McIlvaine Hot Topic Hour

Catalyst Selection for NOx and Other Gases

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Enhanced Mercury Control by Managing SCR Systems for Mercury and NOx

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GENERAL PRECAUTIONS !

SCR Focus: The of the presentation is SCR mercury oxidation. However, many downstream factors will influence mercury speciation and capture. Avoid making the assumption that a speciation change at the SCR will have the same direct quantitative effect on mercury capture at the stack. The system must be treated in an integrated fashion.

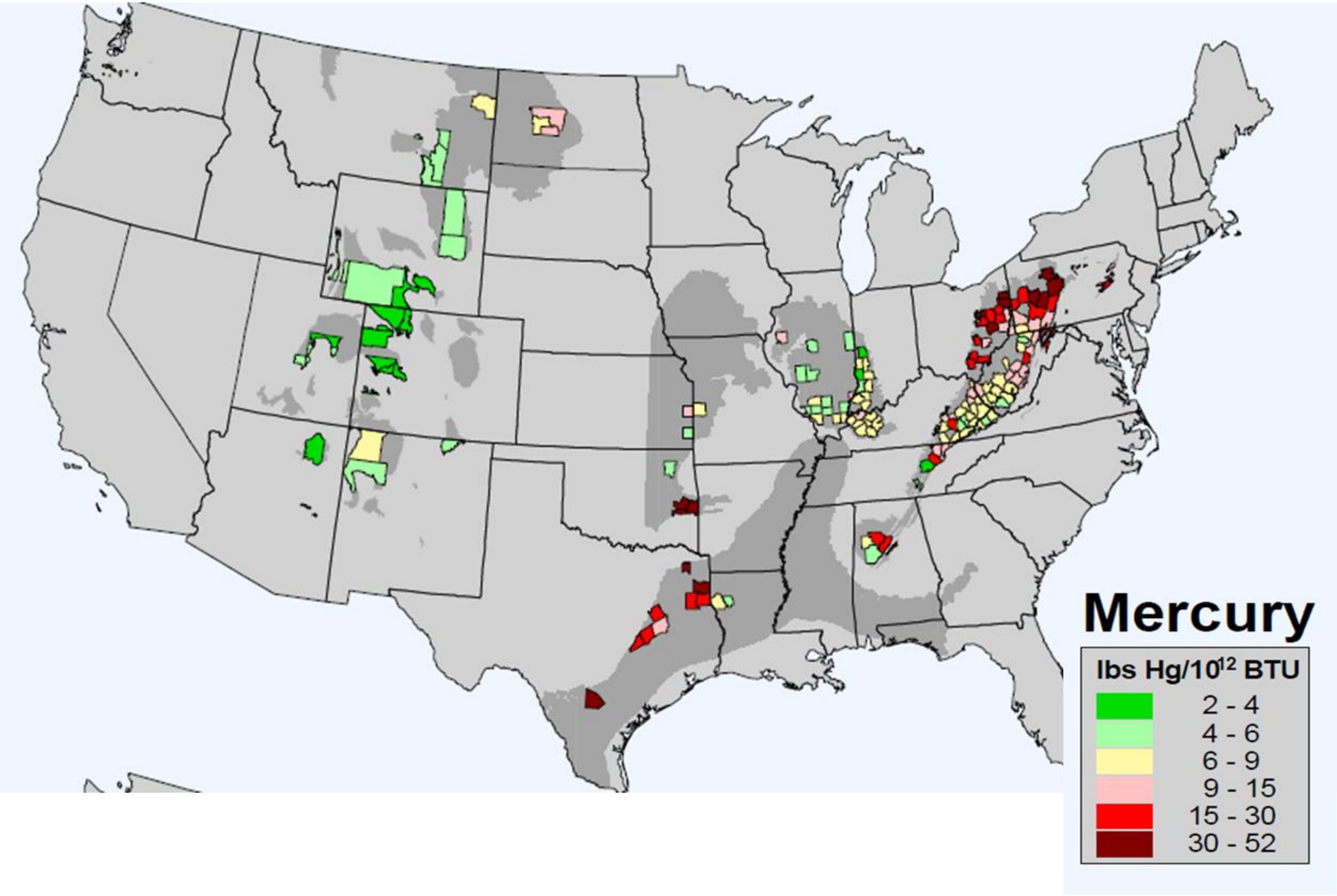
Use Data as Examples Only: Much of the data presented are associated with pilot facilities. These data may not translate directly to full-scale systems, especially in terms of the absolute values for halogens and mercury oxidation. In other words, the scales may be shifted !

Mercury Oxidation is Site Specific ! Data from one facility may not translate directly to another facility, even if facilities appear to be very similar.

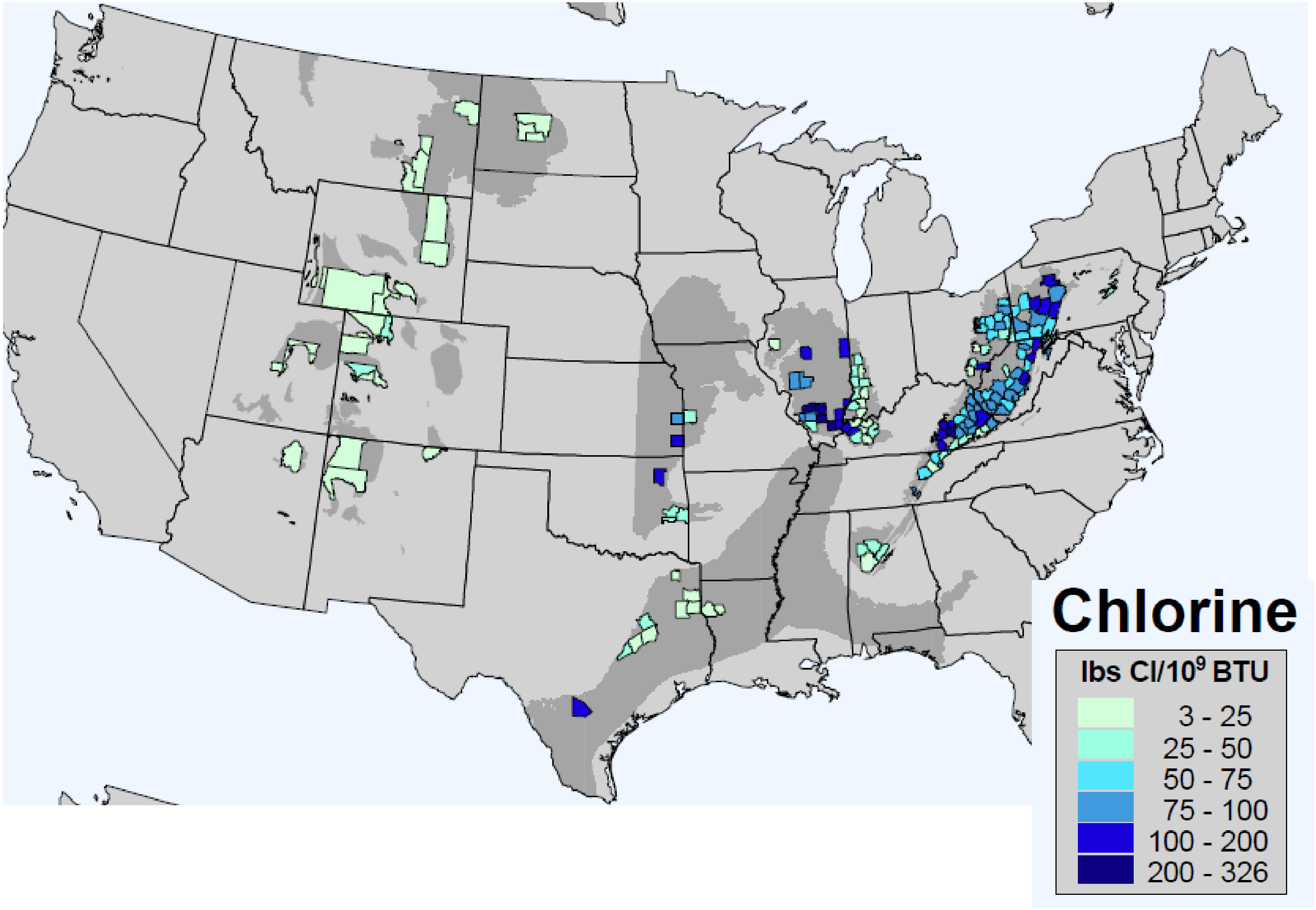
Factors Affecting SCR Mercury Oxidation

- Fuel Composition (mercury and halogen Levels)
- Supplemental Halogens (chlorine or bromine addition)
- Catalyst Design (pitch, formulation, etc.)
- Volume/Potential
- Catalyst Age
- Temperature
- Flow Rate
- Ammonia

Fuel Composition – Mercury Levels

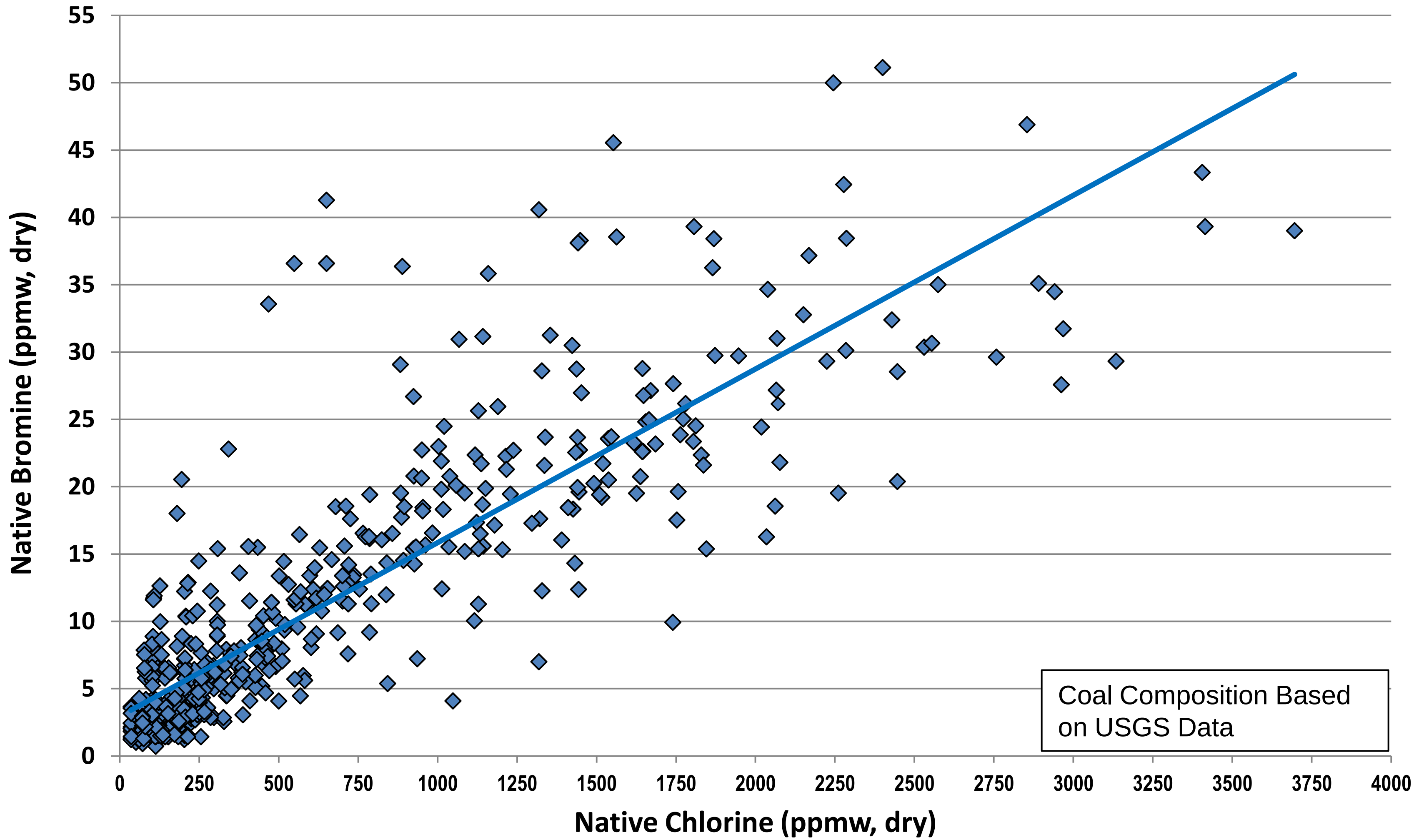


Fuel Composition – Chlorine Levels

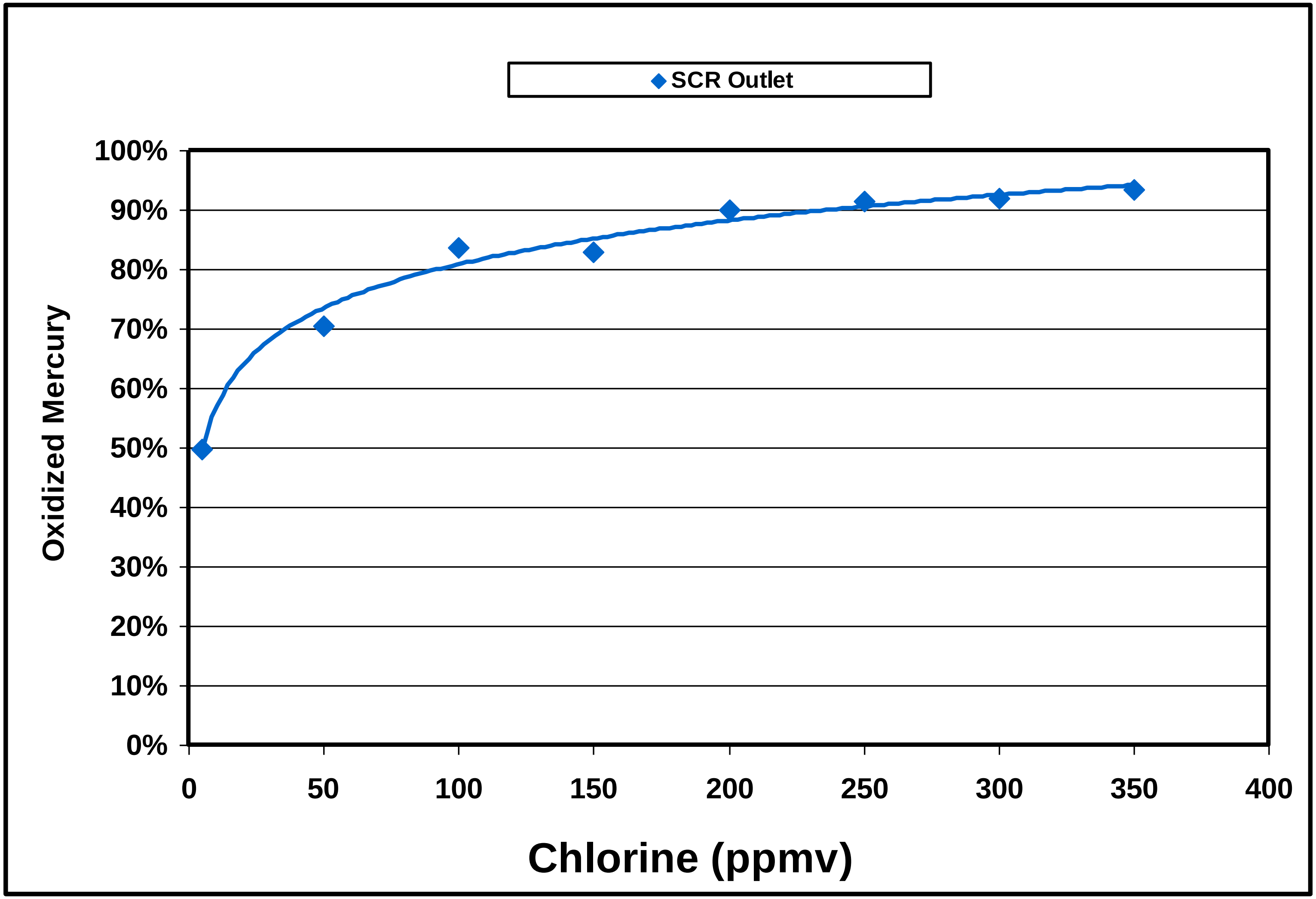


Bromine and Chlorine Inter-Relationship

Coals low in Chlorine will also generally be low in Bromine

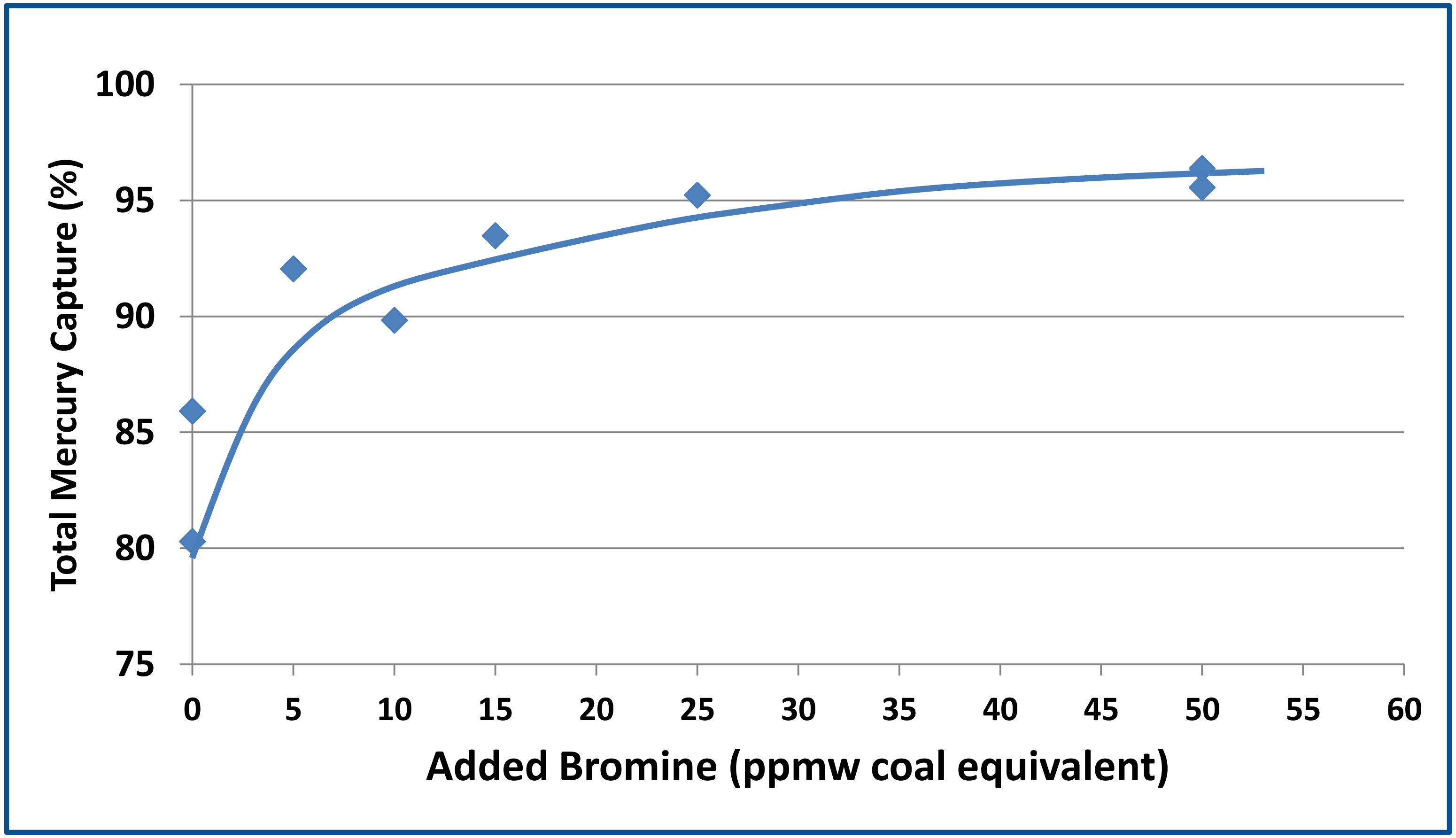


<u>Example</u> Effect of Chlorine on SCR Hg Oxidation



Bromine Addition with SCR-Wet Scrubber

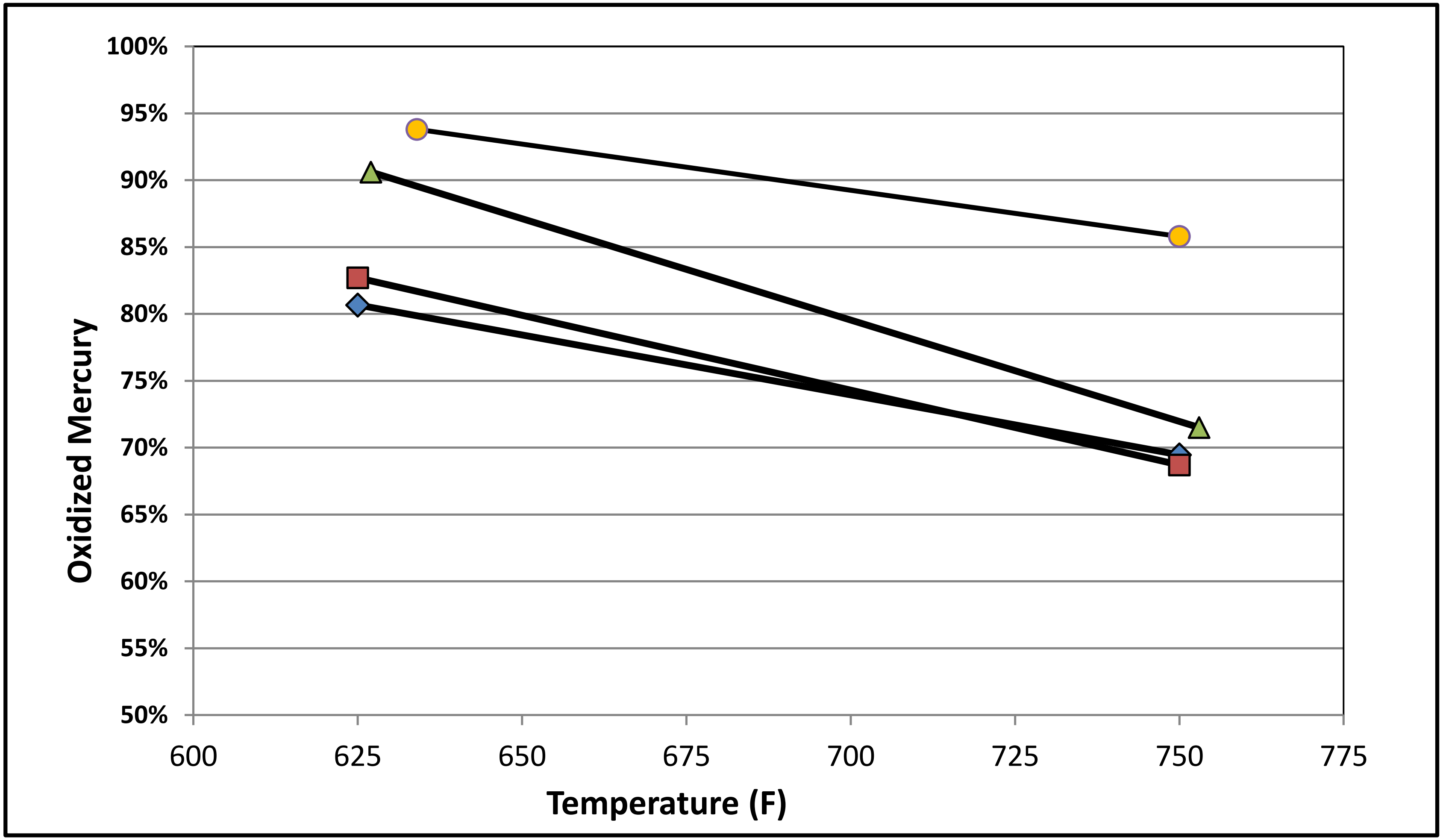
MRC Data - <u>low chlorine</u> eastern bituminous coal



Caution ! Example only –effects may be significantly shifted in the field.

SCR Outlet Oxidized Mercury vs. Temperature

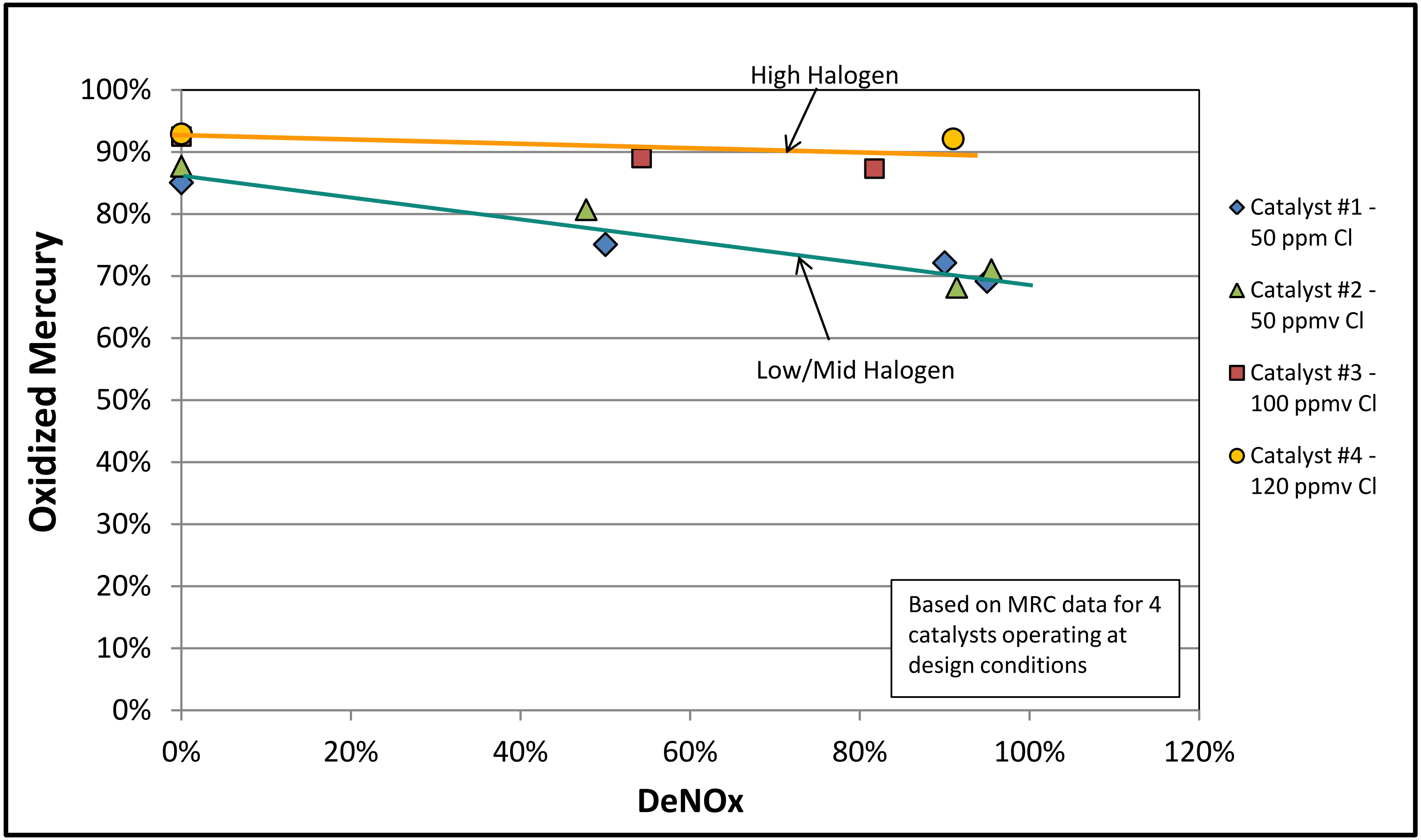
lower temperatures favor oxidized mercury



Based on MRC data
4 catalysts

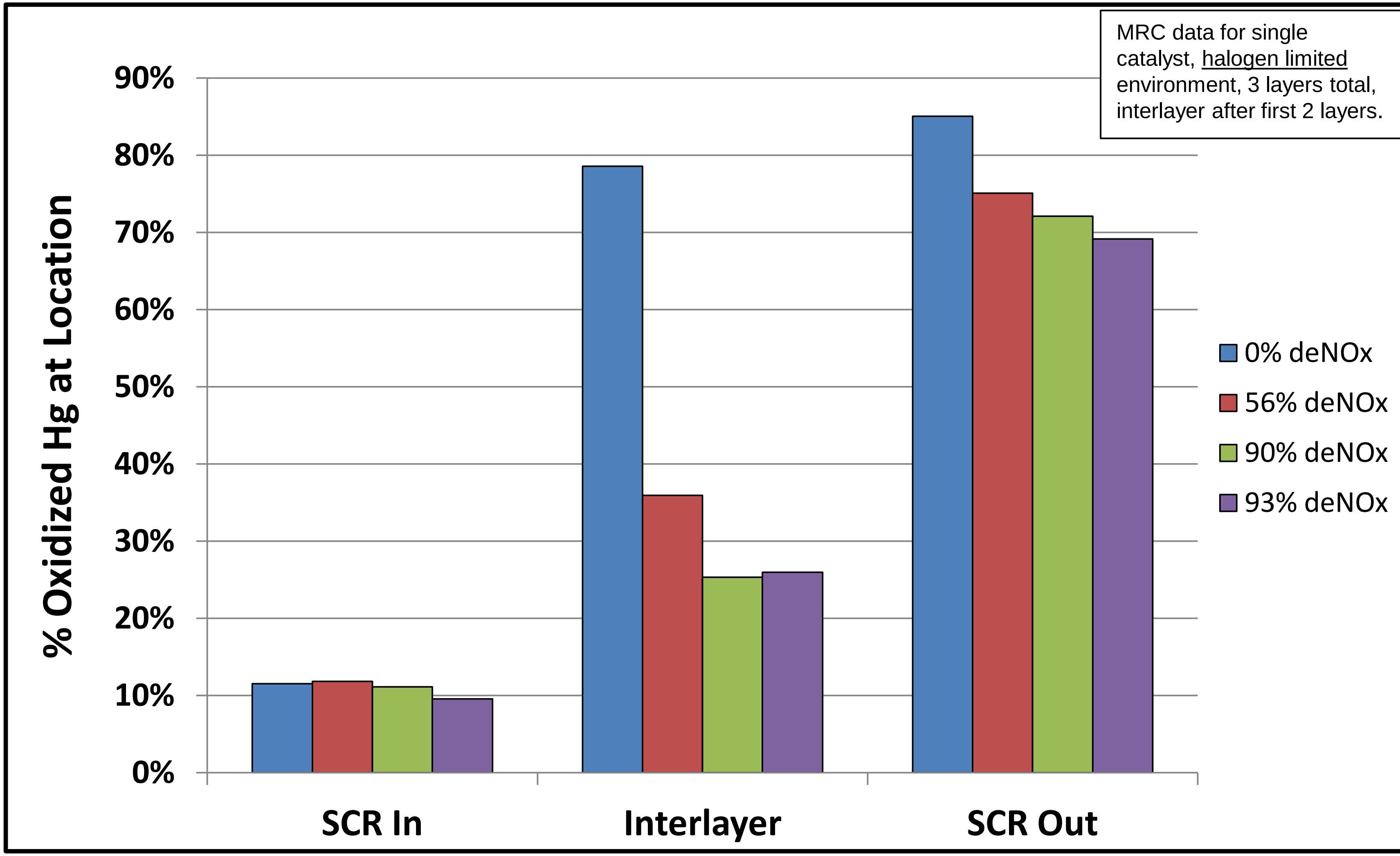
Effect of Ammonia: Suppression of Hg Oxidation

halogens can help to mitigate the effect

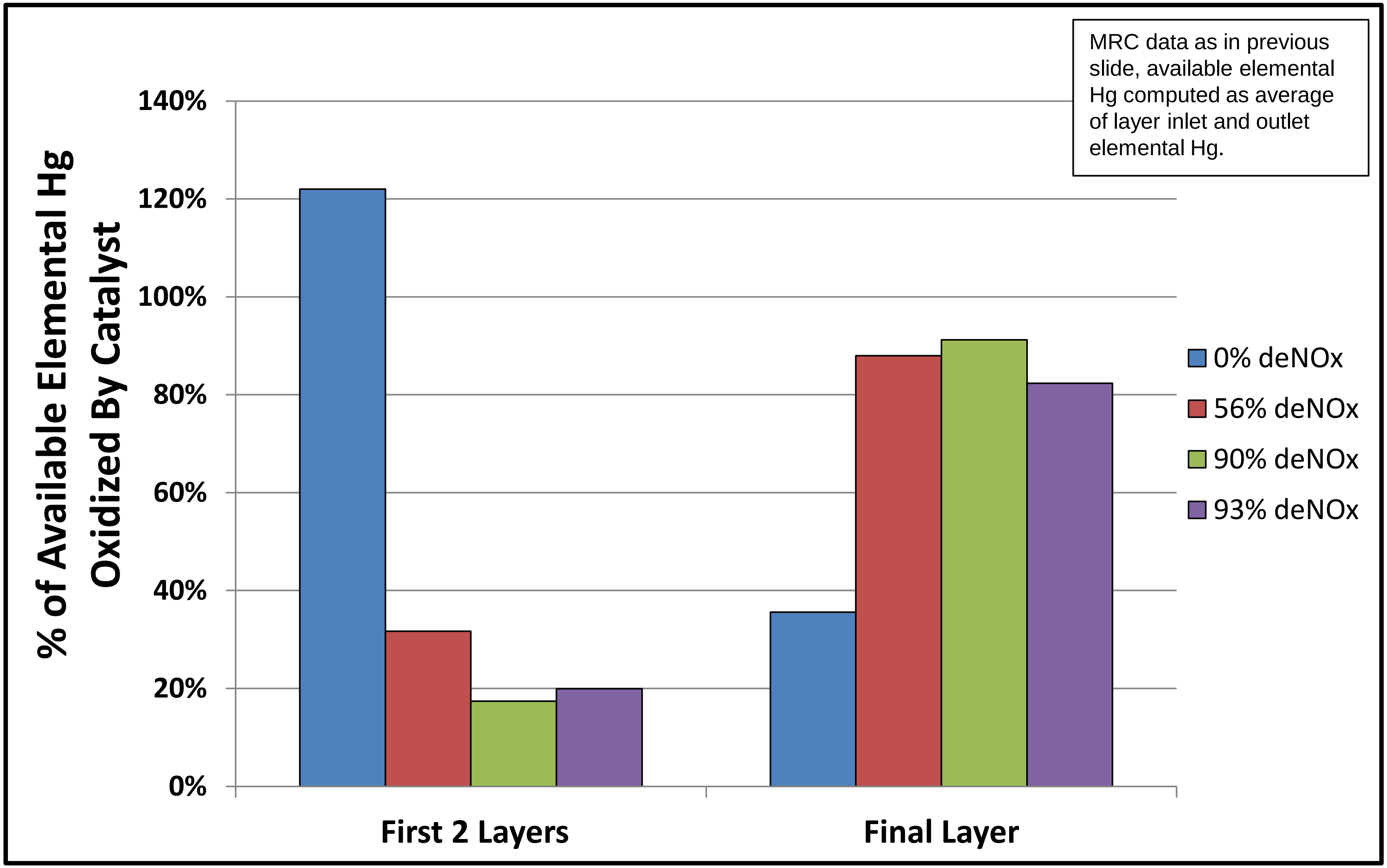


Caution ! Example only – halogen effects may be significantly shifted in the field.

Effect of Ammonia: Speciation as a Function of Catalyst Layer



Effect of Ammonia: Speciation as a Function of Catalyst Layers



GENERAL OPERATING GUIDLEINES TO MAXIMIZE MERCURY OXIDATION AND MINIMIZE EMISSIONS

- **Avoid High-Mercury in Fuel**
- **High Halogens**
  (through fuel purchasing, blending, or supplementation)
- **Lower Temperatures**
- **Lower Flow Rates/Low Space Velocity**
- **Minimize the Ammonia Profile**
  (through good SCR maintenance, AIG tuning, cleanliness, distributions, etc.)

TWO CATALYST MANAGEMENT STRATEGIES TO IMPROVE MERCURY OXIDATION AND MAINTAIN DENOX

Strategy A – Aggressively Maximizes Mercury Oxidation

Strategy B – Modest Approach to Improve Mercury Oxidation

Strategy A

- **Most Aggressive Strategy**
- **Manages Upper Catalyst Layers for DeNOx**
- **Manages Final Catalyst Layer for Mercury Oxidation**
- **Insures that Entire Final Catalyst Layer Operates with Very Low Slip (< 2 ppmv normally)**
- **Results in One Extra Layer Always Being Present in Reactor**
- **Fine Tuning Parameters: Frequency of Final Layer Replacement, Use of Advanced Catalyst, Allowable Slip Entering Final Layer, Halogen Injection Level** (if used)
- **Costs:** Full Layer of Additional Catalyst, Pressure Drop, Maintenance, Sootblowing/Horn Provisions, More Frequent Management Events

STRATEGY A – Manages Reactor in Two Parts

4-Layer Reactor Design

Layer 1
High deNOx – Very Limited Hg Oxidation

Layer 2
Moderate deNOx – Limited Hg Oxidation

Layer 3
Low deNOx – Moderate Hg Oxidation

NH_3 Slip = 2-5 ppmv

Layer 4
~No deNOx – High Hg Oxidation

NH_3 slip ≈ 0, Hg Oxid. ≈ 90%+

3-Layer Reactor Design

Layer 1
High deNOx – Very Limited Hg Oxidation

Layer 2
Moderate/Low deNOx - Limited Hg Oxidation

NH_3 Slip = 2-5 ppmv

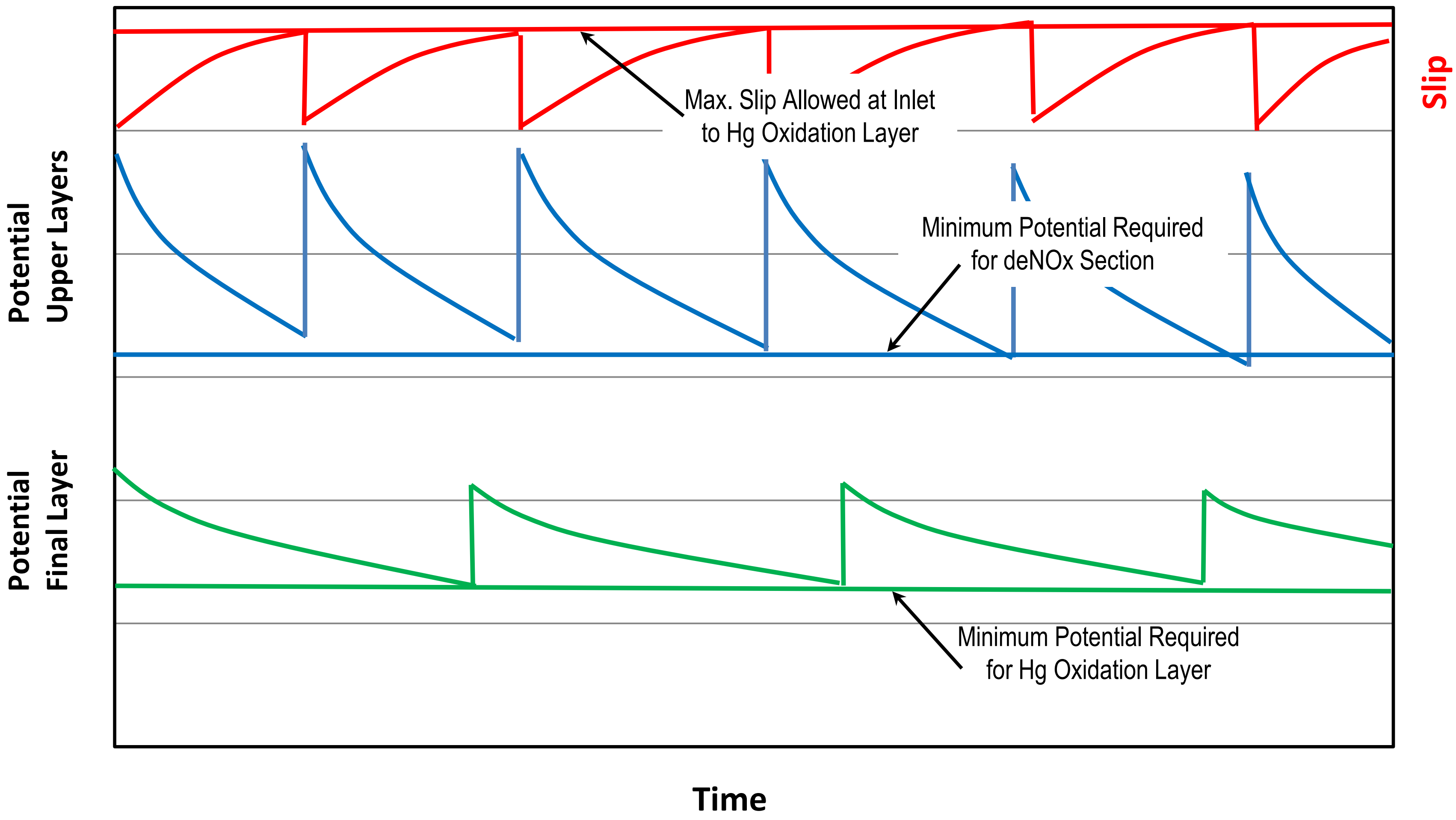
Layer 3
~No deNOx – High Hg Oxidation

NH_3 slip ≈ 0, Hg Oxid. ≈ 90%+

Key

- DeNOx Layers
- Mercury Oxidation Layers

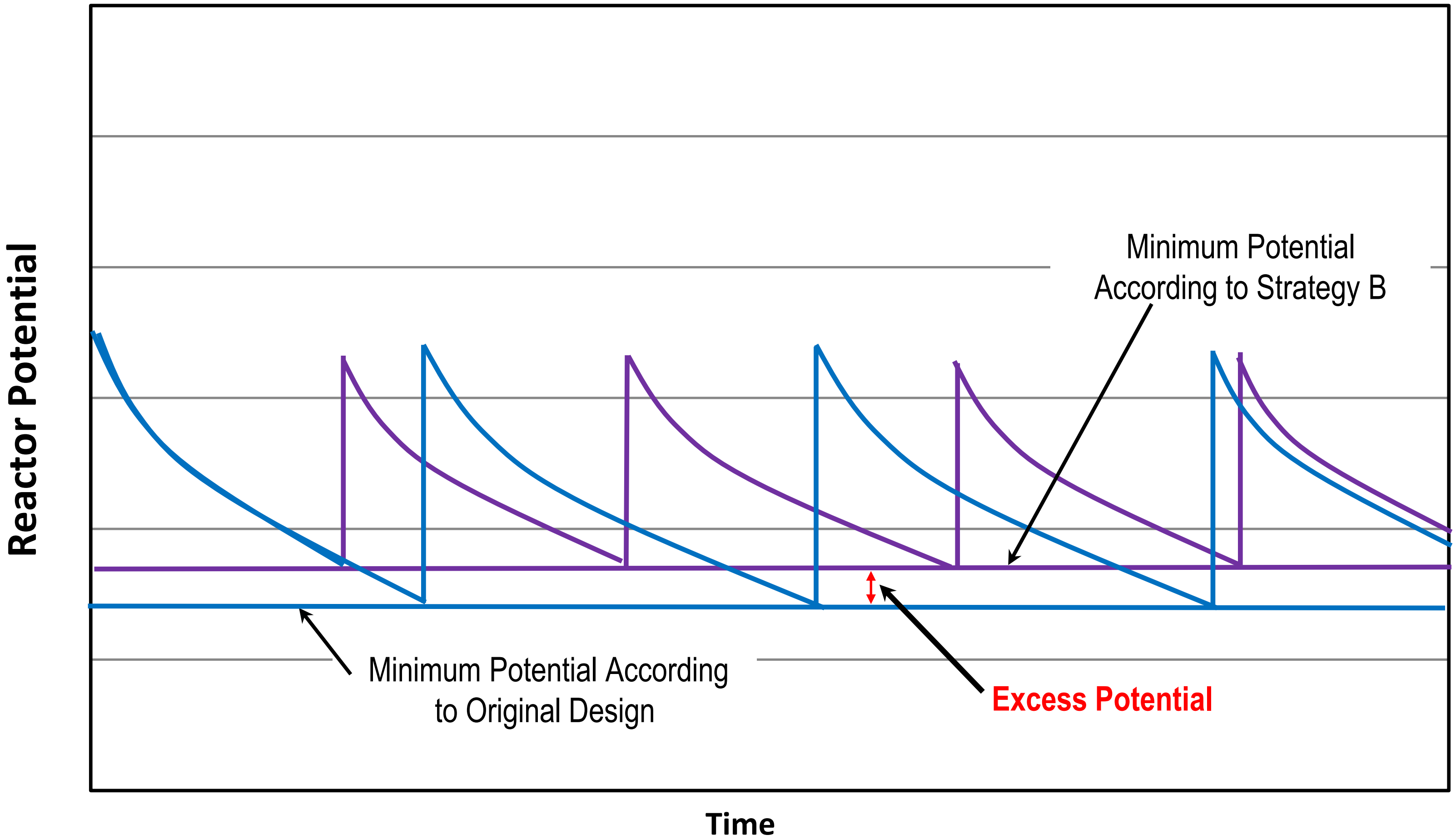
STRATEGY A – CATALYST MANAGEMENT PLAN



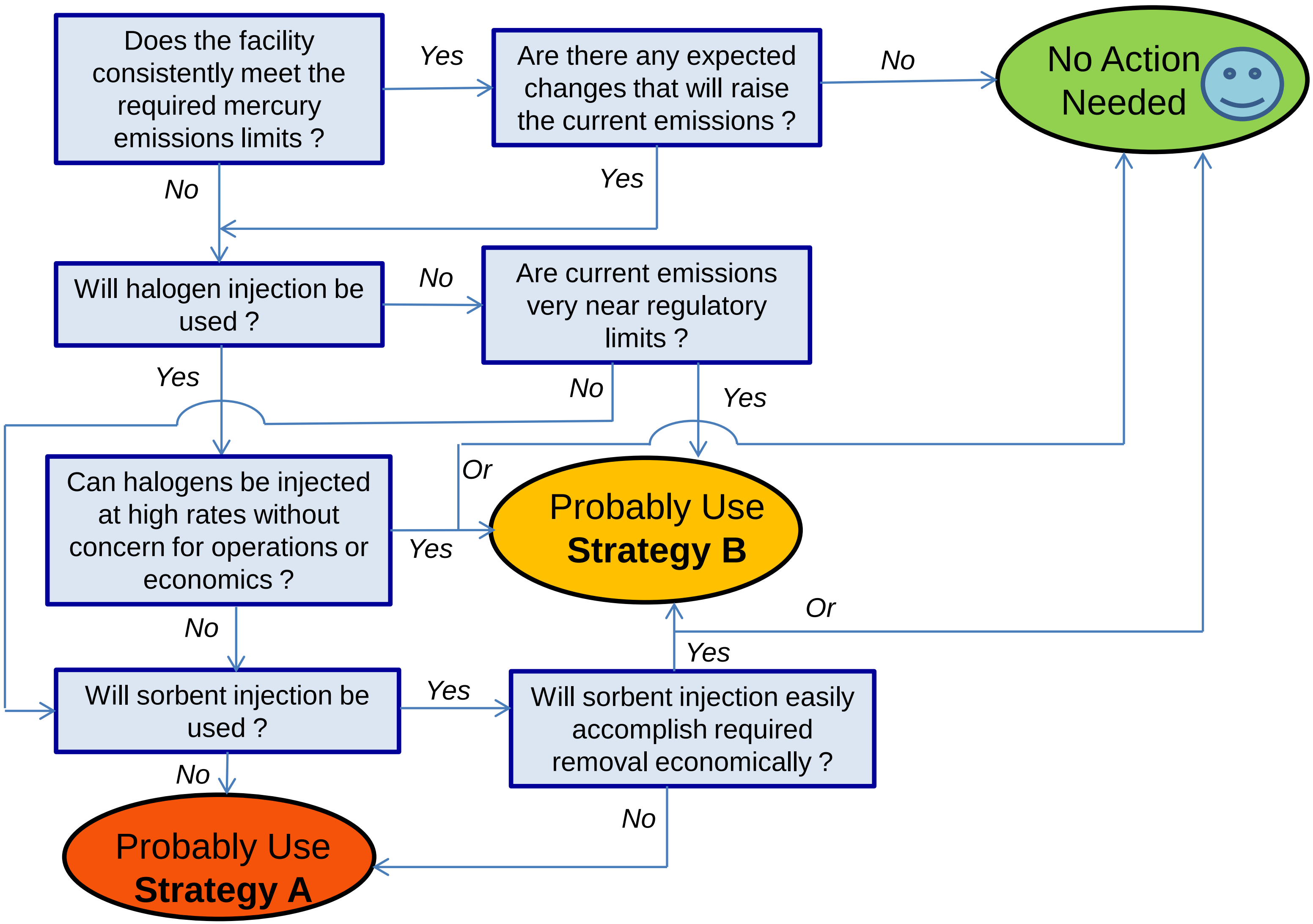
Strategy B

- **Moderate Strategy to Improve Mercury Oxidation**
- **Manages Reactor as a Whole, Following Typical Management Strategy in General Approach**
- **Relies on "Excess Potential" to Insure that Some Portion of Catalyst Operates at Very Low Slip Over the Life of the Installation.**
- **Results in More Frequent Catalyst Replacements, or Requires More Potential Per Layer (via deeper beds, tighter pitch, or possibly more active catalyst)**
- **Caution: Do Not Allow Excess Potential to be an Excuse for Sloppy Operation and Maintenance of the SCR System**
- **Fine Tuning Parameters: Required Excess Potential, Use of Advanced Catalyst, Halogen Injection Level** (if used)
- **Costs:** additional catalyst, more frequent management events

Strategy B – Catalyst Management Plan



Management Strategy Selection: Decision Tree



SUMMARY - CATALYST MANAGEMENT STRATEGIES FOR MERCURY CONTROL

Strategy	A	B
Aggressiveness	**High**	**Moderate**
General Application	Facilities that have very limited mercury oxidation under normal operation	Facilities that routinely achieve, or nearly achieve, the required mercury removal under normal operation
Halogen Level	Often low native halogen coals (PRB and domestic/foreign low-chlorine coals), with halogen supplementation required/other facilities for which demand for SCR mercury oxidation is high	Usually moderate to high-halogen coals where no halogen supplementation is required/ other facilities for which demand for SCR mercury oxidation is low or moderate
Approach	Manage final catalyst layer as a mercury oxidation catalyst with very low ammonia – upper catalyst layers managed for deNOx	Manage entire reactor as a whole using excess reactor potential to insure adequate mercury oxidation
Variables (fine tuning parameters)	1) Allowable slip entering the final catalyst layer 2) Allowable deactivation of final layer prior to replacement 3) Halogen and/or sorbent injection rate, if utilized 4) Use of Advanced Catalyst	1) Amount of excess potential required to meet the desired margin in mercury removal 2) Halogen and/or sorbent injection rate, if utilized 3) Use of Advanced Catalyst

Economic Considerations of Catalyst Management for Mercury Control

Category	Costs		Benefits
	Strategy A	Strategy B	
Fixed Capital	Cost of full catalyst layer, possibly cost of cleaning system and instrumentation for additional layer	Cost of additional catalyst potential	Possible avoidance of sorbent injection or halogen injection
Variable	Pressure drop associated with additional catalyst	Pressure drop associated with additional catalyst	Reduction in sorbent or halogen usage
Maintenance	General maintenance catalyst replacement events associated with final layer	More frequent catalyst replacement events	Possible benefit to downstream equipment due to lower ammonia slip

DATA SHORTFALLS

- **Quantitative speciation benefit from the management strategies as a function of fuel and operating conditions.**
- **Direct quantitative effect on emissions due to SCR oxidation change, as a function of operating conditions.**
- **Advantages of advanced catalyst over conventional catalyst as a function of operating conditions, and location in reactor.**

ADVANCED VERSUS CONVENTIONAL CATALYST

- Advanced catalyst is designed to offer higher mercury oxidation while maintaining deNOx and SO2 conversion.
- Some price premium is expected.
- Both catalyst management plans can utilize advanced catalyst.
- Advanced catalyst probably most beneficial in last layer.
- Most aggressive strategy is to use Strategy A with advanced catalyst in entire reactor, or alternately only the last layer would use advanced catalyst.
- Currently the differential mercury oxidation between advanced catalyst and conventional catalyst is not know independently.
- Cost analyses will depend on the above and the price differential.

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