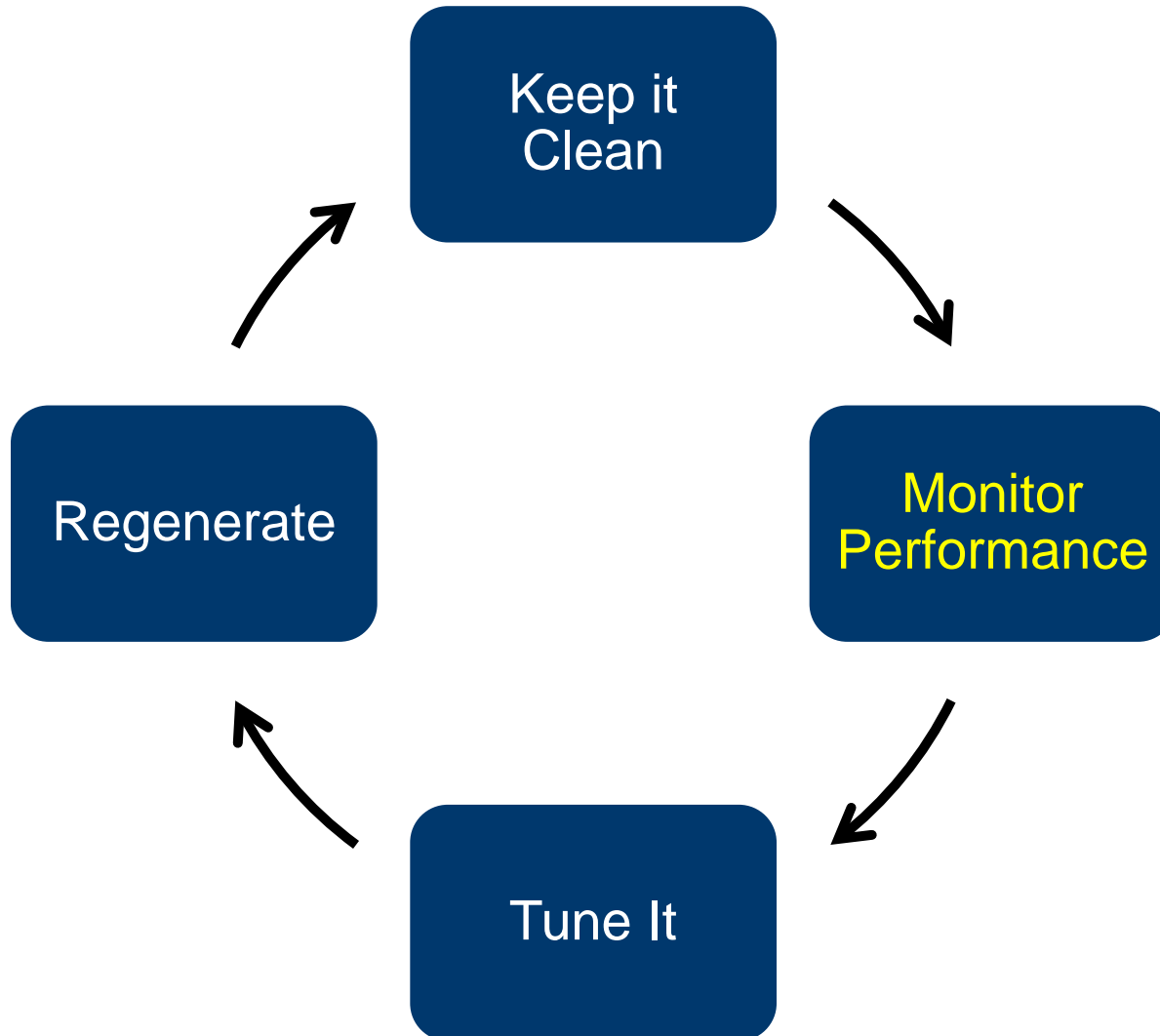


Preventing pluggage

- Increases catalyst selection flexibility
- Reduces risk
- Reduces cost

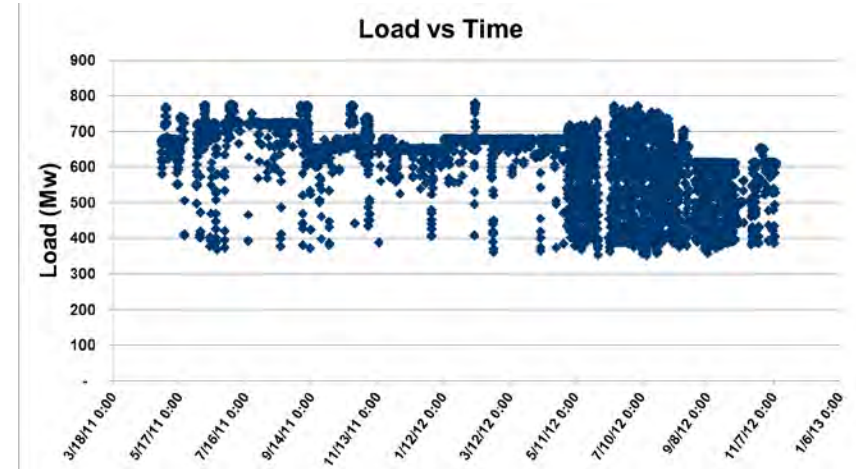


SCR – The Circle of Life



Monitor Performance

- Regular DCS data reviews
- Catalyst laboratory testing
- SCR field testing



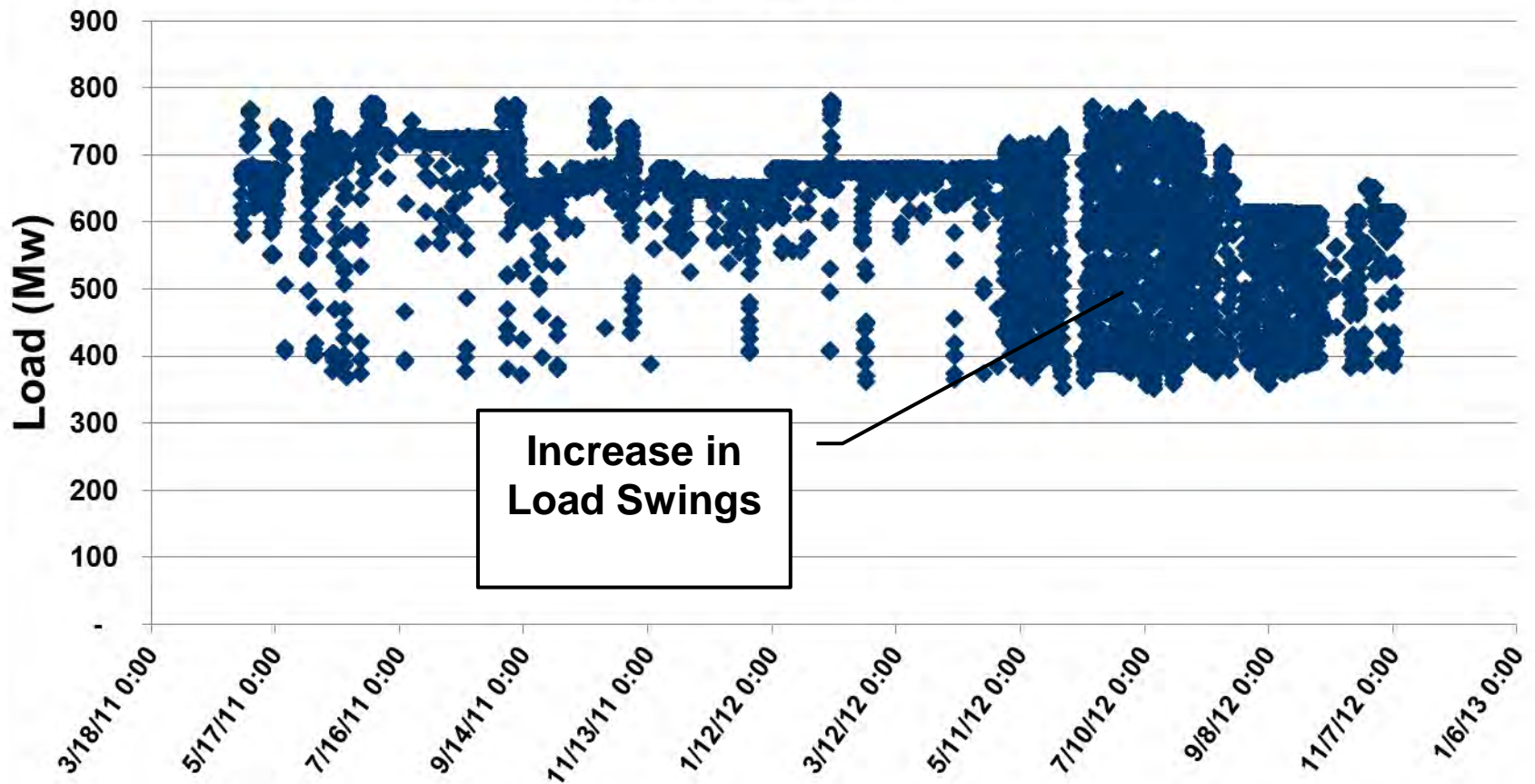
DCS Data Review

- **Monthly**
- **Use hourly average data**
- **Properly filter data**
- **Maintain DCS instrumentation**

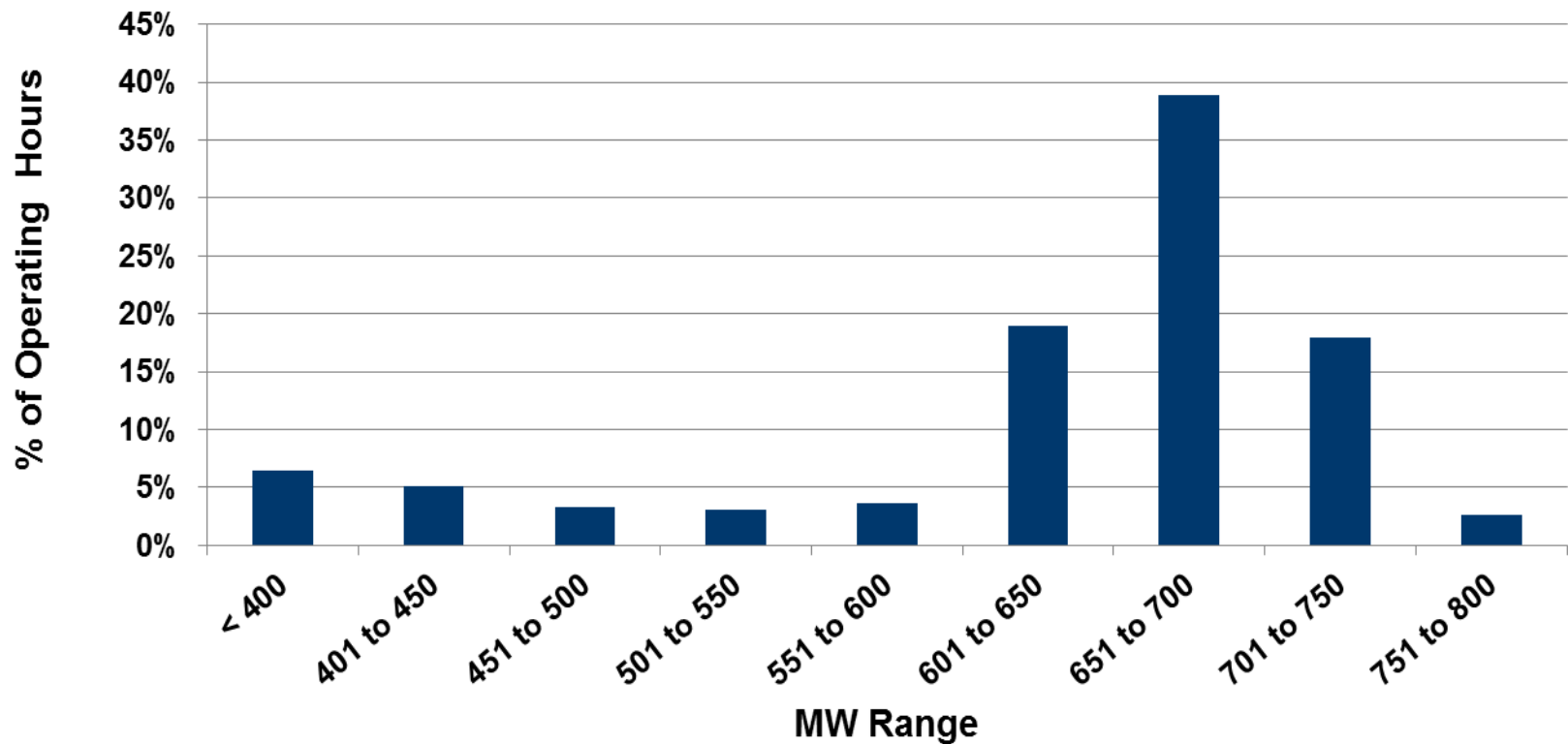


DCS Data Review

Load vs Time

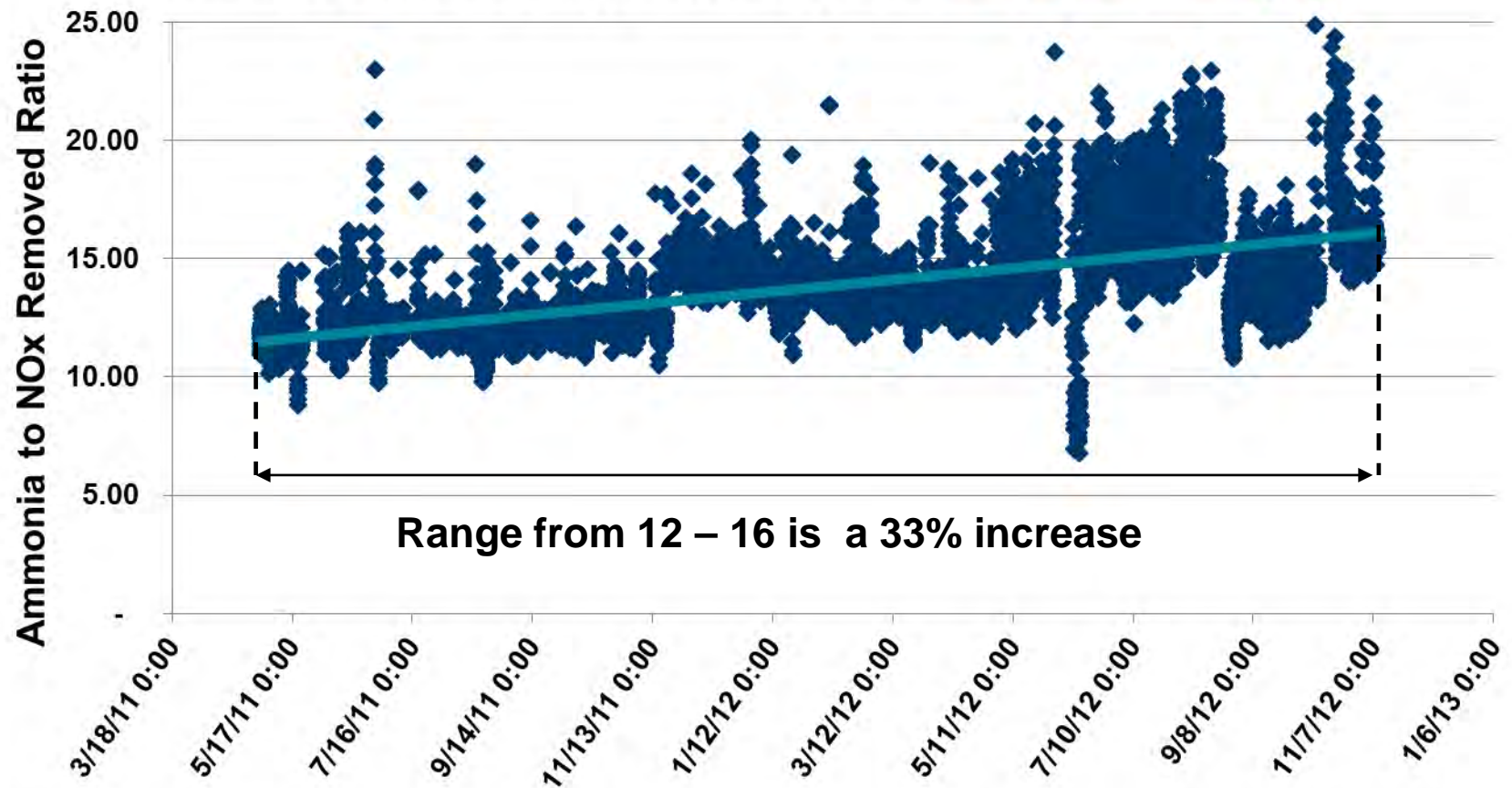


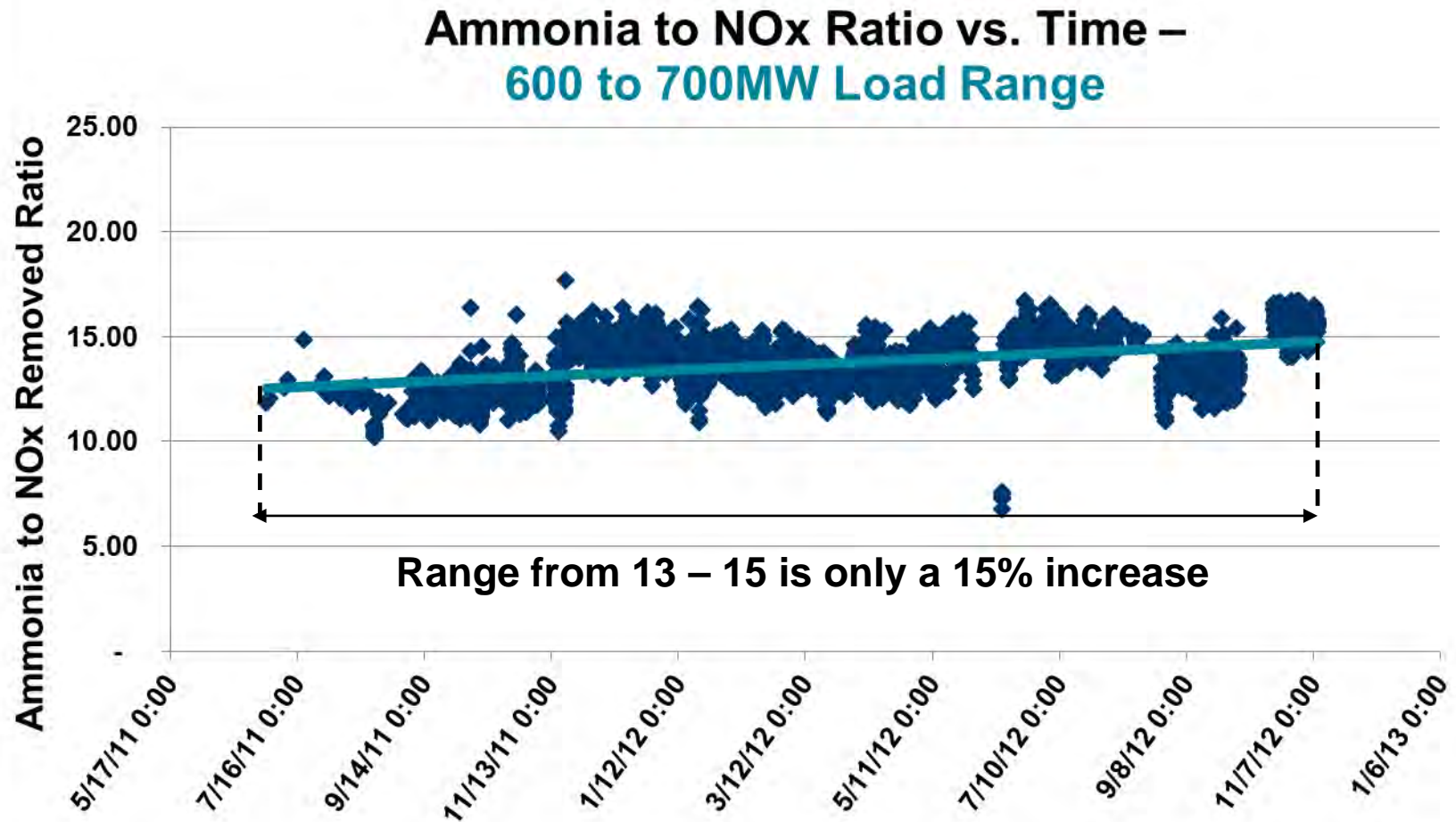
% of Hours vs MW Range



DCS Data Review

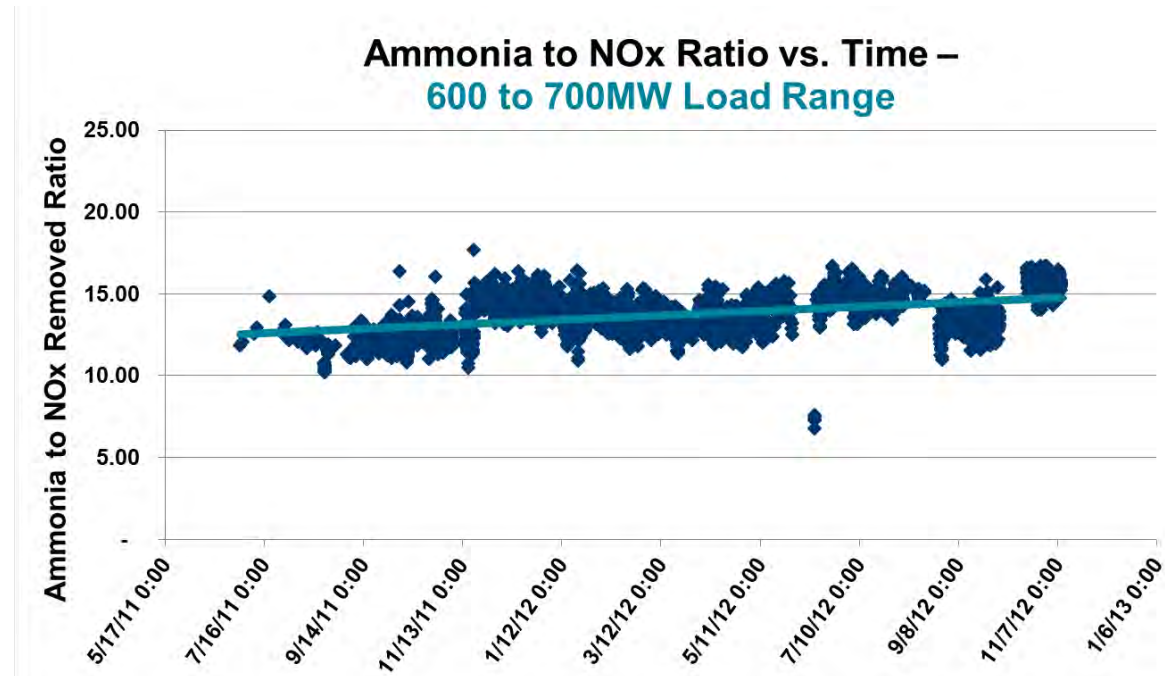
Ammonia to NOx Ratio vs. Time - All Load Ranges





DCS Data Review – Typical Trends

- Load
- Flue gas flow
- Pressure drop
- Ammonia flow
- Temperature
- Inlet NO_x
- Outlet NO_x
- Ammonia usage per NO_x removed



Catalyst Laboratory Testing

Types of tests

- Micro (short length)
- Micro (mid-length)
- Full bench



Recommend annual sample / layer / reactor

Proper sample selection

- Minimal pluggage
- Location with representative full gas flow
- Plate catalyst – 2 to 6 plates per module
- Sample size - 1 of 7,000 to 1 of 1,500



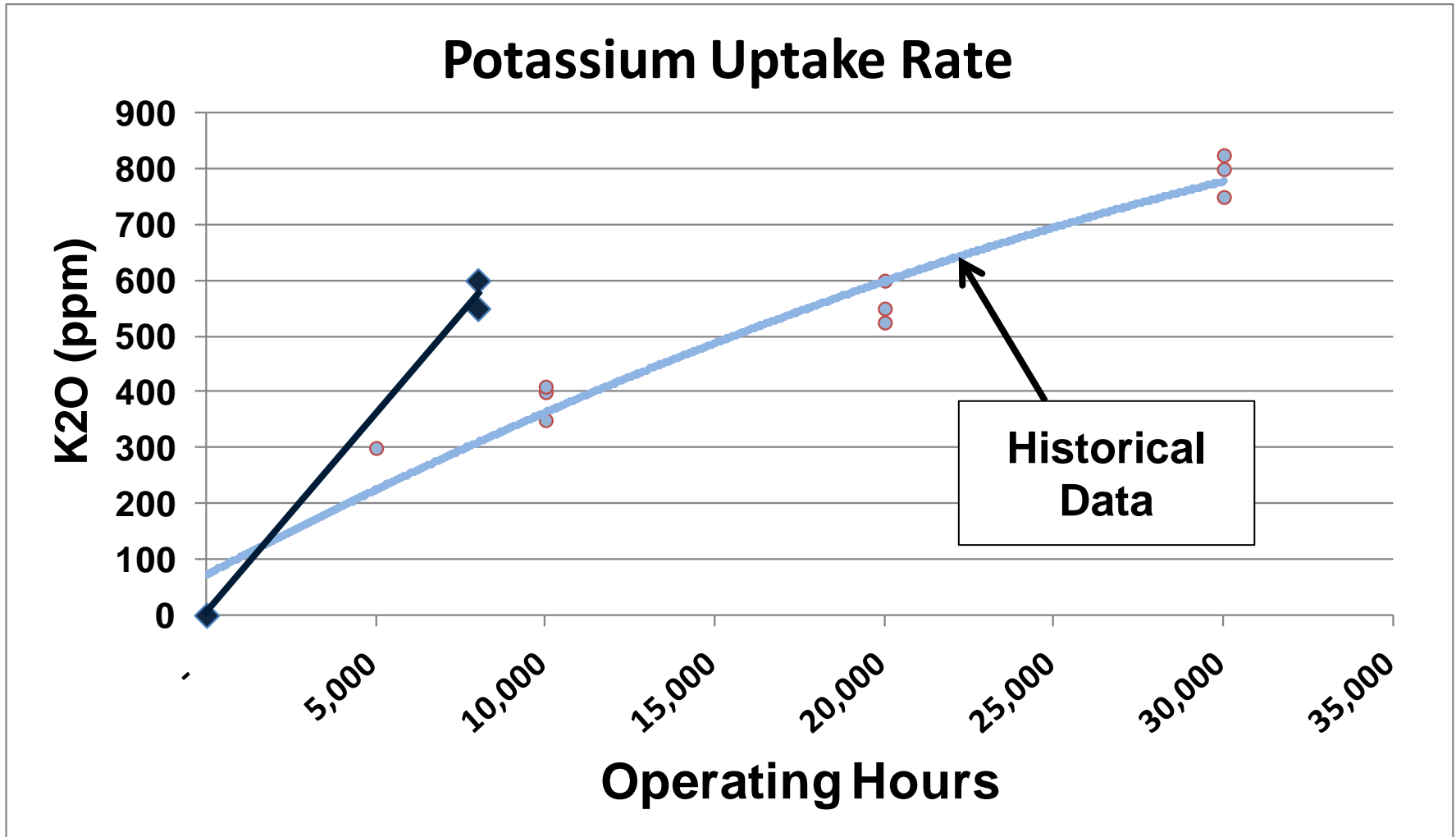
Catalyst Laboratory Testing

XRF analysis

- Complimentary to performance testing
- Reveals key decay mechanisms
- Reveals decay agents uptake rates
- Economical
- Fast turnaround
- Early predictor of future problems



Catalyst Laboratory Testing



Catalyst Laboratory Testing

Know your testing vendor

- EPRI and VGB compliant is not good enough
- Quality control procedures
- Plate catalyst stacking technique is critical
- Transparent with test data and conditioning times
- Willingness to verify results with other testing vendors

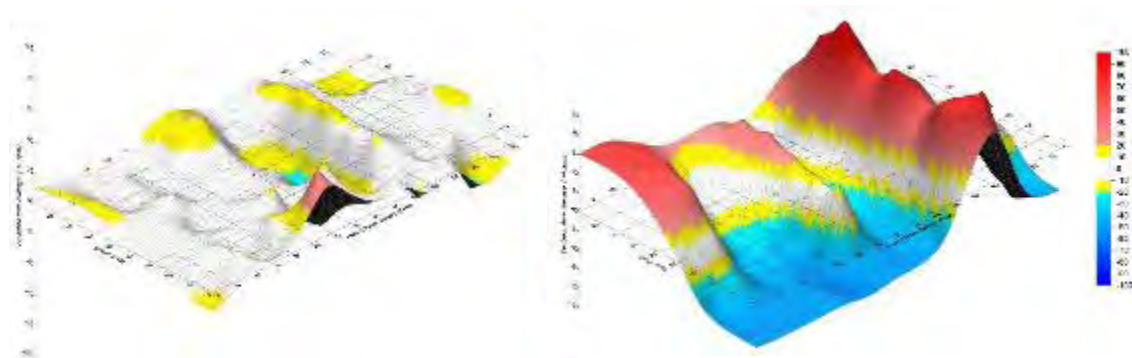


Standard Parameters

- NH_3 / NO_x molar ratio distribution
- NO_x removal efficiency distribution
- Ammonia slip

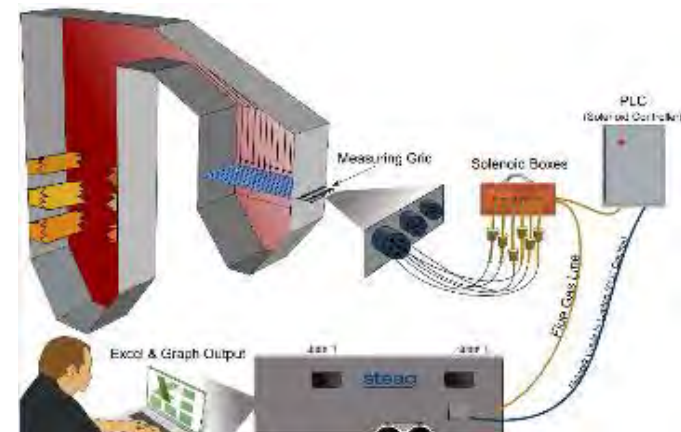
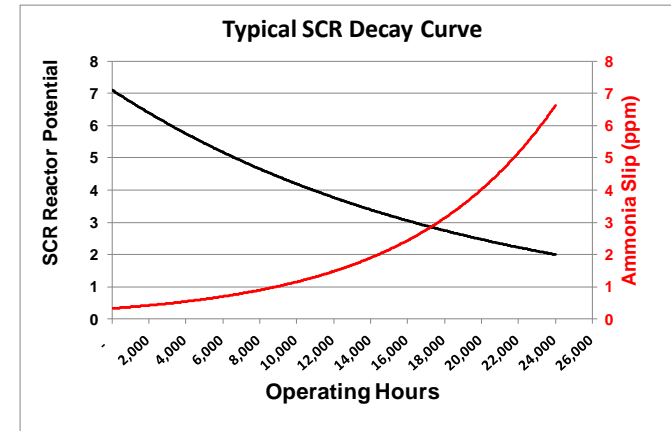
Other Parameters

- Temperature distribution
- Flow distribution
- SO_2 conversion
- Mercury oxidation
- Halogens

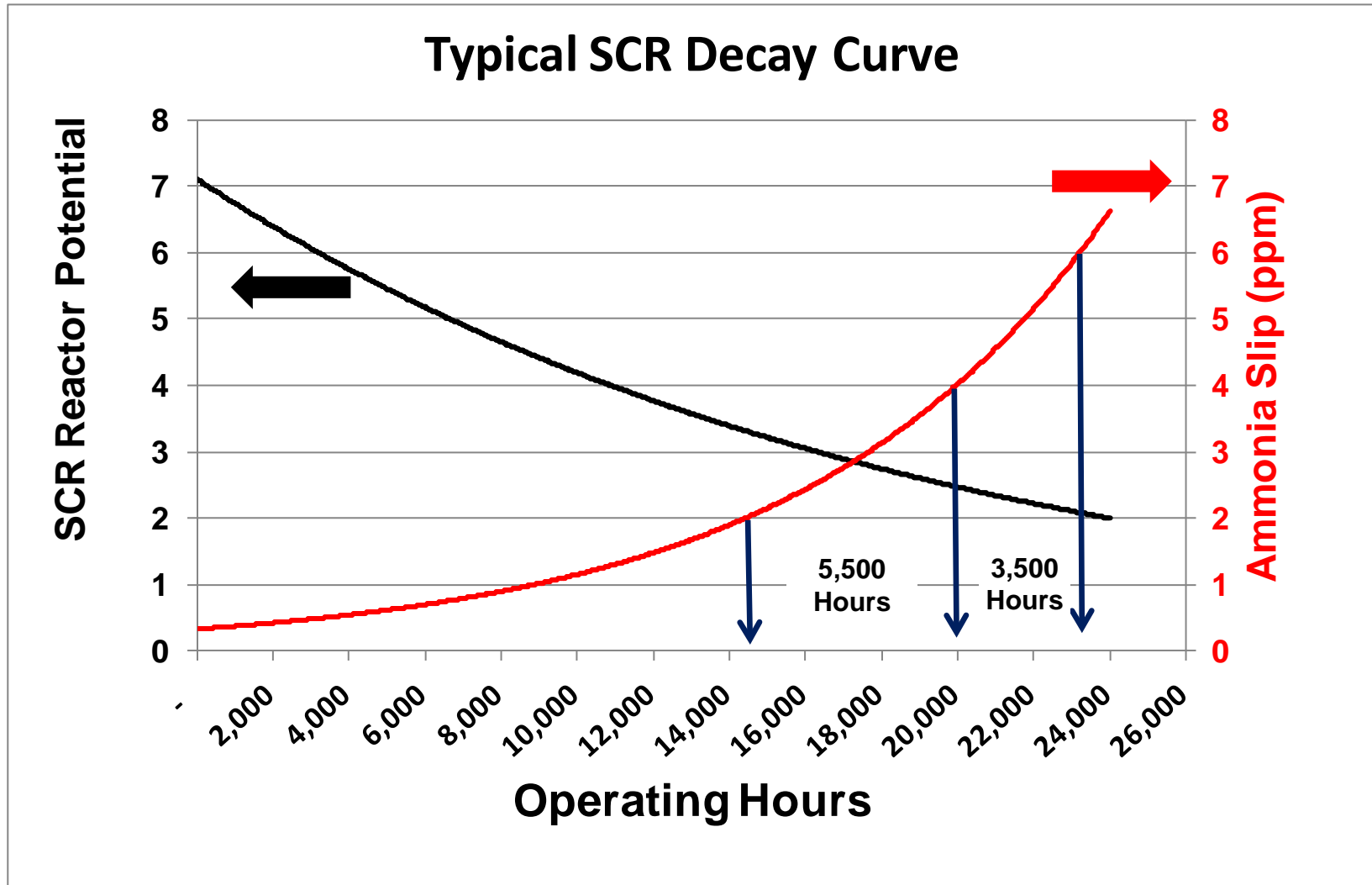


SCR Field Testing Benefits

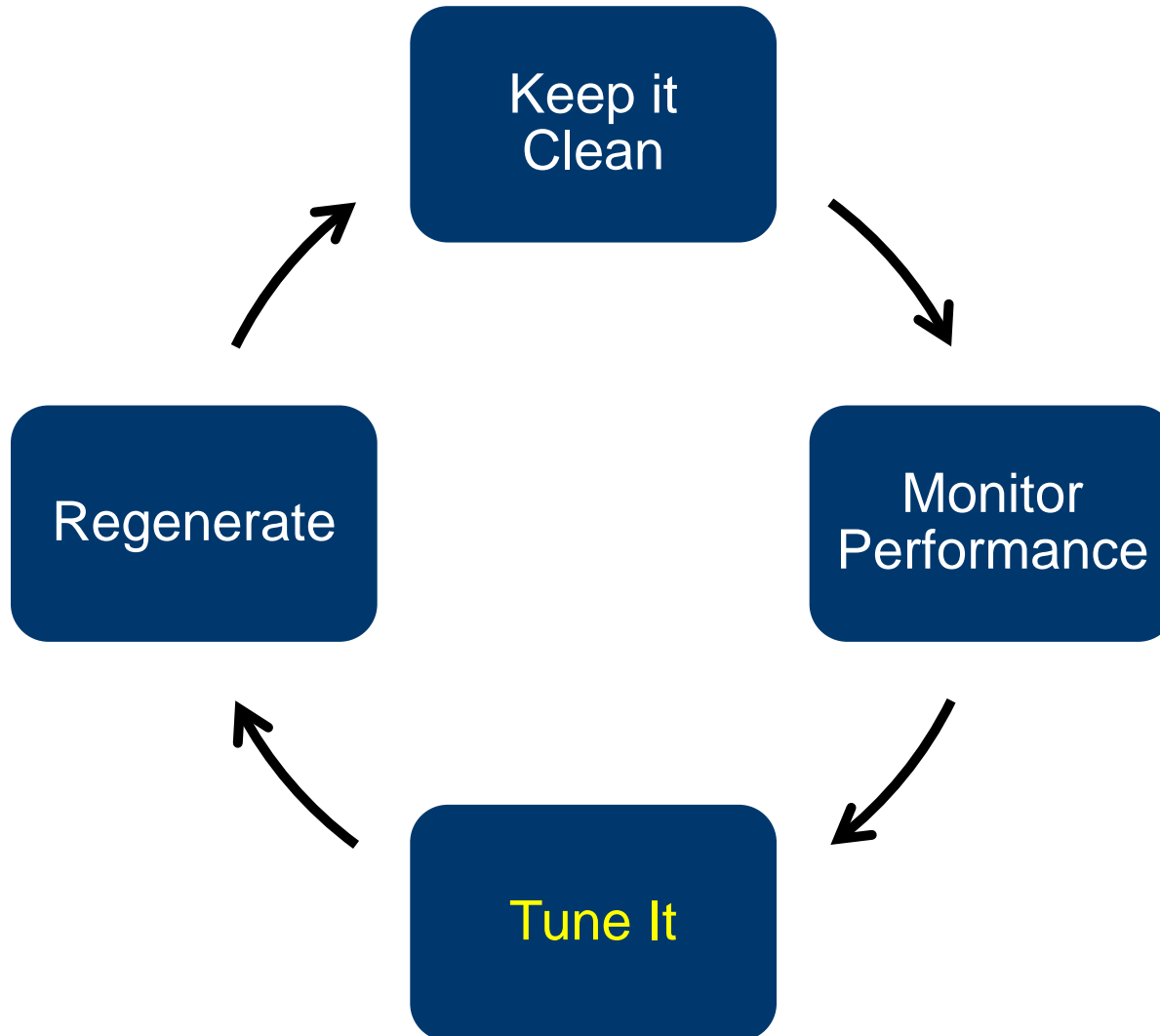
1. **Verify SCR forecast models**
2. **Measures actual SCR performance**
3. **Accounts for parameter interactions laboratory testing cannot duplicate**
Especially true for mercury oxidation.



SCR Field Testing Benefits



SCR – The Circle of Life



AIG tuning

- After catalyst replacement
- After catalyst in-situ cleaning
- When DCS data indicates the need
- Delaying catalyst exchange

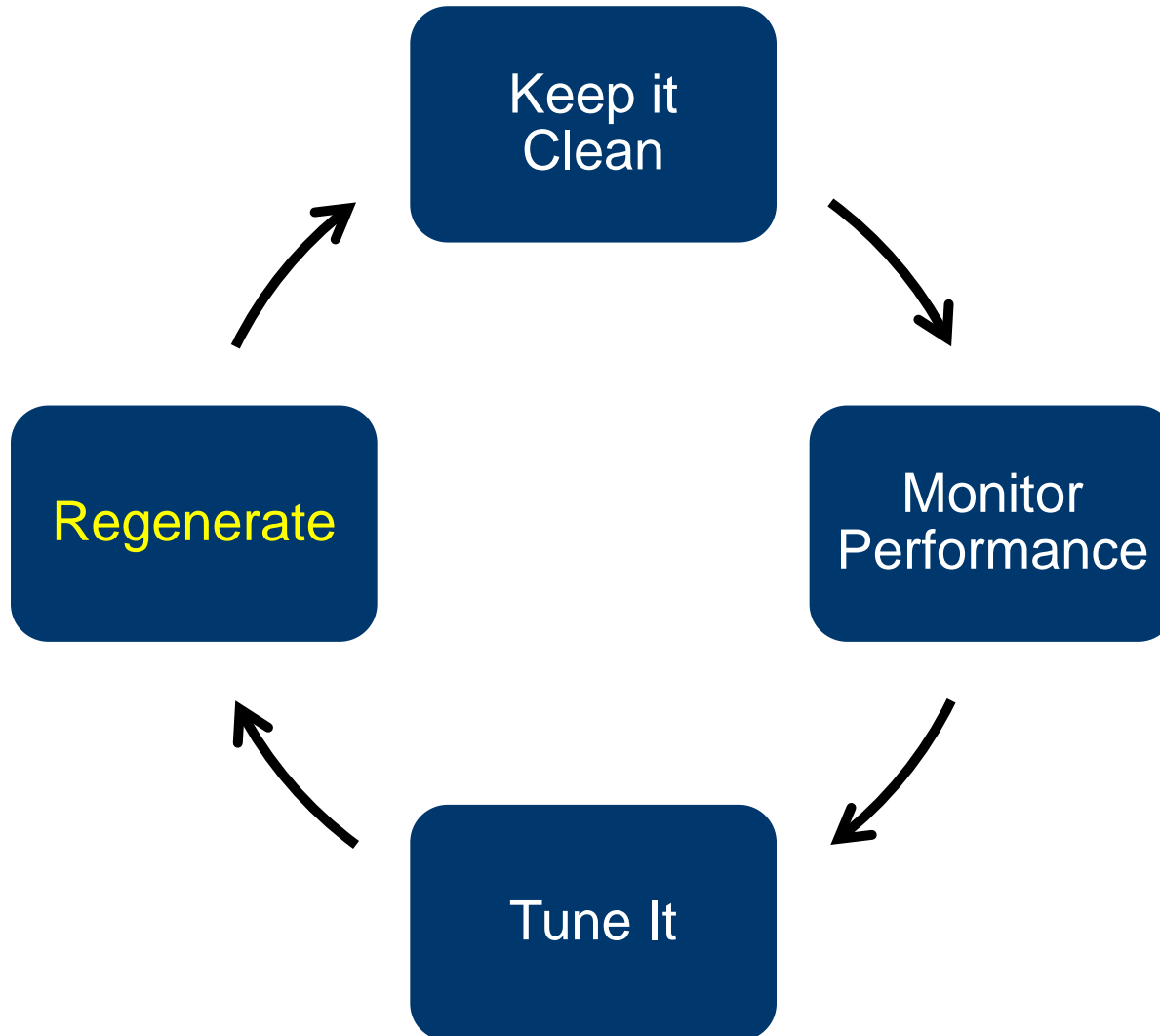
Inspection / Repairs

- Ammonia delivery system
- Baffles and turning vanes
- Flue gas mixing devices
- Seals
- Damaged catalyst

It's
**TUNE-UP
TIME!**



SCR – The Circle of Life



Regeneration Process

- Removes visible pluggage
- Removes chemically bonded contaminants
- Modifies the catalytic engine
- Replaces damaged catalyst
- Repairs module frame and packing



Should I Regenerate?

Regeneration Candidates



Not Regeneration Candidates



Should I Regenerate?

Physical evaluation (Determines attrition %)

Performance evaluation

Can it meet your current requirements?

- Pluggage resistance
- NO_x removal efficiency
- SO₂ conversion
- Mercury oxidation
- Life
- Pressure drop

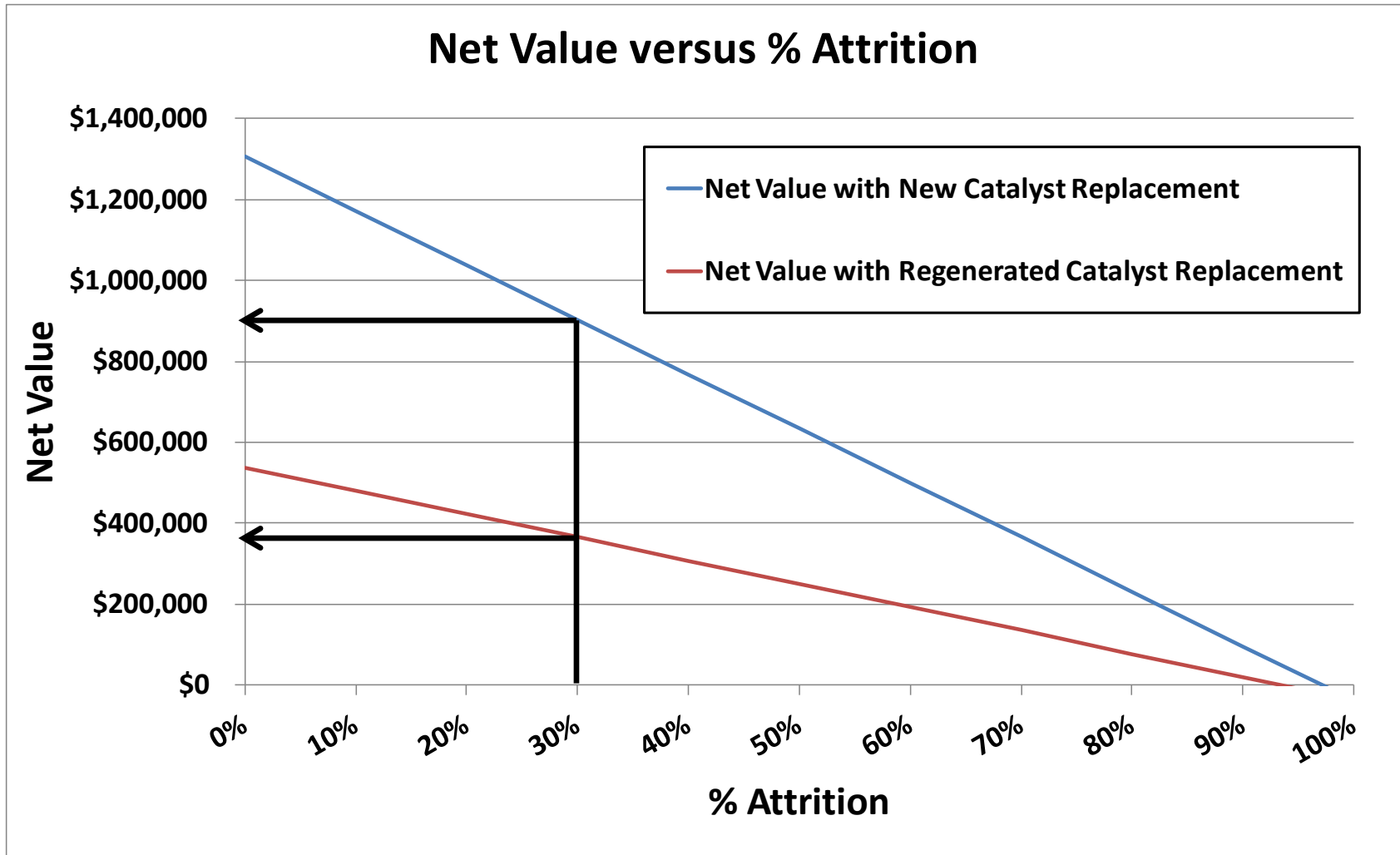
Economic evaluation





















Attrition % - Example

- **Attrition % - % of non-regenerable modules**
- **Modules per layer – 192**
- **Cost to pre-consolidate - \$200/module or a maximum of \$38,400**
- **Value of new catalyst - \$7,000/module**
- **Value of regenerated catalyst - \$3,000/module**
- **Net value – Value of recovered catalyst minus \$38,400**
- **How does net value vary versus attrition %?**

Attrition % - Example



Physical Evaluation (Attrition %)

	Corrugated	Honeycomb	Plate
Erosion			
Wall thickness			
Internal damage			
Dissect some cassettes/logs			
Top and bottom cassette rows			
Strength testing			
Delamination			
Corrosion			
Mesh material and strength			

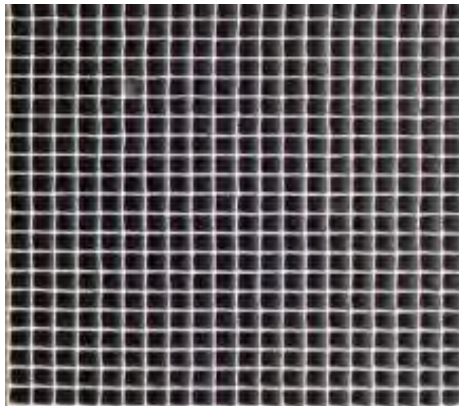
Performance Evaluation

Test regeneration

- Element or cassette
- Full module – Preferred method

Establish guarantees

- NO_x removal efficiency
- SO₂ conversion
- Life
- Pressure drop
- Mercury oxidation



Should I Regenerate? - Summary

Procedure exists to answer this question

Procedure includes

- Physical evaluation
- Performance evaluation
- Economic evaluation

Significant “Net Value” exists even with a relatively high attrition %



Economic Evaluation - Catalyst

1. **Purchase price**
2. **Operating costs**
3. **Performance**
4. **Value**



Economic Evaluation - Catalyst



	Catalyst 1	Catalyst 2	Cat 1 minus Cat 2
Purchase Price	\$ 1,100,000	\$ 1,000,000	\$ 100,000
Area Velocity	19.0	25.0	(6.0)
Initial K (Alpha = 1)	42.0	45.0	(3.0)

Economics of SCR Management

Basis - 192 Modules / Layer, 2 Year Outage Cycle

	New Catalyst		Regenerated Catalyst	
	5%	25%	5%	25%
Average Pluggage (%)	5%	25%	5%	25%
Catalyst Purchase (1 Layer)	\$ 1,200,000		\$ 800,000	
Catalyst Purchase (2 Layers)		\$ 2,400,000		\$ 1,600,000
Catalyst Installation	\$ 400,000	\$ 700,000	\$ 400,000	\$ 700,000



Summary

Proper SCR management is critical to:

- Minimize risk
- Reduce costs

Be aggressive in pluggage prevention

Many options exist

Frequent re-evaluations are required

Take a proactive role





STEAG SCR-Tech

An Environmental Services Company