REINHOLD ENVIRONMENTAL Ltd.

2011 NOx-Combustion Round Table & Expo Presentation

February 7-8, 2011, in Birmingham, AL / Hosted by Southern Company

2011 NOX-Combustibles Roundtable

In Situ NOx for Ammonia Injection Grid Control Improvements

HORIBA

Explore the future

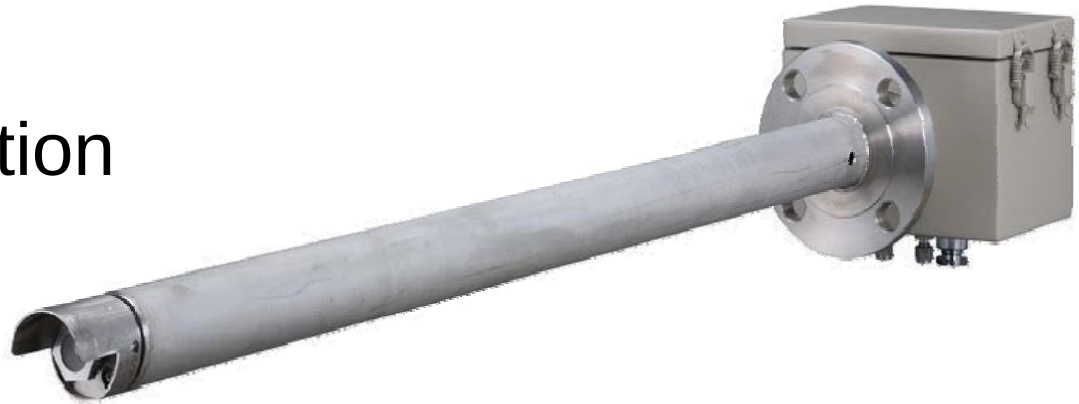
8 February 2011

Harold Henry

Introduction

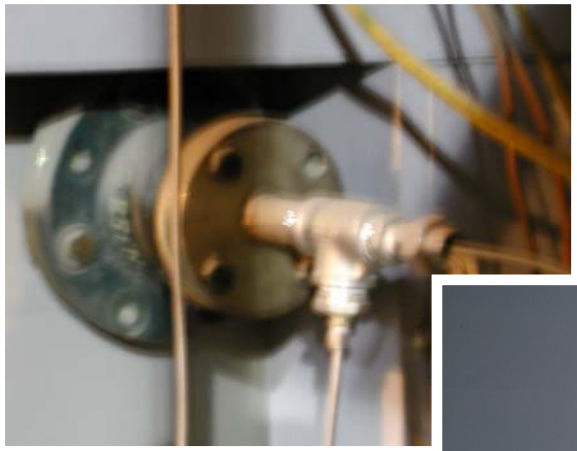
In-situ NO_x/O_2 analyzer for improved SCR process monitoring and control:

- Rapid control capability
- Lower life cycle costs
- Simple installation and operation



Instrument Development History

Automotive



Plant prototype

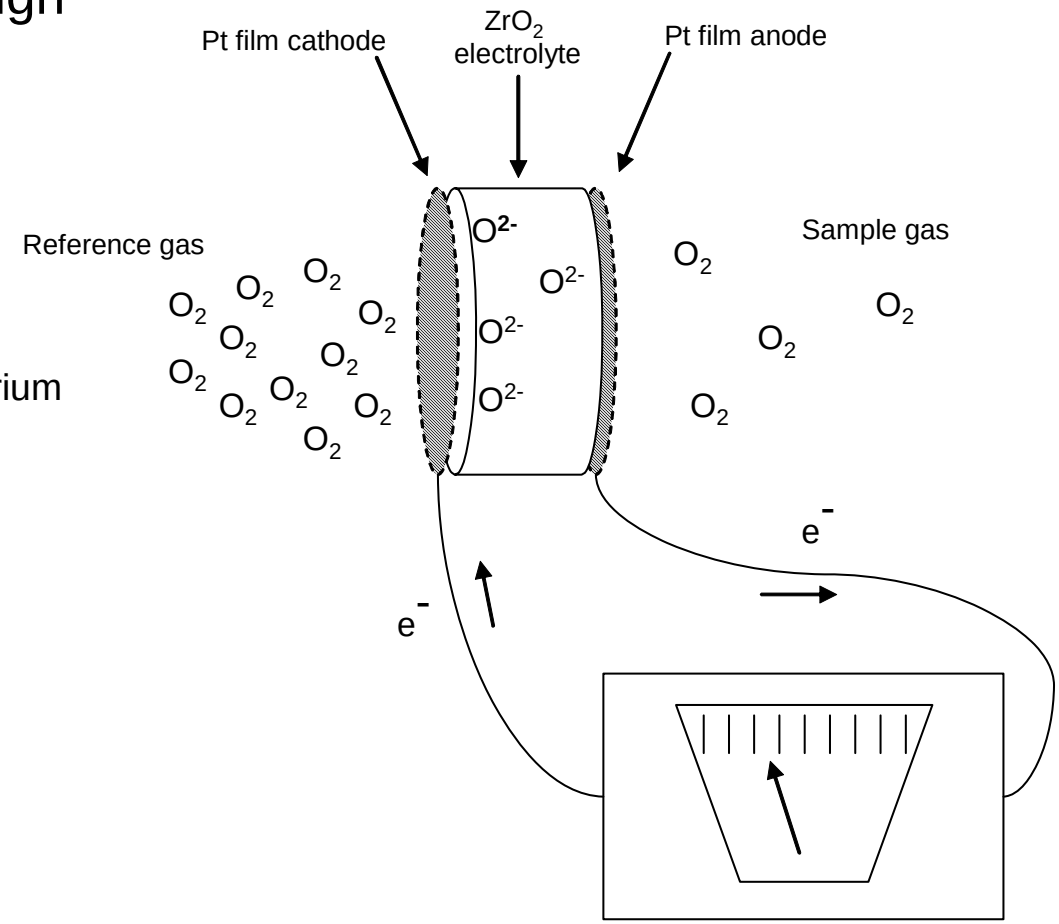
INM-700 product

Versatile Zirconium Oxide

- Porosity to oxygen ions at high temperatures (~650 C)
- Electrochemistry enables:

O_2 sensor
  - Partial pressure differential
  - Ions migrate to restore equilibrium
  - Results in current flow

O_2 pump
  - Applied current drives redox reaction
  - Results in partial pressure differential



NO_x Sensor

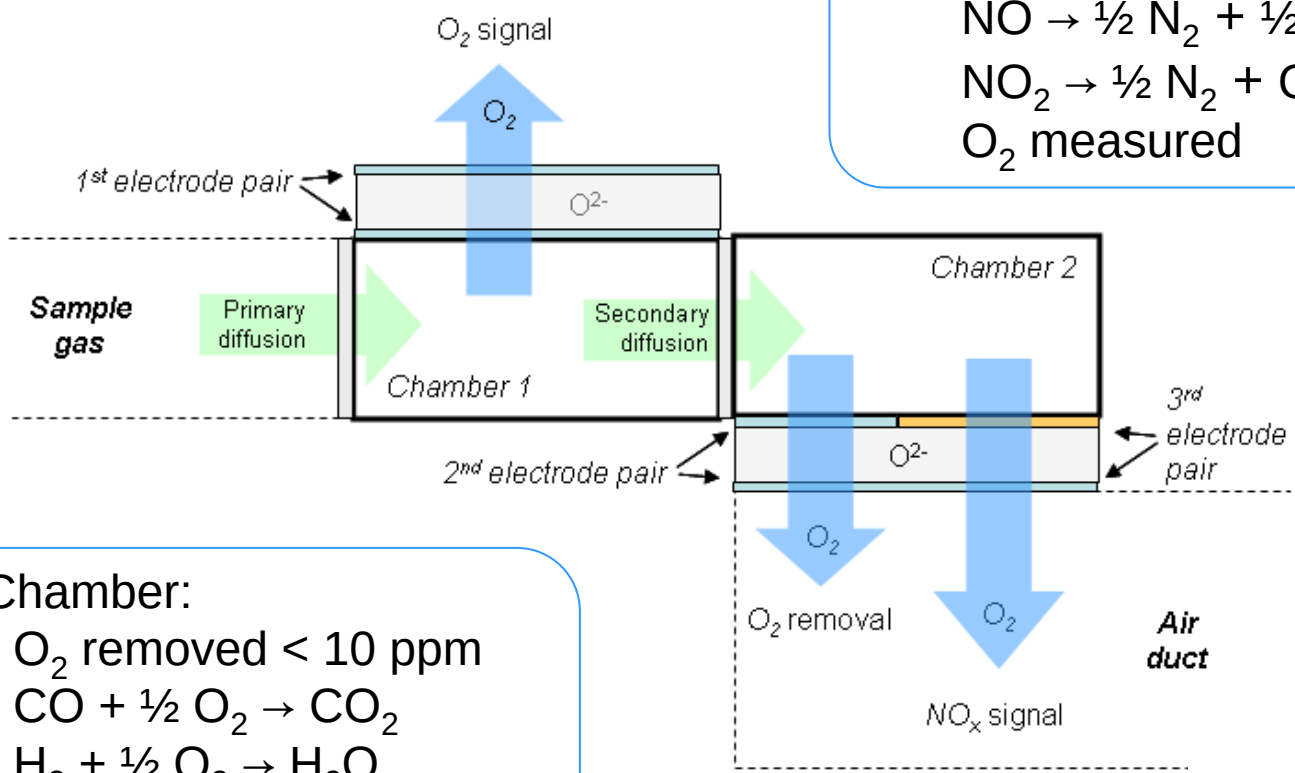
2nd Chamber:

O_2 removed < 0.01 ppm

$NO \rightarrow \frac{1}{2} N_2 + \frac{1}{2} O_2$

$NO_2 \rightarrow \frac{1}{2} N_2 + O_2$

O_2 measured



1st Chamber:

O_2 removed < 10 ppm

$CO + \frac{1}{2} O_2 \rightarrow CO_2$

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$

NO, NO_2, N_2, CO_2, and H_2O to 2nd chamber

Outline

- NO_x control using SCRs
- Need for spatially resolved, real time monitoring and control of NO_x
- Approach
- Results to date
- Next steps

NO_x Sources

1. Thermal formation

$$N_2 + O_2 \rightarrow NO + N$$

$$N + O_2 \rightarrow NO + O$$

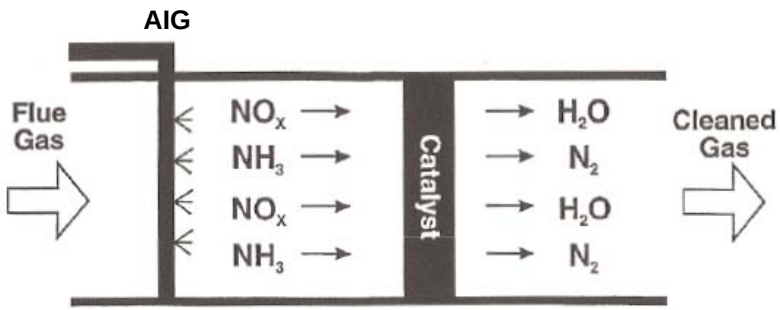
$$N + OH \rightarrow NO + H$$

2. Combustion of fuels containing nitrogen
   - bound within molecular structure
3. Prompt formation
   - N_2 reaction with free radicals (OH, HCO, CH_3…)

Regulations require monitoring & control

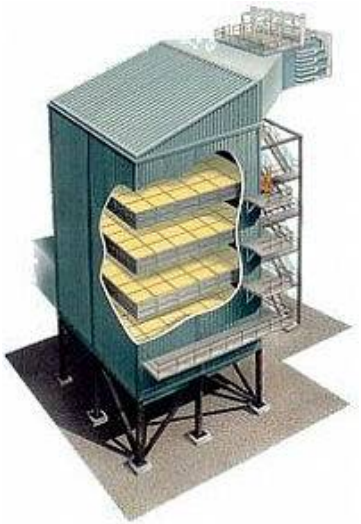
Selective Catalytic Reduction (SCR)

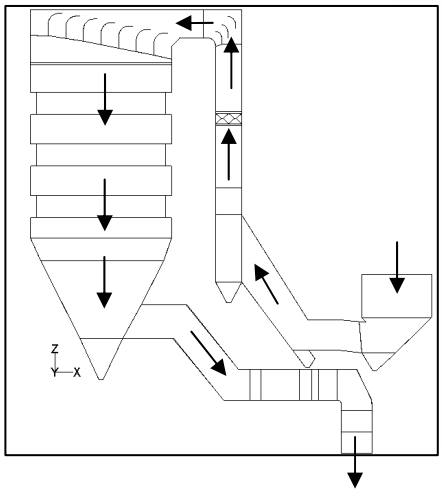
- Reduction of NO_x by catalytic reaction with NH_3 to produce N_2 and H_2O
- Components
  - Ammonia injection grid (AIG)
  - Reactor chamber
  - Catalyst bed

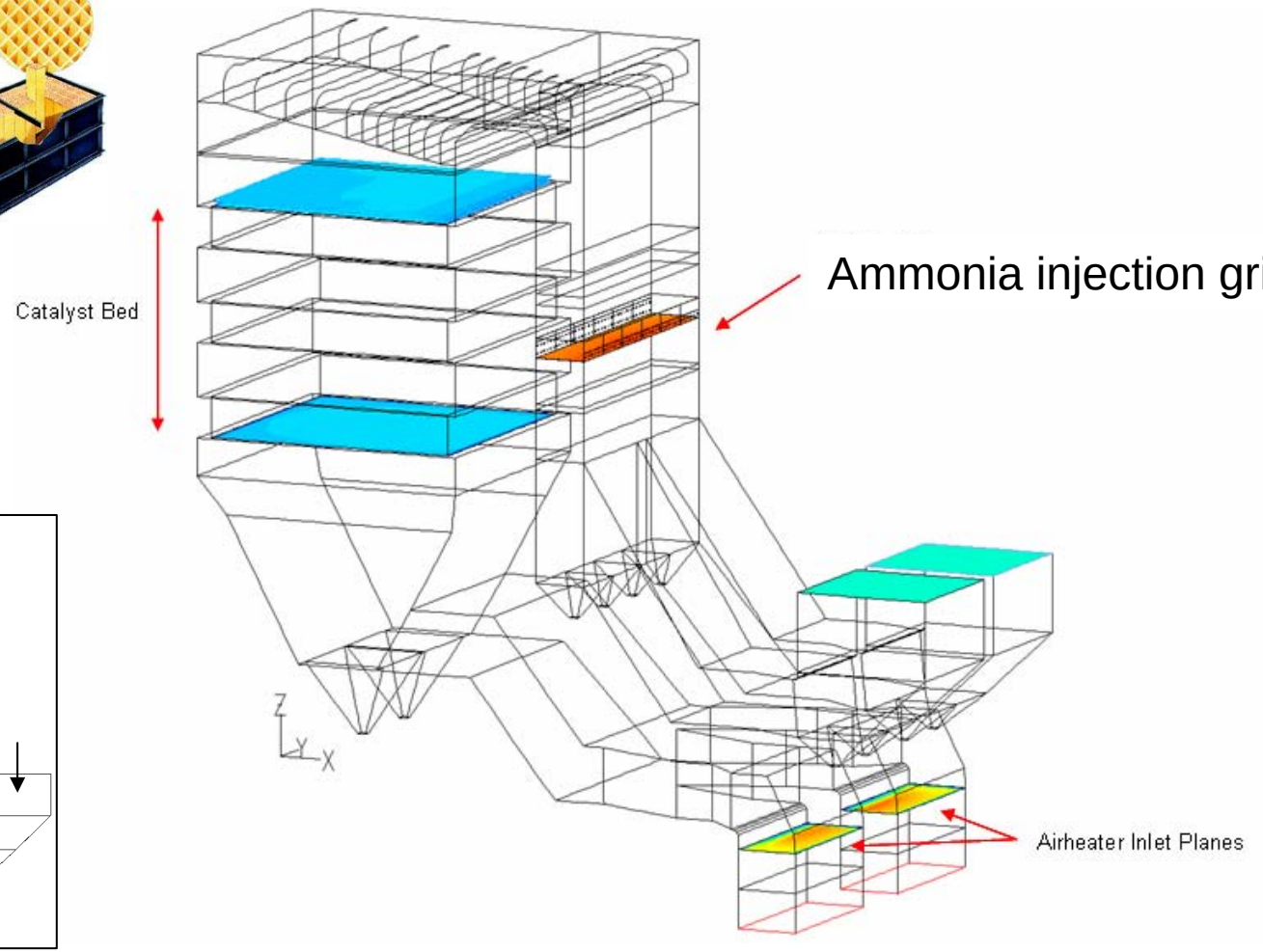


Excess NH_3 called ammonia slip

Typical SCR Design







Ammonia Slip Issues

- Formation of ammonium salts on air preheater and other downstream surfaces

Ammonium bisulfate on preheater

- Ammonium chloride plume from the stack and gaseous ammonia emissions
- Ammonia odor in fly ash
- Costs of ammonia reagent

Process Control

- Fundamentals
  - It starts with the Analysis
  - Requirements?
    - Specific
    - Timely
    - Appropriate
    - Maintainable
- SCR Control
  - Problem : NO_X based upon NH_3 addition
  - Solution : Appropriate NO_X monitor

SCR Control - Analysis

- Extractive NO_X
  - Sample transport time
  - Expensive installation – probe + heated sample line
  - Expensive maintenance – CLA
- In-situ NO_X
  - Instantaneous measurement
  - Flange-mounted installation
  - Minimal maintenance

SCR Control – Control scheme

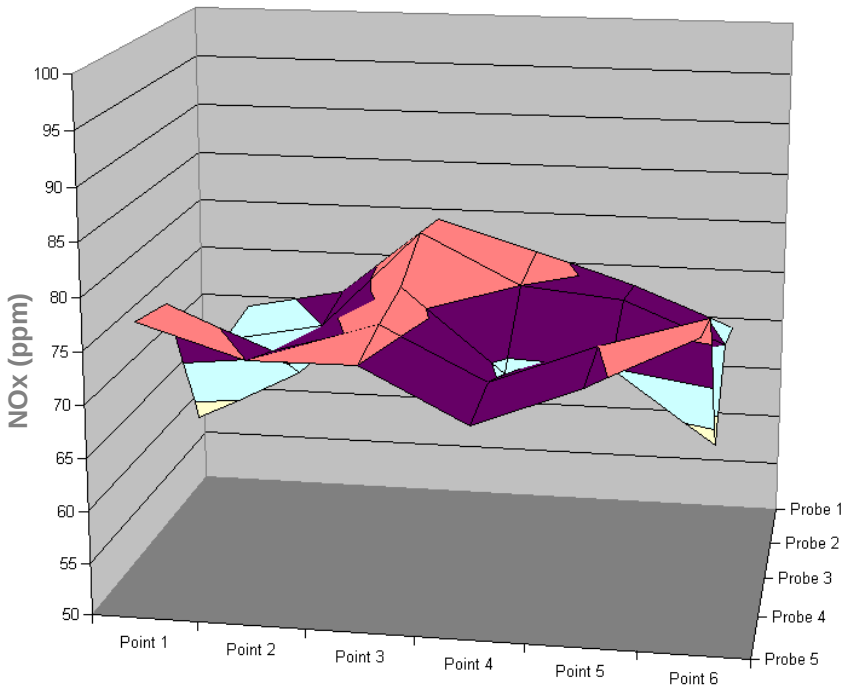
- Feed-forward
  - Before the catalyst
  - Direct correlation NO_X vs NH_3
  - Variable is incoming NO_X
- Feed-back
  - After catalyst
  - Function of NO_X / NH_3 reaction
  - Trims Feed-forward flow setting

Monitoring Catalyst Performance

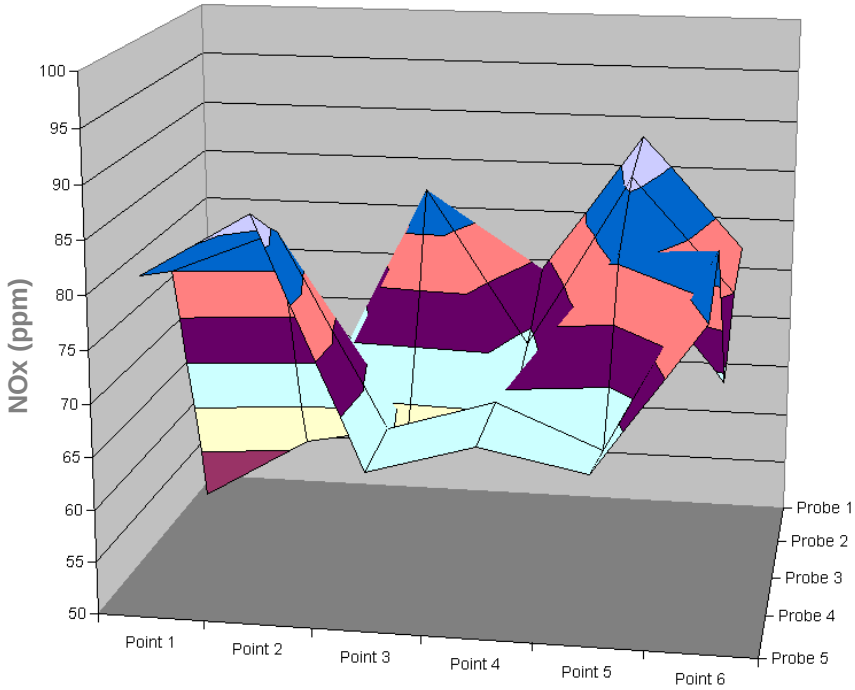
- Catalyst maintenance – periodic sampling, cleaning
- Catalyst management – when to replace or refurbish, planned outages
- Maintain good ammonia distribution through tuning

SCR Performance Non-uniformity

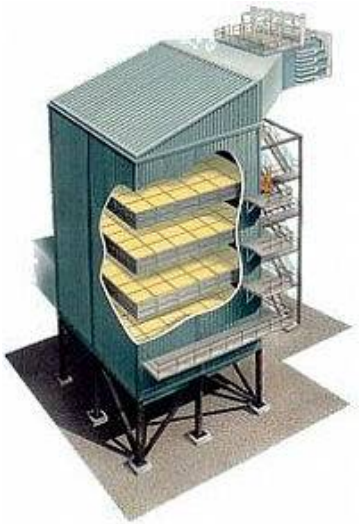
NOx Reference

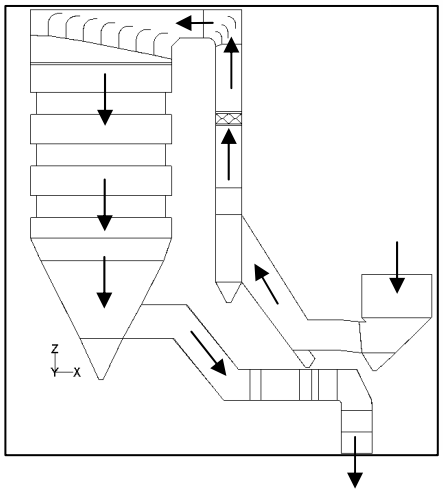


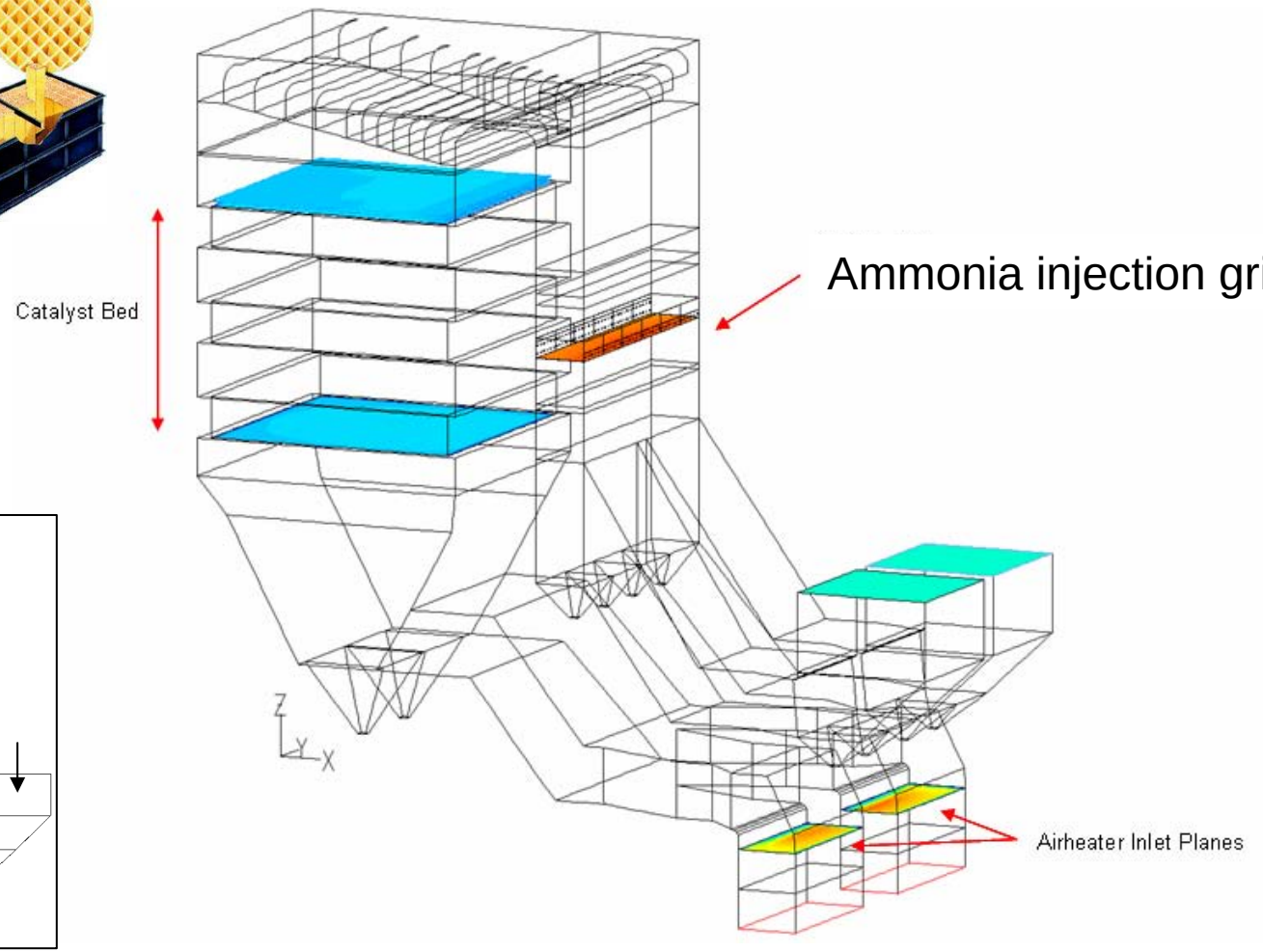
1 Year Later



Typical SCR Design

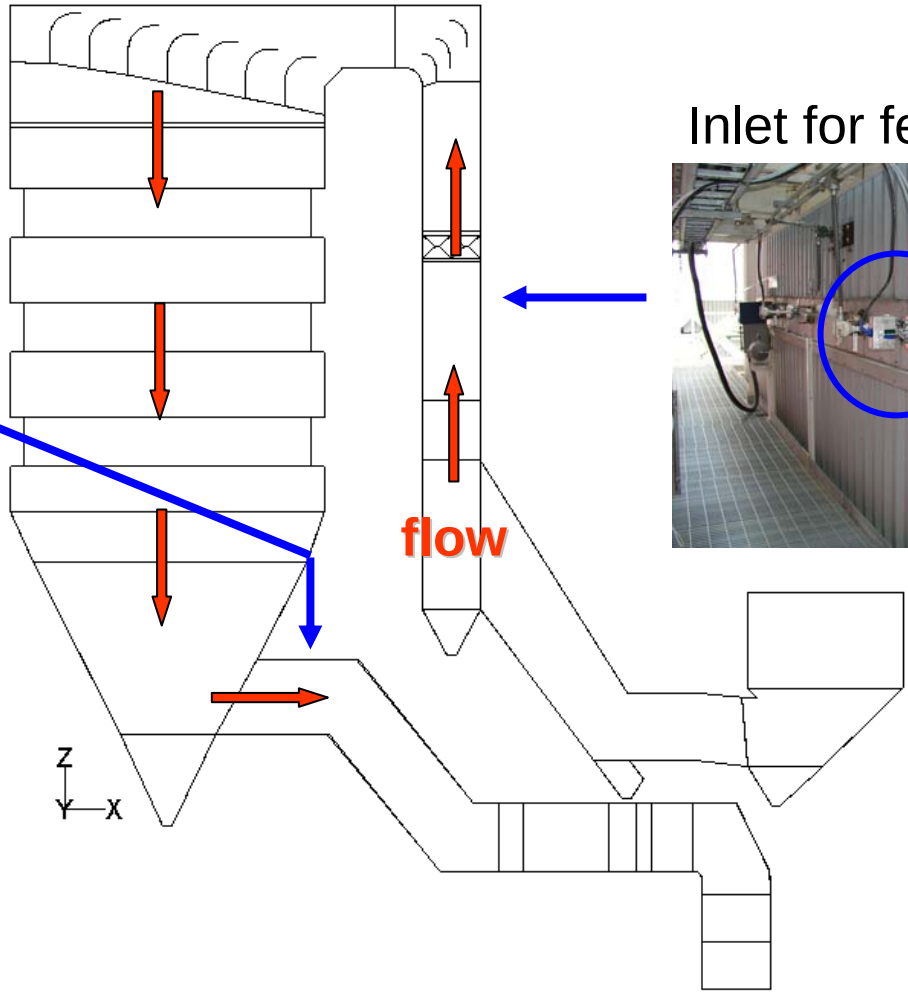






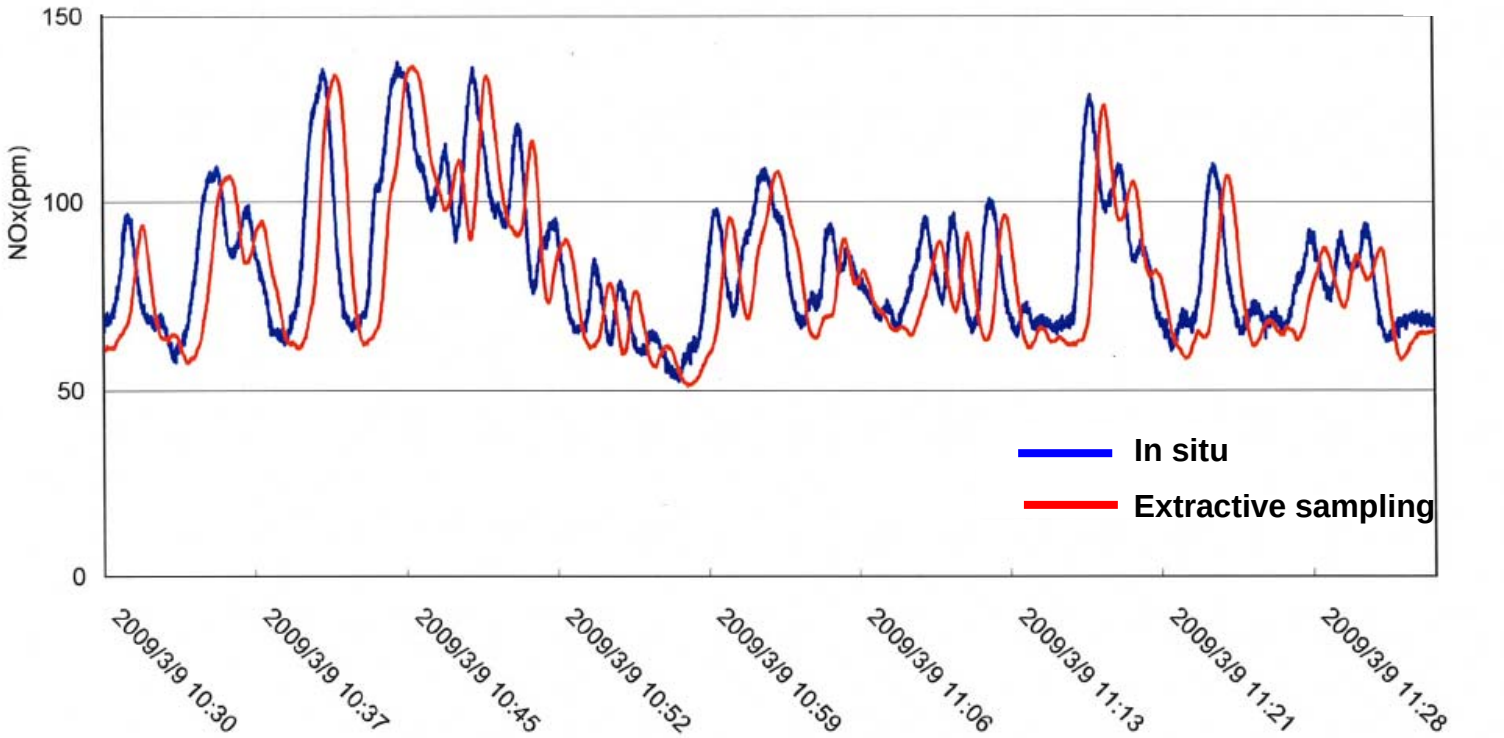
Probe Locations

Outlet for trim



Inlet for feed forward

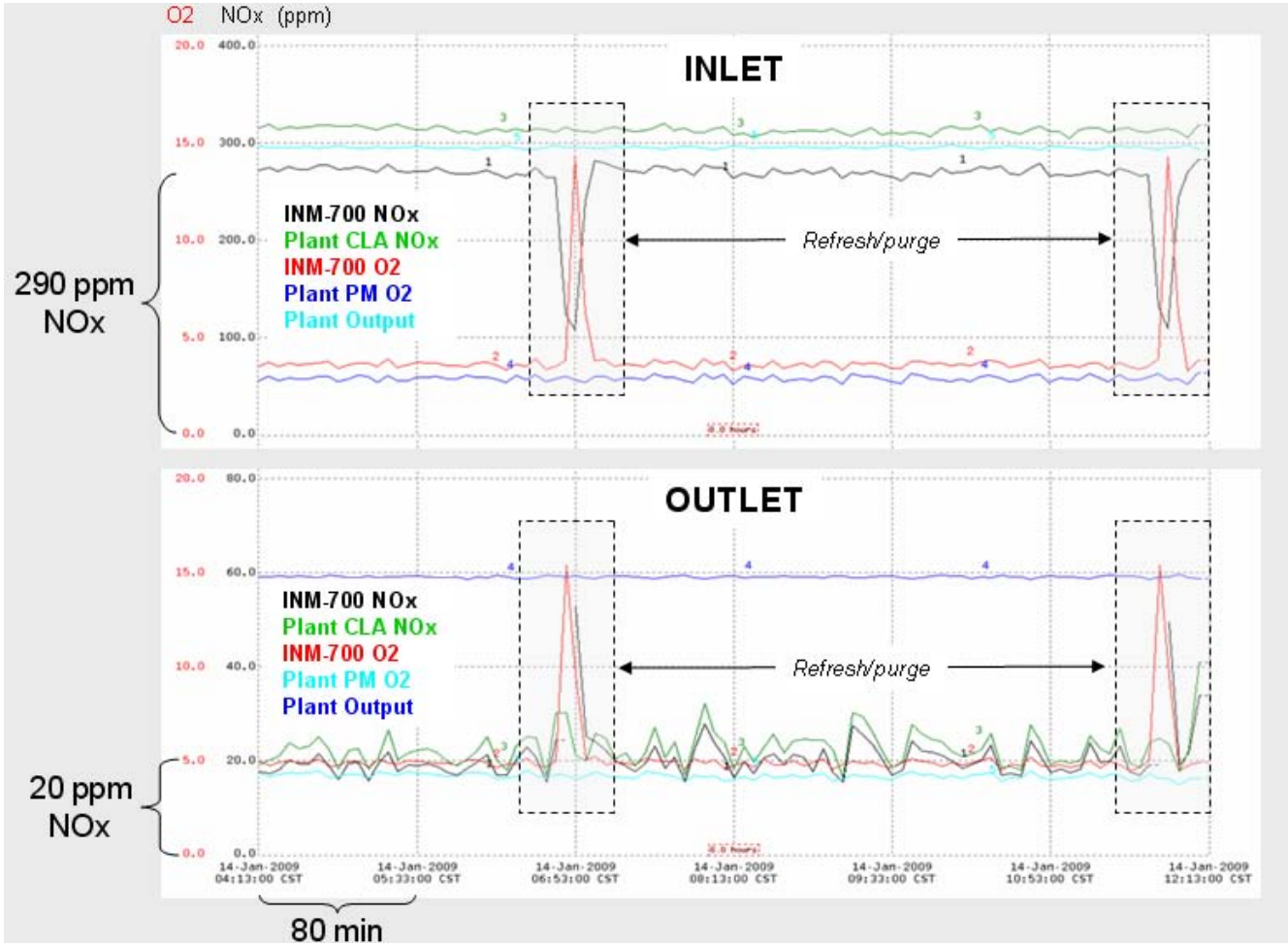
System Response Comparison



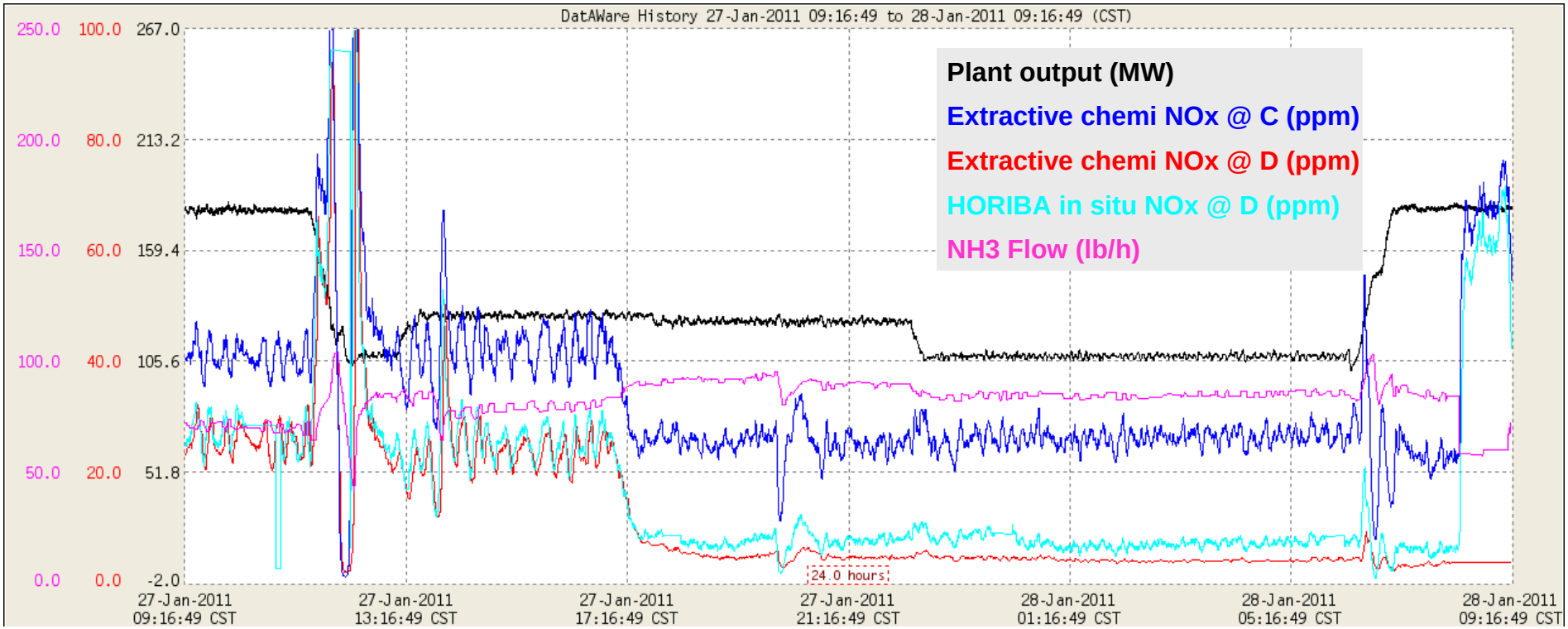
In situ is ~40 sec faster in this example*

*waste incinerator, Japan

SCR Inlet & Outlet Data

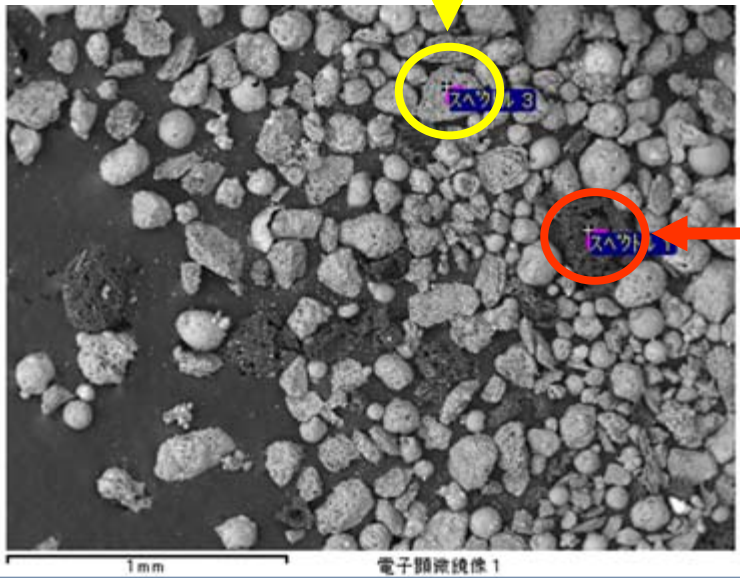


Tracking Recent Upset Event



Dust Analysis: x-ray fluorescence (XRF)

O, Al, Si; 200 μm

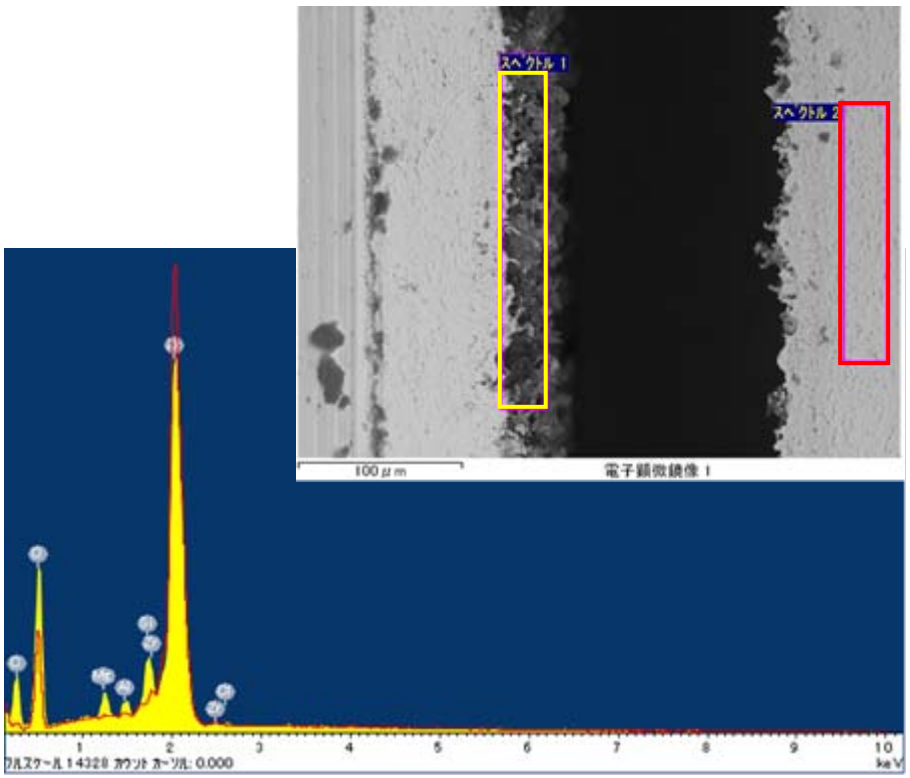


C; 300 μm

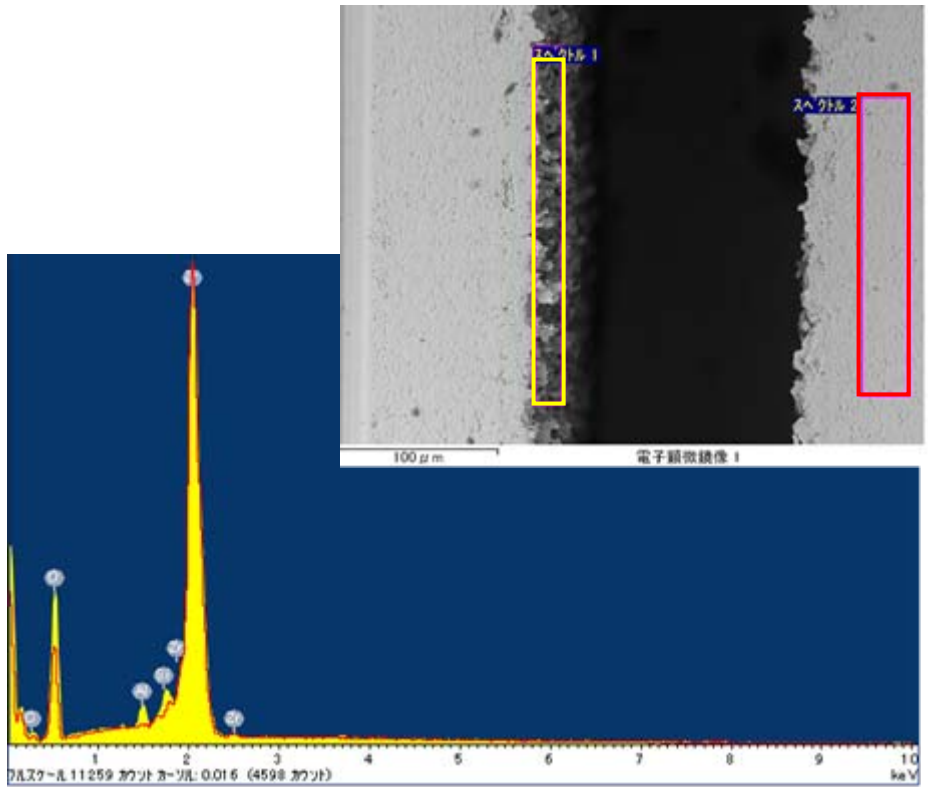
No ammonium bisulfate

Post Test Sensor Analysis: XRF

New Sensor



Sensor from Unit 6



No signs of poisoning or contamination

Summary

- New approach to NO_x developed, tested, and manufactured
  - Additional feature of simultaneous O_2
- In situ, low cost, low maintenance
- Integrated on coal plant SCR applications
- Demonstrated
  - High stability, accuracy, and responsivity
- Next steps
  - Quantify cross sensitivity
  - Set up for active control

Thank you