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SCR Catalyst Selection and Management for Improved Hg Oxidation Performance

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Background

- SCR co-benefit for Hg oxidation is a key component of MATS Hg compliance strategies.
- Catalyst management now has to consider Hg oxidation performance threshold along with DeNOx performance.
- Catalyst management for Hg oxidation is analogous to DeNOx
  - added complexity due to the nature of Hg oxidation kinetics.
- COMET™ technology
  - Characterization and modeling tools
  - Advanced Hg oxidation catalyst
  - Tools for analyzing and defining catalyst management strategies.

Key Differences for Hg vs. NOx

More Factors Influence Hg Oxidation

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DeNOx

– Key Parameters

- NOx inlet
- Efficiency
- Slip
  - (NOx inlet, Efficiency, Slip →) ***Performance Threshold***
- Temperature
- O_2, H_2O, SO_2 (lower impact)
- SO_2 conversion (formulation)
- Fuel → contaminants → K/Ko
- Reactor condition

Hg

– Key Parameters

- Hg oxidation → **Performance Threshold**
- NOx inlet
- Efficiency
- Slip
  - (NOx inlet, Efficiency, Slip →) ***NH_3 (negative impact)***
- Layer position (NH_3)
- Halogen (Fuel or additive)
- Temperature
- CO
- O_2, H_2O, SO_2 (can be larger impact)
- SO_2 conversion (formulation)
- Fuel → contaminants →K/Ko
- Reactor condition

Key Differences for Hg vs. NOx

Hg Ox Catalyst Potential, K/AV

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- **Hg Oxidation K_{HgOx}/AV defines:**
  - Capacity for X% Hg oxidation
- **Activity, K_{HgOx}, depends on:**
  - Catalyst composition and age
  - Flue gas conditions (+HCl, HBr, NH_3, CO, SO_2, HC)
- AV = Area Velocity = (Gas Flow) / (Total GSA)
- First order rate equation can be applied for Hg oxidation tests, *but be careful! This K value is strongly condition dependent!*

$$\frac{K_{HgOx}}{AV} = -\ln\left[1 - \eta_{HgOx}\right]$$

$$\eta_{HgOx} = fraction\ of\ Hg^0\ oxidation$$

MHI Semi-Bench Reactor – reflects years of experience

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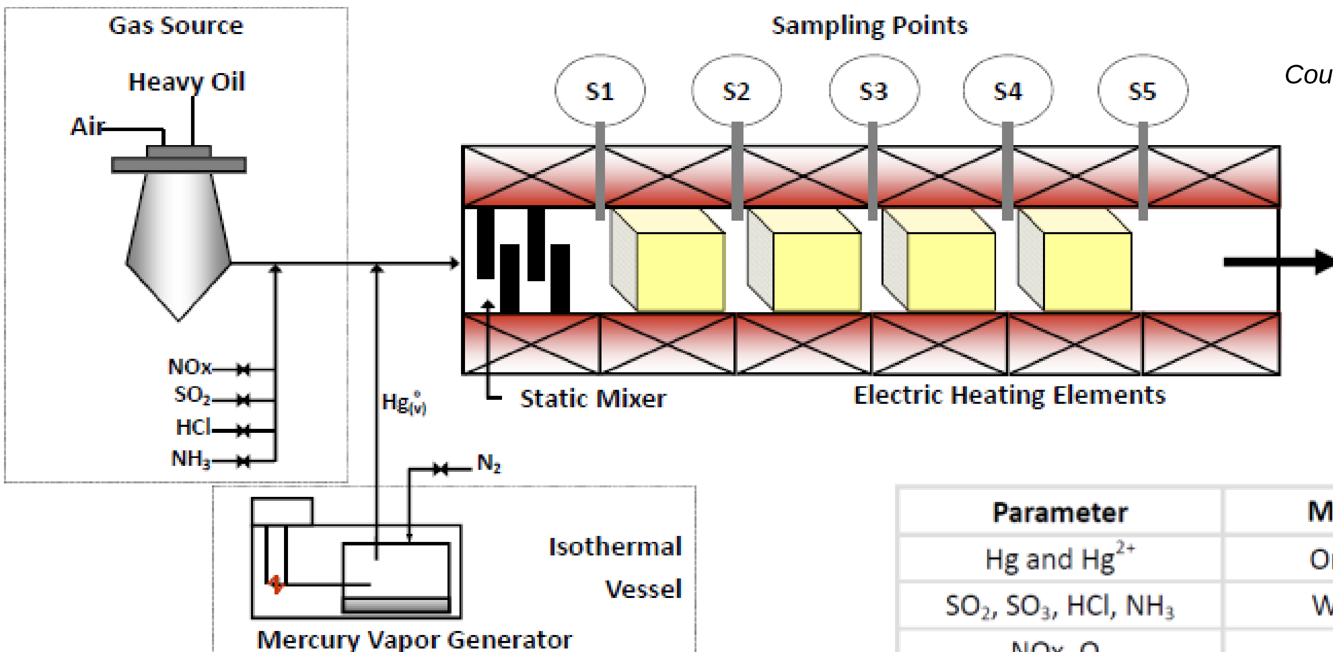
- Collected Hg oxidation data for development, designs, deactivation studies, and quality assurance since 2002.
- Total system testing (fresh and deactivated) up to 4 layers



Courtesy of: MITSUBISHI HEAVY INDUSTRIES, LTD. TECHNICAL HEADQUARTERS

Parameter	Measurement Method
Hg and Hg^{2+}	Ontario Hydro Method
SO_2, SO_3, HCl, NH_3	Wet Chemical Analysis
NOx, O_2	CEMs

Mercury Assurance Testing Reactor

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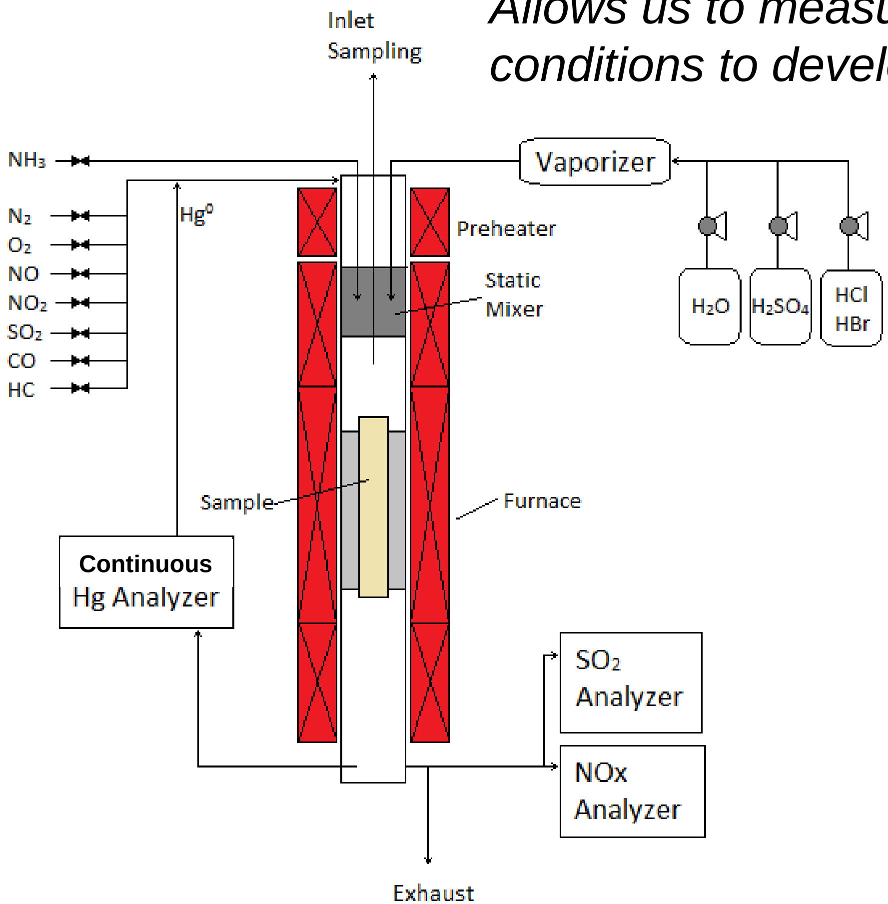
Versatile and fully-automated for efficient data collection. *CEMS for Hg, NO_x, SO_2*

Allows us to measure Hg oxidation under a full range of conditions to develop catalysts and management strategies.

Capable of characterizing any catalyst type/vintage.

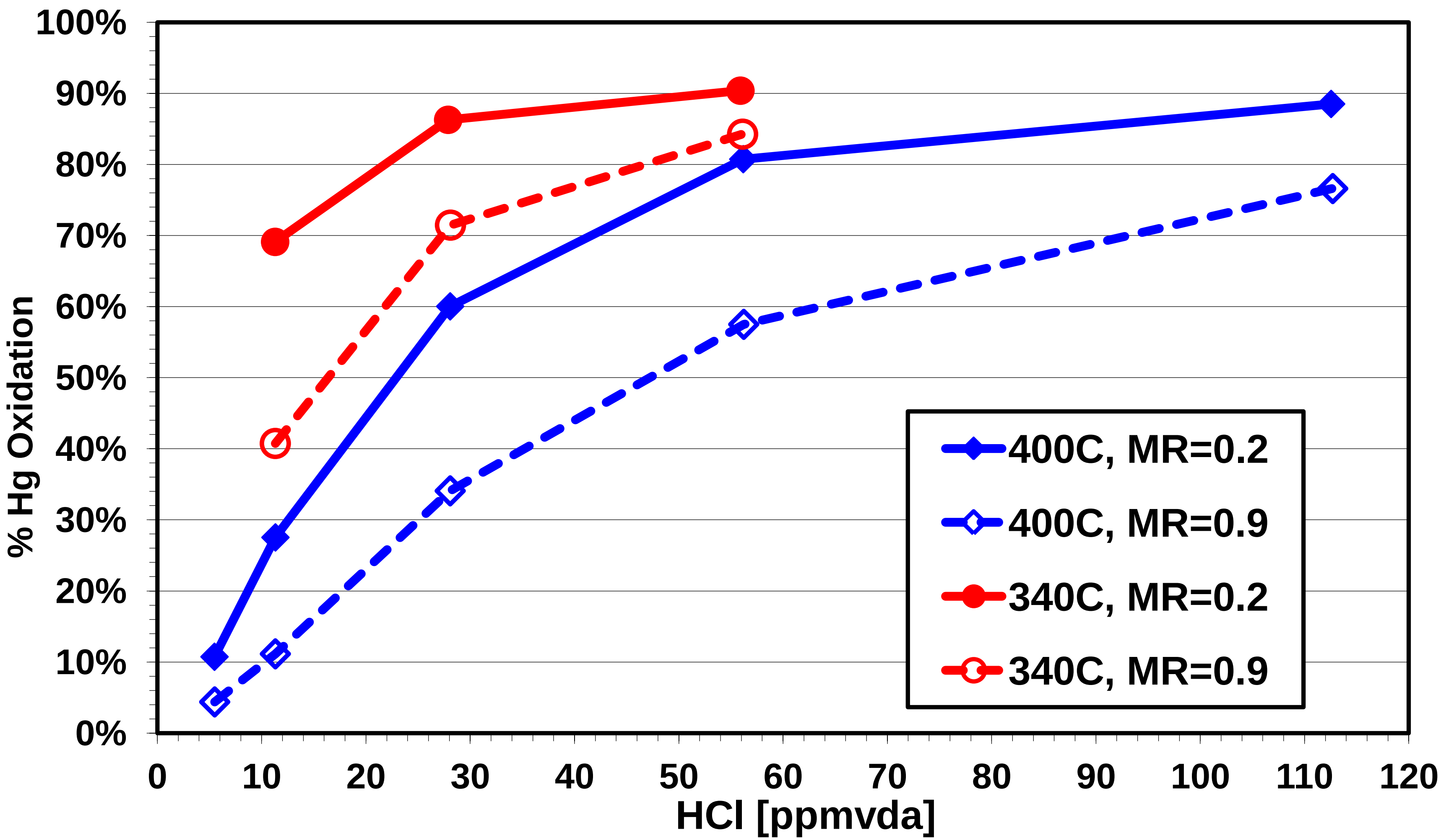


Cormetech Bench Reactor

- Added Bench scale Hg oxidation testing capability.
  - Construction complete
  - Validation testing underway

- Full size element testing
- Individual element and multi-layer testing
- Any catalyst type or combination
- Fresh or deactivated
- HCl/HBr, O_2, H_2O, SO_2, SO_3, NO_x, CO, HC

Catalyst characterization



Layer Dependency: MR = 0.9 represents top layer
MR = 0.2 represents a lower layer

Catalyst Type Dependency

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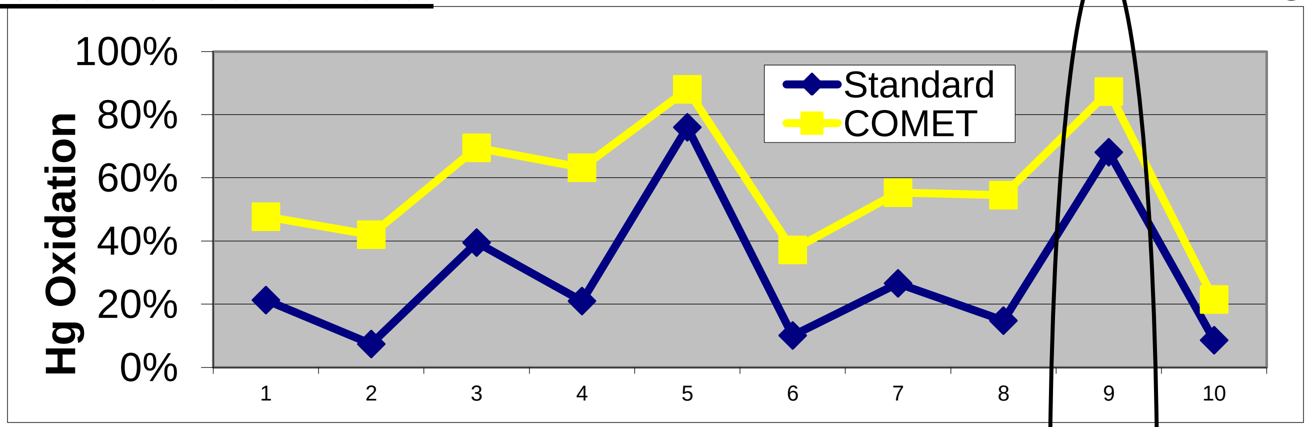
PRB Unit - Lab Testing Case Study: COMET™ –vs- Standard

At same SO2 oxidation rate.

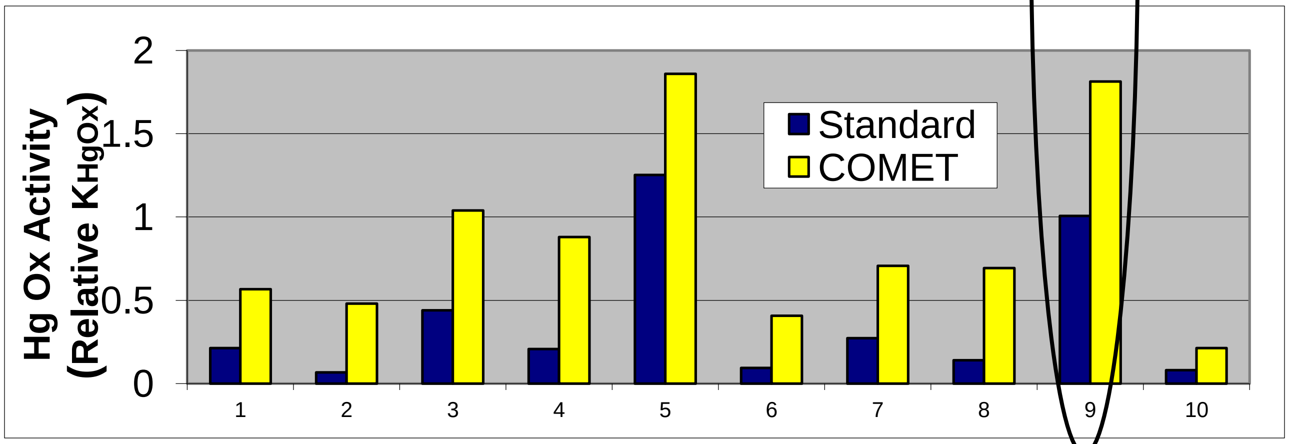
Design Case

Constants	
Temp C	403
NOx ppm	107
O2 %	3.5
H2O %	14
SO2 ppm	345
HCl ppm	**8**



NH3	**ppm**	**0**	**0**	**0**	**0**	**0**	**21**	**21**	**21**	**21**	**86**
CO	**ppm**	**0**	**100**	**0**	**100**	**0**	**0**	**0**	**100**	**0**	**0**
HBr	**ppm**	**0**	**0**	**0.1**	**0.1**	**1**	**0**	**0.1**	**0.1**	**1**	**0**

80% higher Hg ox Activity at design case! (Range: 50% - 400%)



Integrated Approach to Solutions

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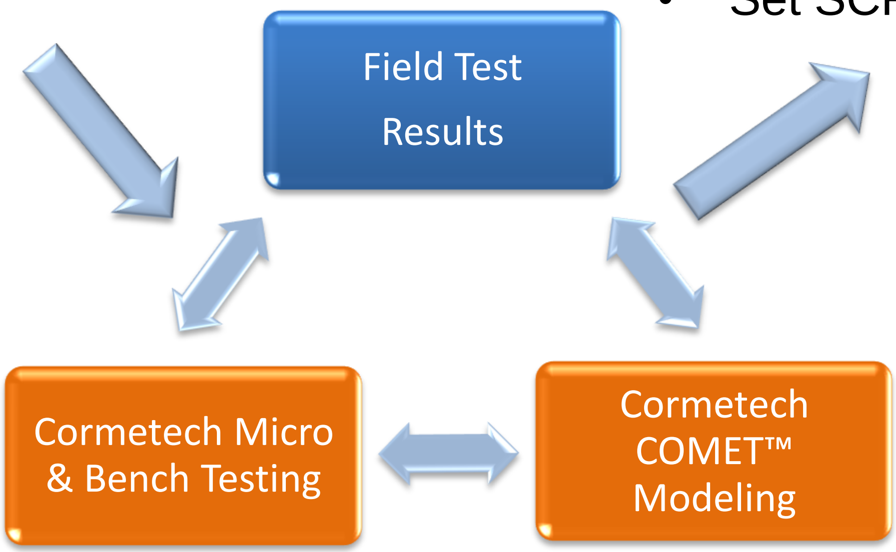
- Understand the needs & options
- Define SCR requirement

- Evaluate multiple scenarios
- Develop management plans
- Select catalyst type:
  - Standard, or
  - COMET™ Advanced Hg Ox Catalyst
- Set SCR performance guarantees.



- Obtain and test catalyst samples
- Use COMET™ modeling technology
- Evaluate against available field data

Case study: System characterization and analysis

- Evaluation of impacts to Hg oxidation and DeNOx performance for catalyst replacement options.
- 4 layer system – replacement of first and last layer
  - Layer 1: Honeycomb A
  - Layer 2: Honeycomb B
  - Layer 3: Honeycomb B
  - Layer 4: Plate
- Layer 1 – replace with fresh catalyst (already purchased)
- Options for Layer 4 replacement:
  - Regenerated honeycomb (from layer 1)
  - Fresh COMET™ catalyst

Case study (cont.)

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- Lab tested 7 samples of field and fresh catalyst
  - MR = 0, 0.2, 0.3
  - over 60 tests completed.
- Validated lab data against model
  - Average absolute deviation within 3% across range of MR
- Field data in good agreement
- Options analyzed and management plan developed.

	Baseline	Option 1	Option 2
Layer 4	Existing	Fresh Regen	Fresh COMET
Hg Oxidation (System)	40%	55%	70%

  - Higher oxidation can be achieved with additional COMET layers.

Summary

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- Hg oxidation is influenced by multiple factors.
  - Layer dependency
  - More factors in setting design conditions
  - Impacts of catalyst type & formulation
- Cormetech has developed testing capabilities needed to characterize performance under all operating conditions.
- COMET™
  - testing and modeling technology allows us to predict system performance and evaluate options for catalyst actions.
  - advanced Hg oxidation catalyst can significantly improve SCR co-benefit for Hg oxidation.
  - Used in combination to provide optimal solutions.

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Thank You!

Questions/Discussion

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