REINHOLD ENVIRONMENTAL Ltd.

2018 NOx-Combustion Round Table & Expo Presentation

February 19-20, 2018, in St. Louis, MO / Hosted by Dynegy

SCR O&M 101

Ronald L Richard
Senior Consultant
RE Consulting

Selective Catalytic Reduction

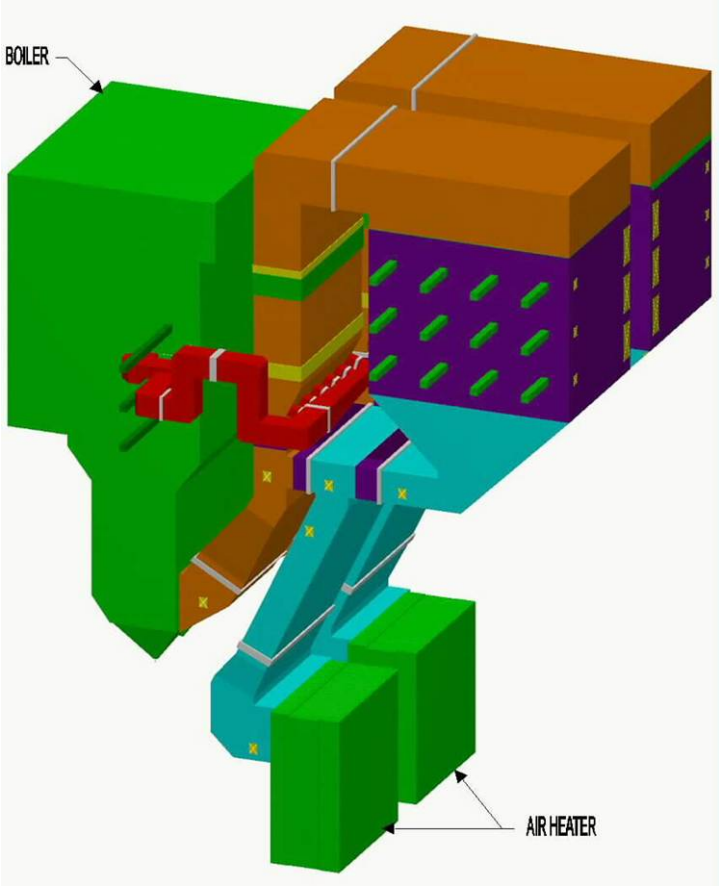
Chemical Reactions in SCR

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$
$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$
$$NO + NO_2 + 2NH_3 \rightarrow 2N_2 + 3H_2O$$

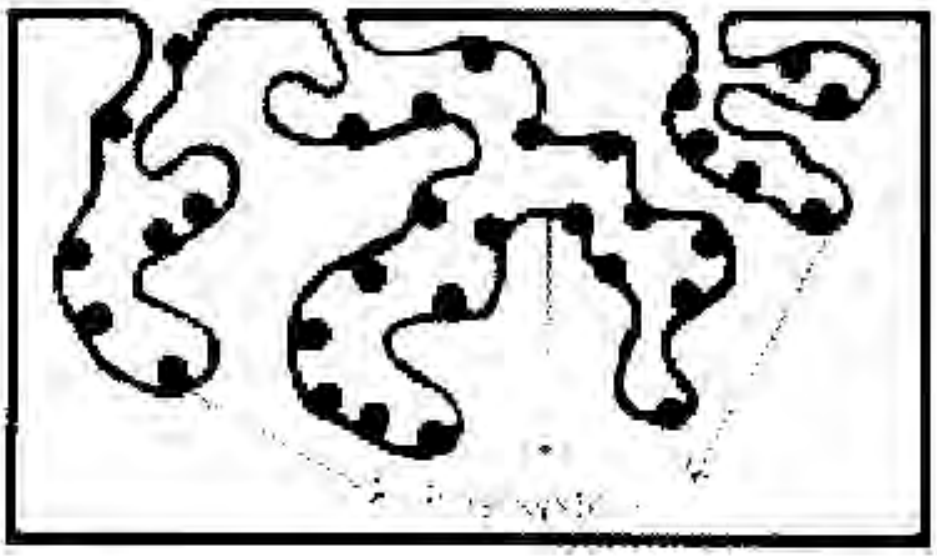
With several secondary reactions:

$$2SO_2 + O_2 \rightarrow 2SO_3$$
$$2NH_3 + SO_3 + H_2O \rightarrow (NH_4)_2SO_4$$
$$NH_3 + SO_3 + H_2O \rightarrow NH_4HSO_4$$

Typical SCR Layout



The SCR Catalyst



Catalyst Poisons

- Arsenic
- Phosphorus
- Sodium
- Lead
- HCl

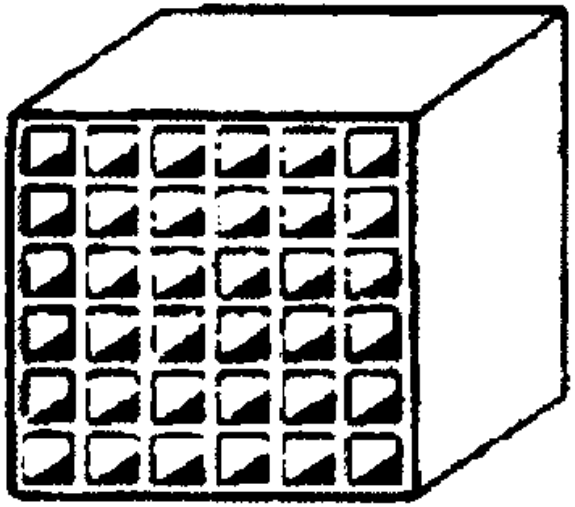
Temporary Ammonia Blinding

- If one operates below the minimum catalyst operating temperature, ammonium sulfate and ammonium bisulfate can plug the catalyst pores. Once one operates above this temperature these compounds can bake out and the pores will be reopened.

Catalyst Masking (PRB Coal)

- The calcium oxide in the PRB coal reacts with SO_2 and SO_3 to form a layer on the catalyst surface which blocks the pores.

Two Types of SCR Catalyst



Honeycomb

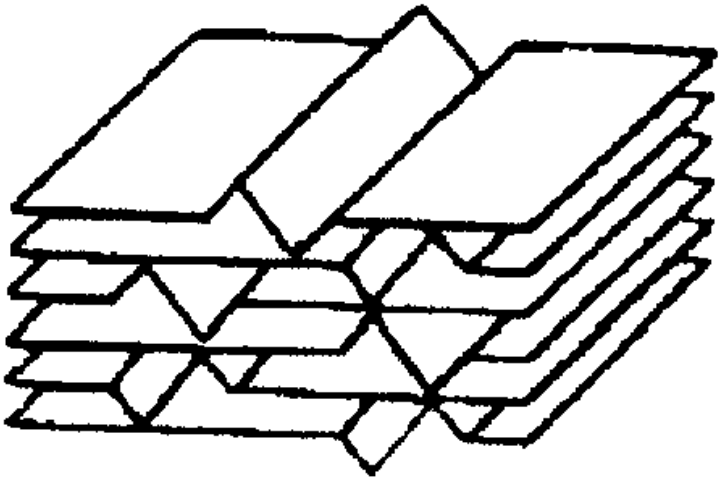
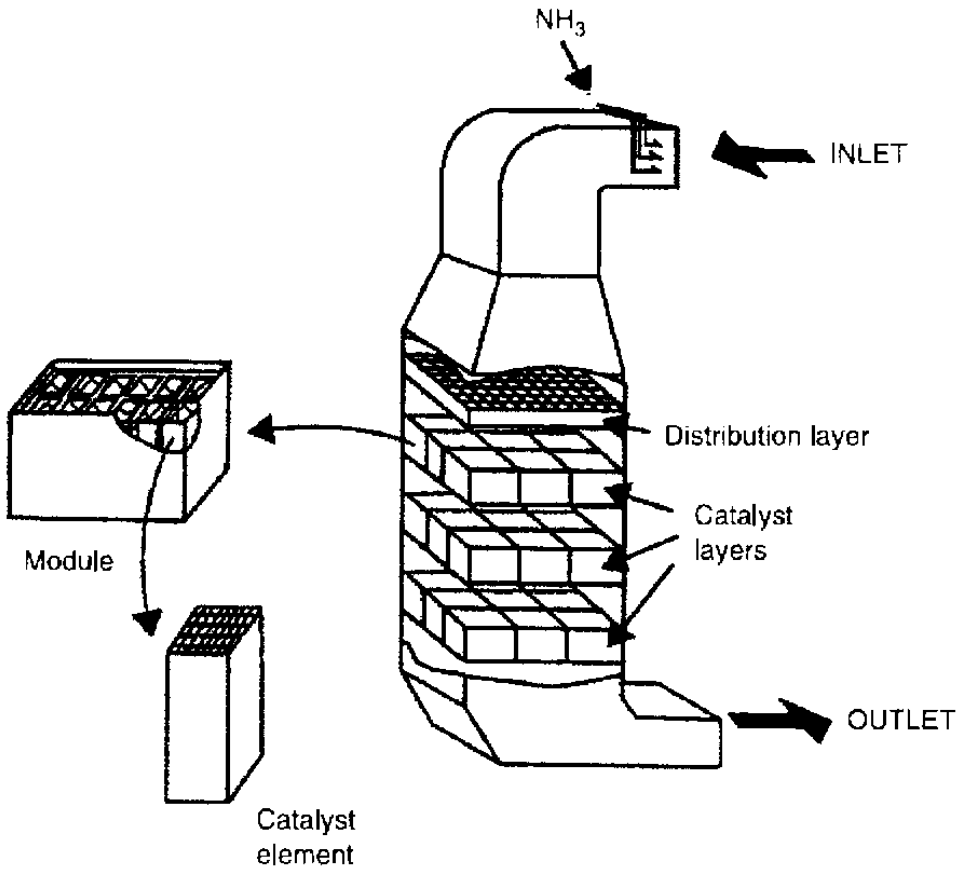


Plate type

How Catalyst Goes In SCR



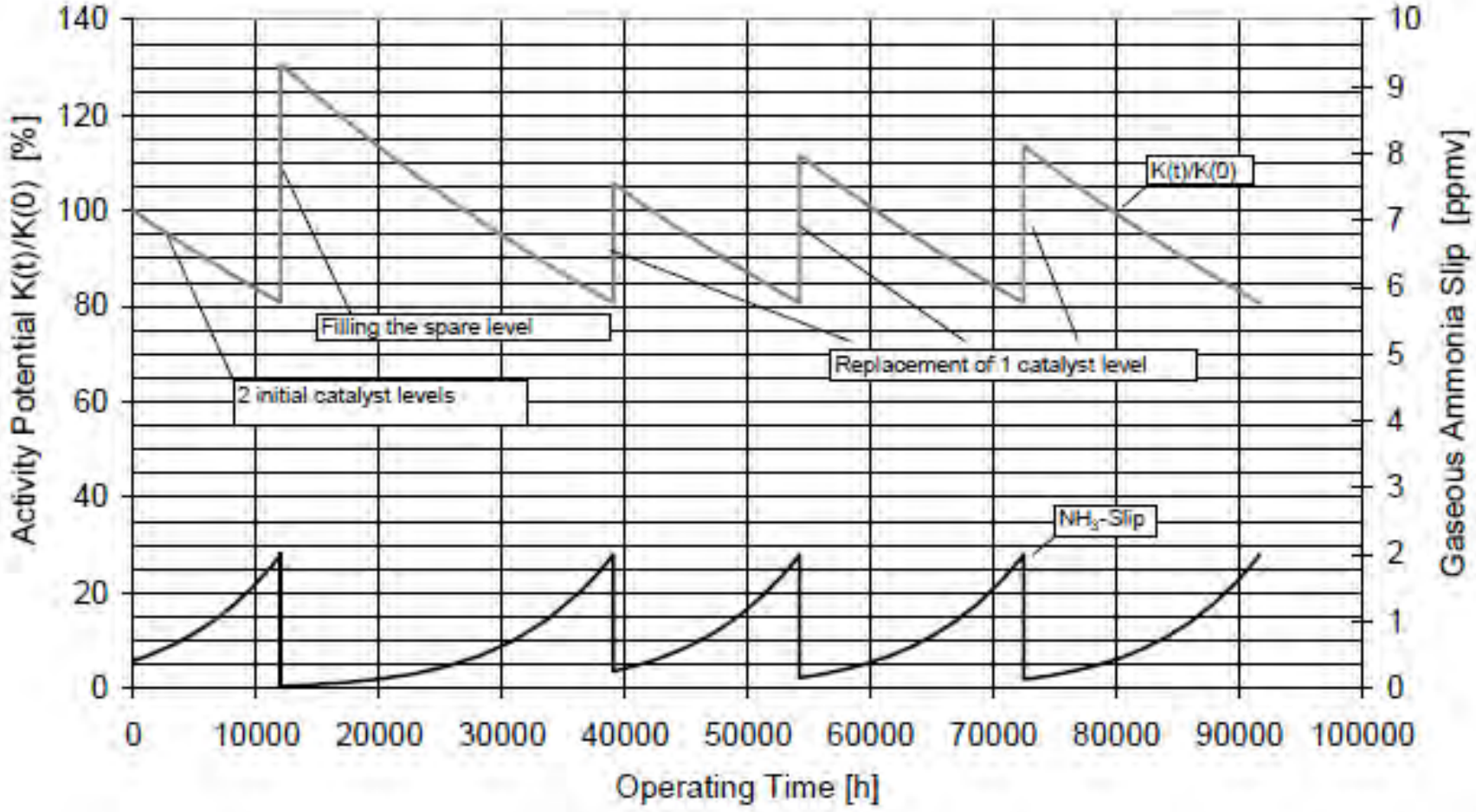
Hoisting Catalyst

Pushing it into SCR

Moving it into Position

Catalyst Sampling

- The more catalyst sampling points that can be plotted on the catalyst activity graph, the more accurate the catalyst replacement needs can be predicted.
- Catalyst may have to be changed early in order to take advantage of a longer planned outage.


Activity Potential K(t)/K(0) [%]
Gaseous Ammonia Slip [ppmv]
Operating Time [h]
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
0
20
40
60
80
100
120
140
0
1
2
3
4
5
6
7
8
9
10
K(t)/K(0)
Filling the spare level
Replacement of 1 catalyst level
2 initial catalyst levels
NH3-Slip

What if you don't sample?

- If one doesn't have enough data points to make a good catalyst life prediction, one may have an unpleasant surprise that will either:
  - Cause a several week unplanned outage to replace catalyst or
  - Cause operating the unit for an extended time with higher than allowed NOx emissions or
  - Cause operating the unit for an extended time at higher than desired ammonia slip

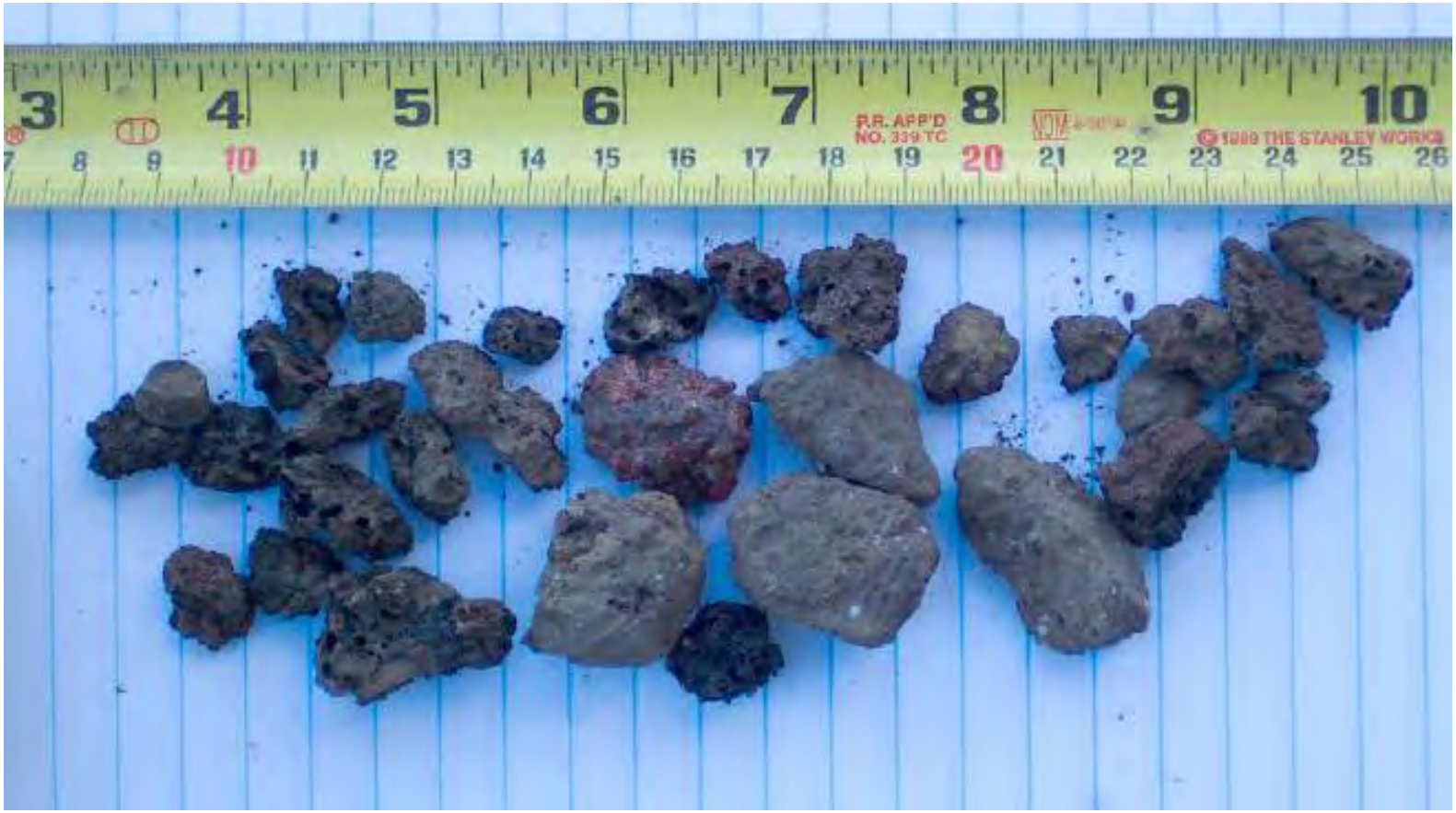
Sampling Plate Catalyst

Source: Argillon

Honeycomb Test Element

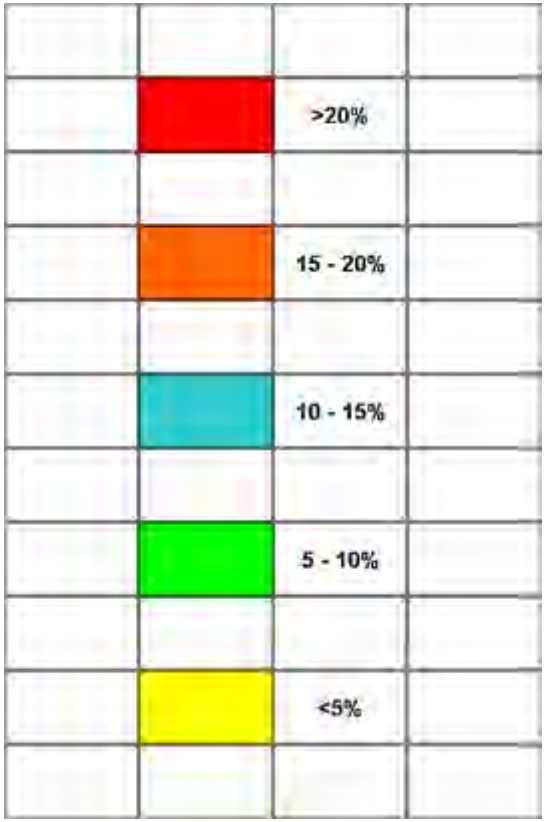
Problems Experienced

LPA (Popcorn Ash)



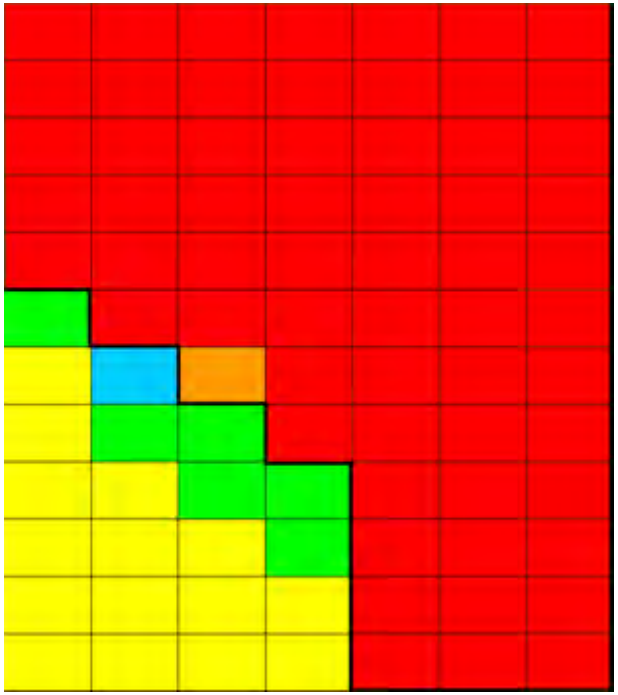
Dirty Catalyst Station X

Color Codes on Diagrams
% Blockage

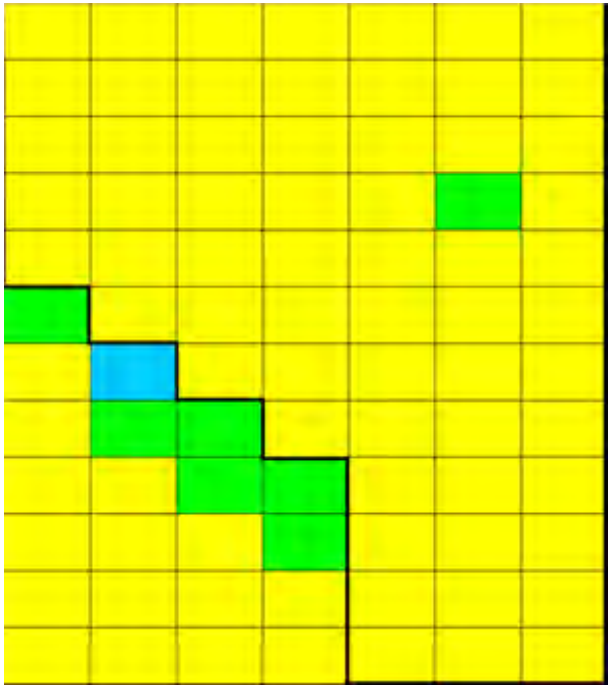


Station X Top Layer

Before Cleaning

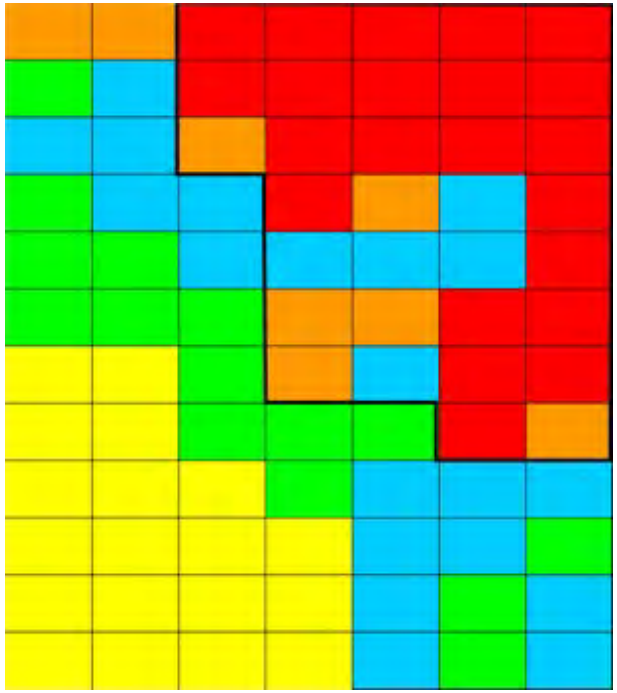


After Cleaning

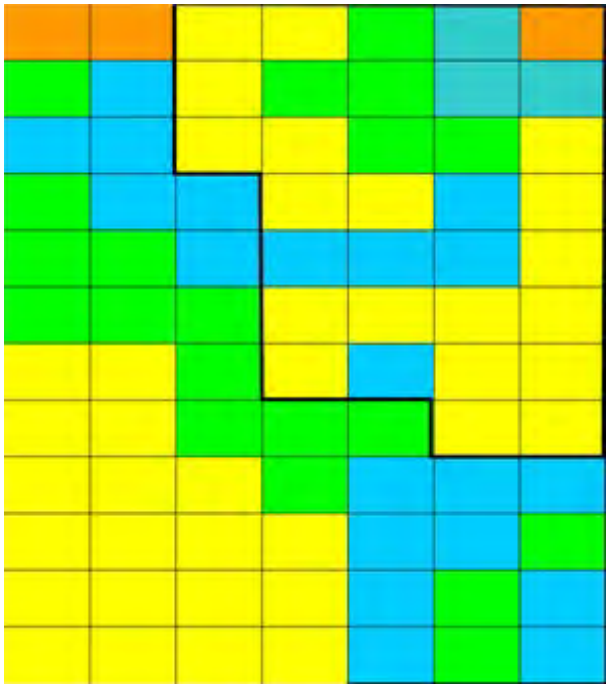


Station X Middle Layer

Before Cleaning

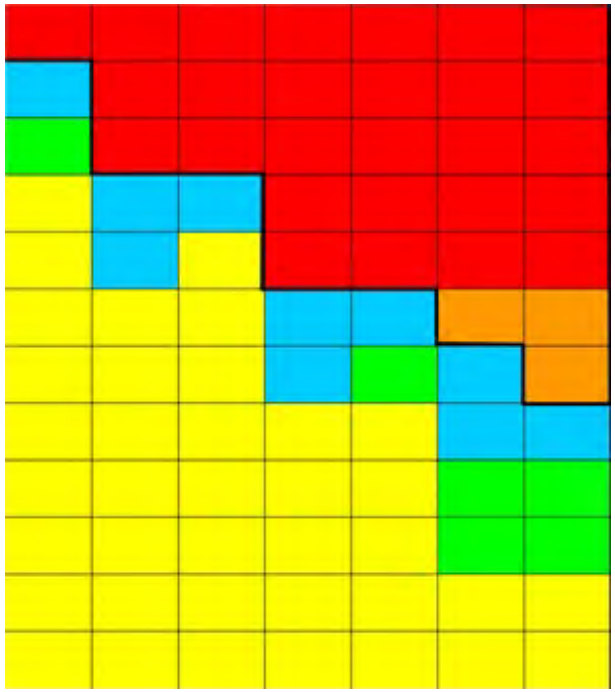


After Cleaning

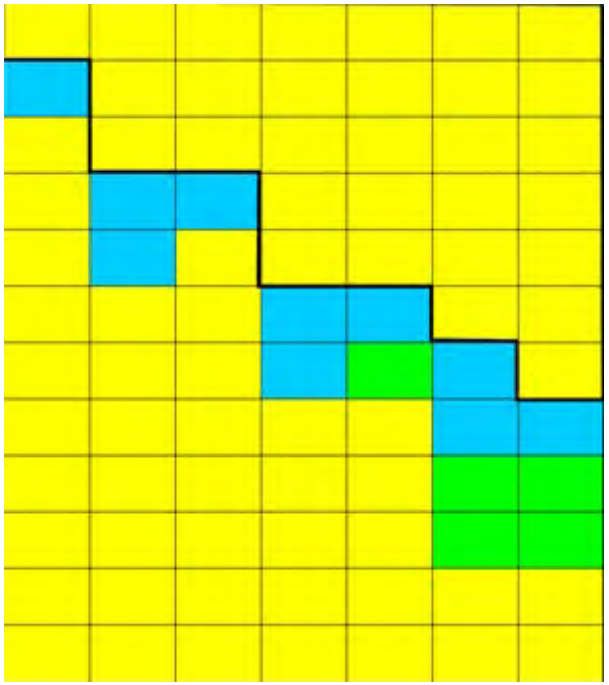


Station X Bottom Layer

Before Cleaning



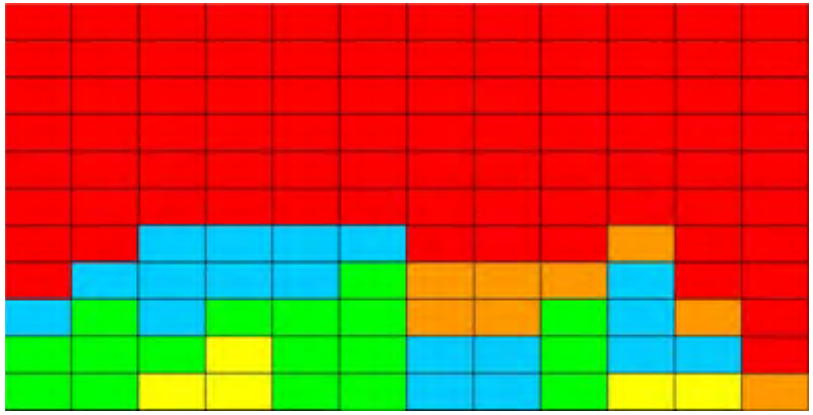
After Cleaning



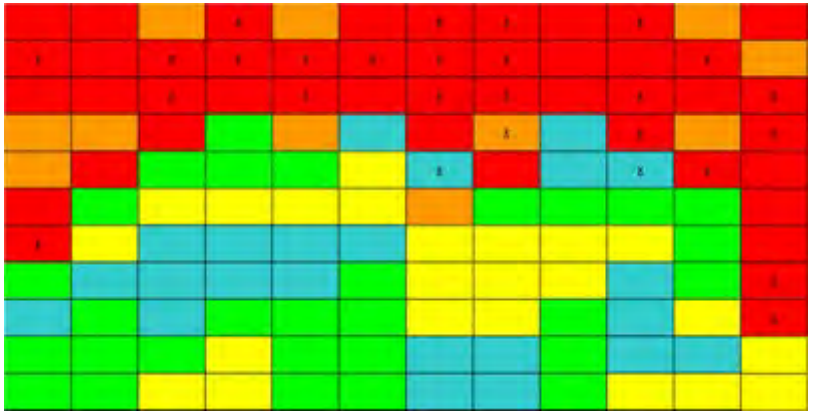
Dirty Catalyst Station Y

Station Y Top Layer

Before Cleaning

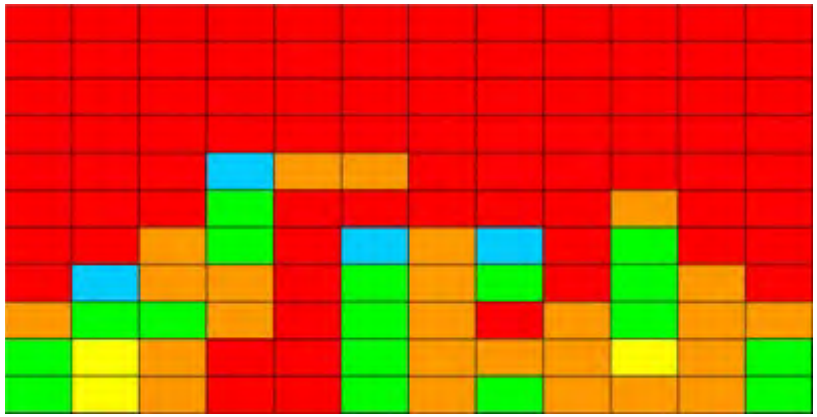


After Cleaning

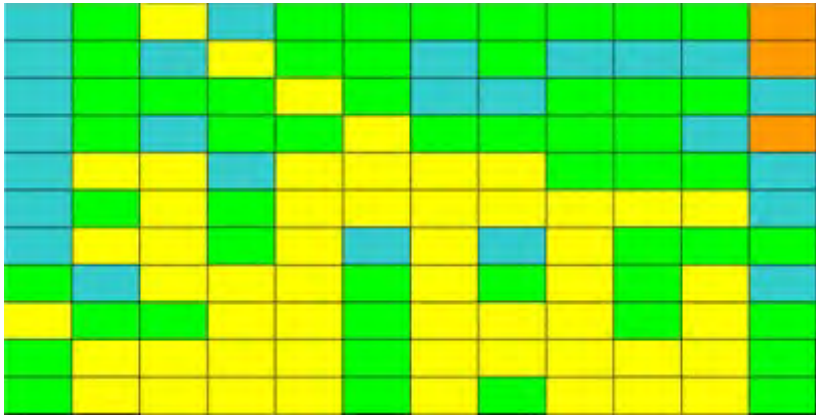


Station Y Middle Layer

Before Cleaning

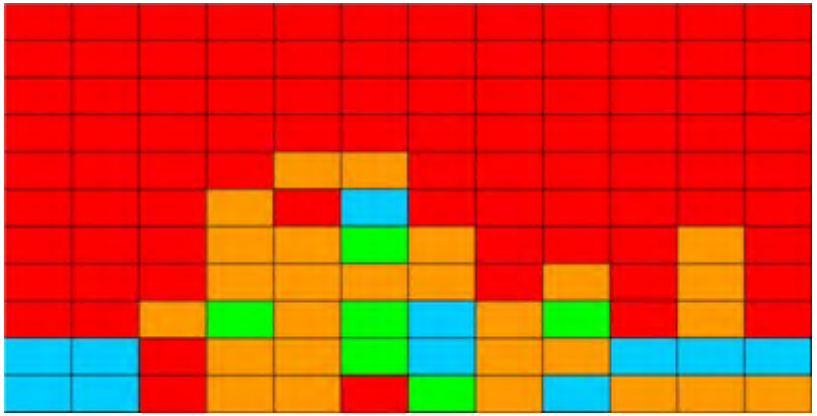


After Cleaning

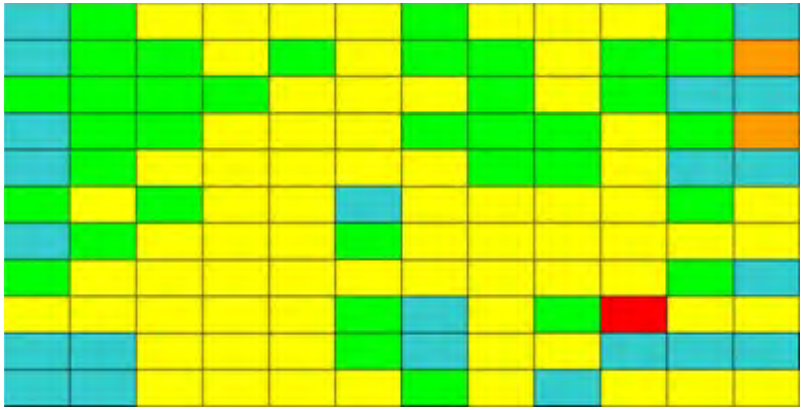


Station Y Bottom Layer

Before Cleaning



After Cleaning



One Vendor's LPA Screen

Rake Type Soot Blower

Sonic Horn

Economizer Leak

Ash Issues

- One won't have as much opportunity to remove ash deposits off catalyst layers. The soot blower operation must be optimized.
- If there are any signs of LPA, then LPA screens will need to be installed or repaired.

Ash Issues

- Any signs of ash build-up in ducts and on turning vanes may be signs of poor gas distribution. One won't have the opportunity to remove ash deposits.
  - Revisit the original flow model results.
  - Take flow data to verify if anything has changed.
  - Do CFD analysis to identify solutions.

Ash Deposits on Vanes

Unburned Carbon

- One needs to minimize the amount of unburned carbon that accumulates on the catalyst since there will be less opportunity to remove it.
- Large accumulations can lead to smoldering deposits or catalyst fires.

Charred Deposit in Catalyst

Ammonia Injection

Ammonia Injection Nozzles

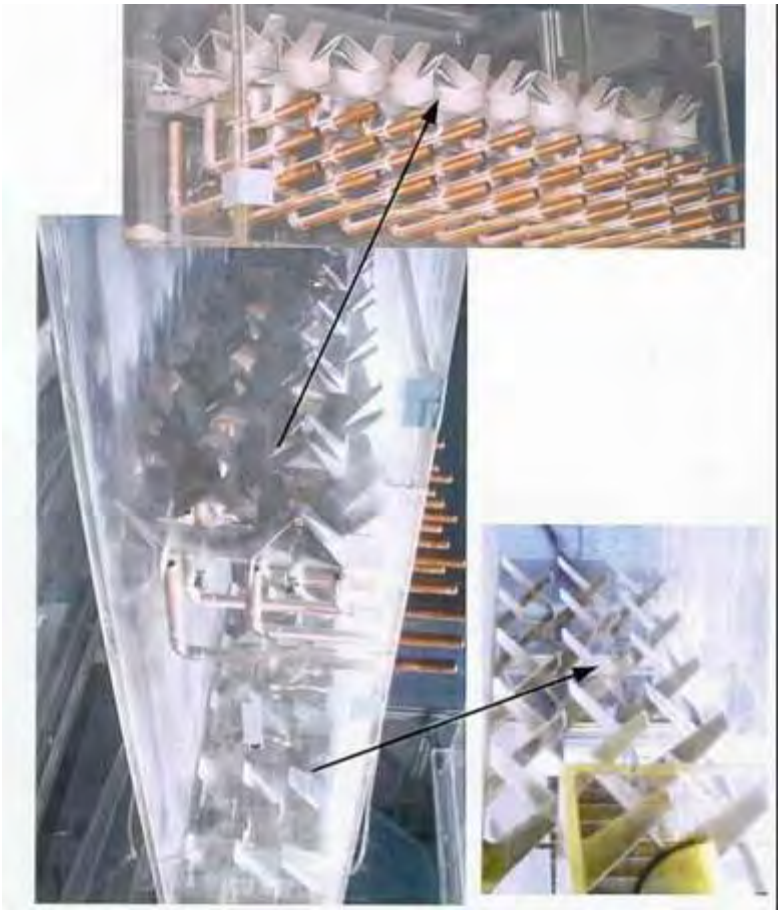
Ammonia Injection Nozzles

Ammonia Injection Piping

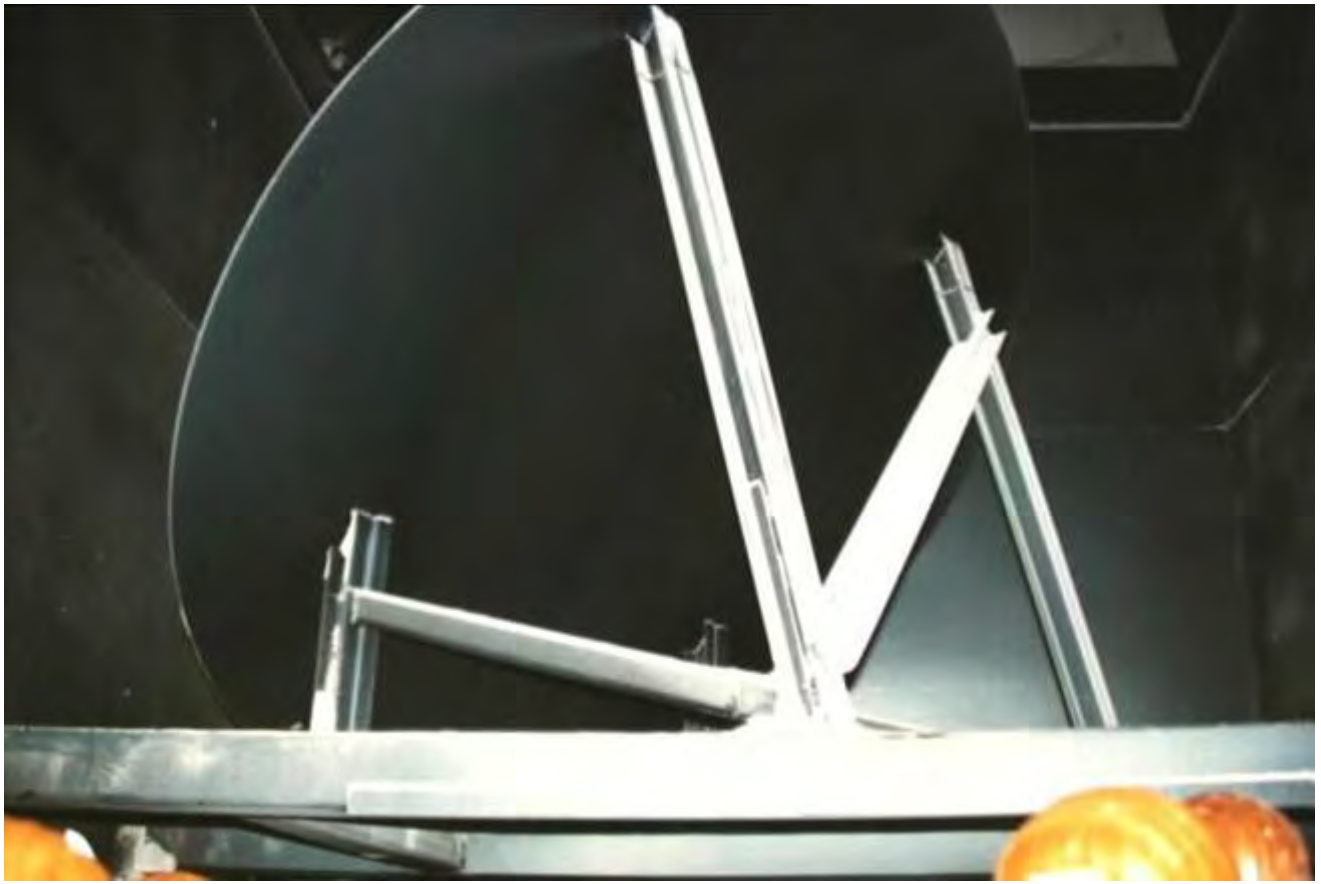
Static Mixer Ammonia Feed

Static Mixer Injector

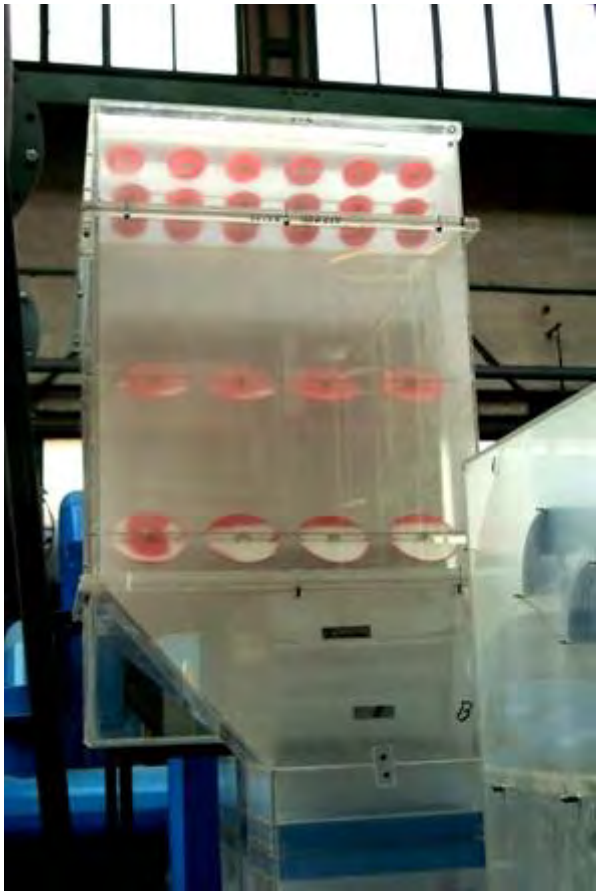
Static Mixer Ammonia Feed



Delta Wing Ammonia Feed

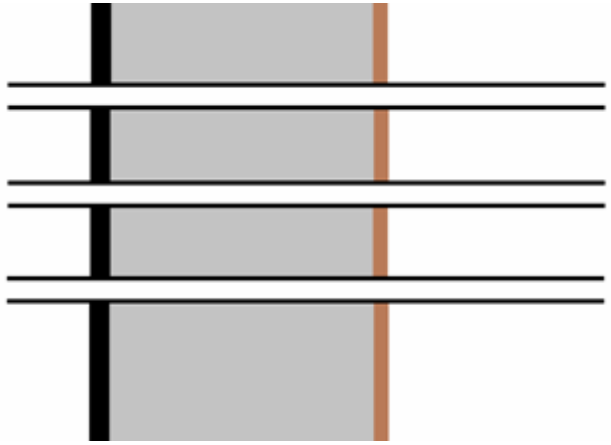


Delta Wing Ammonia Feed



Sampling Grid

- Check that the sample lines are firmly attached and terminate in the correct location
- Look for holes in the lines
- The sample lines tend to plug or corrode holes through the tube wall at the hot/cold interface



Questions?