Mercury oxidation across SCR catalyst

RESEARCH | TECHNOLOGY | CATALYSTS

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At McIlvaine Company Hot Topic Hour

HALDOR TOPSØE

Outline

- Introduction
- Kinetic study of mercury oxidation across SCR catalyst
- Predictions on mercury oxidation across SCR reactors in full-scale

Hg^0 oxidation and the SCR

- Mercury is oxidized by

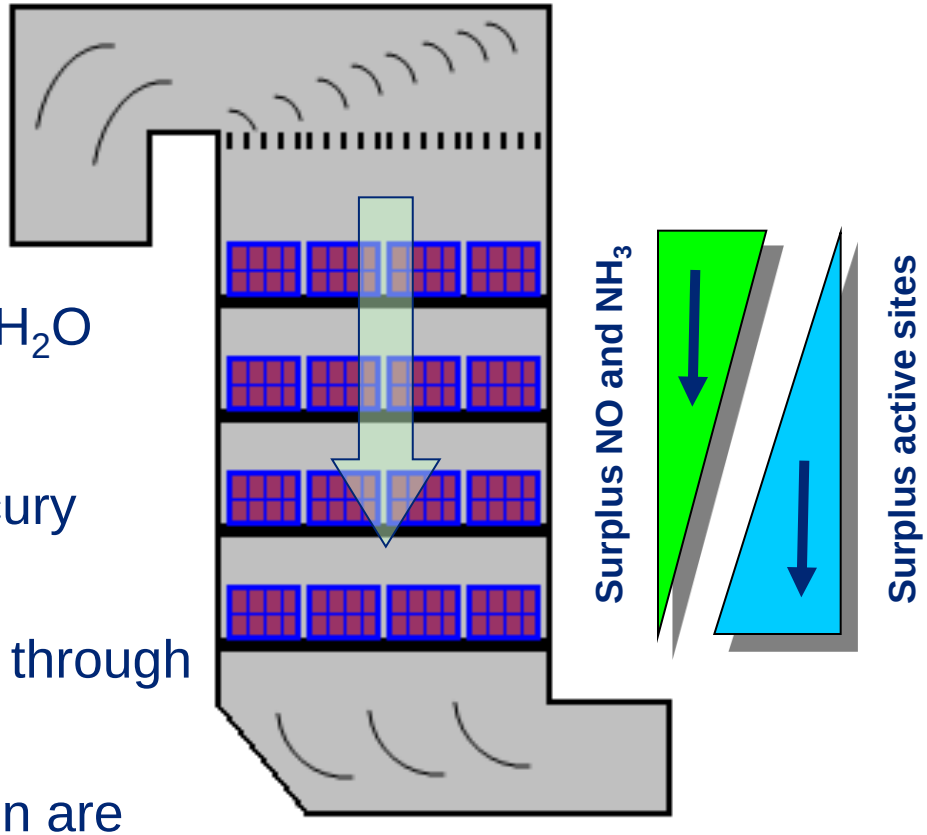
  halogens in the flue gas

  $Hg^0 + 2\ HCl + 1/2\ O_2 = HgCl_2 + H_2O$

- SCR reactors enhance the mercury oxidation in flue gases:

  Catalyst activity increases down through the layers of the SCR reactor

  => DeNOx and mercury oxidation are competing reactions on the catalyst surface



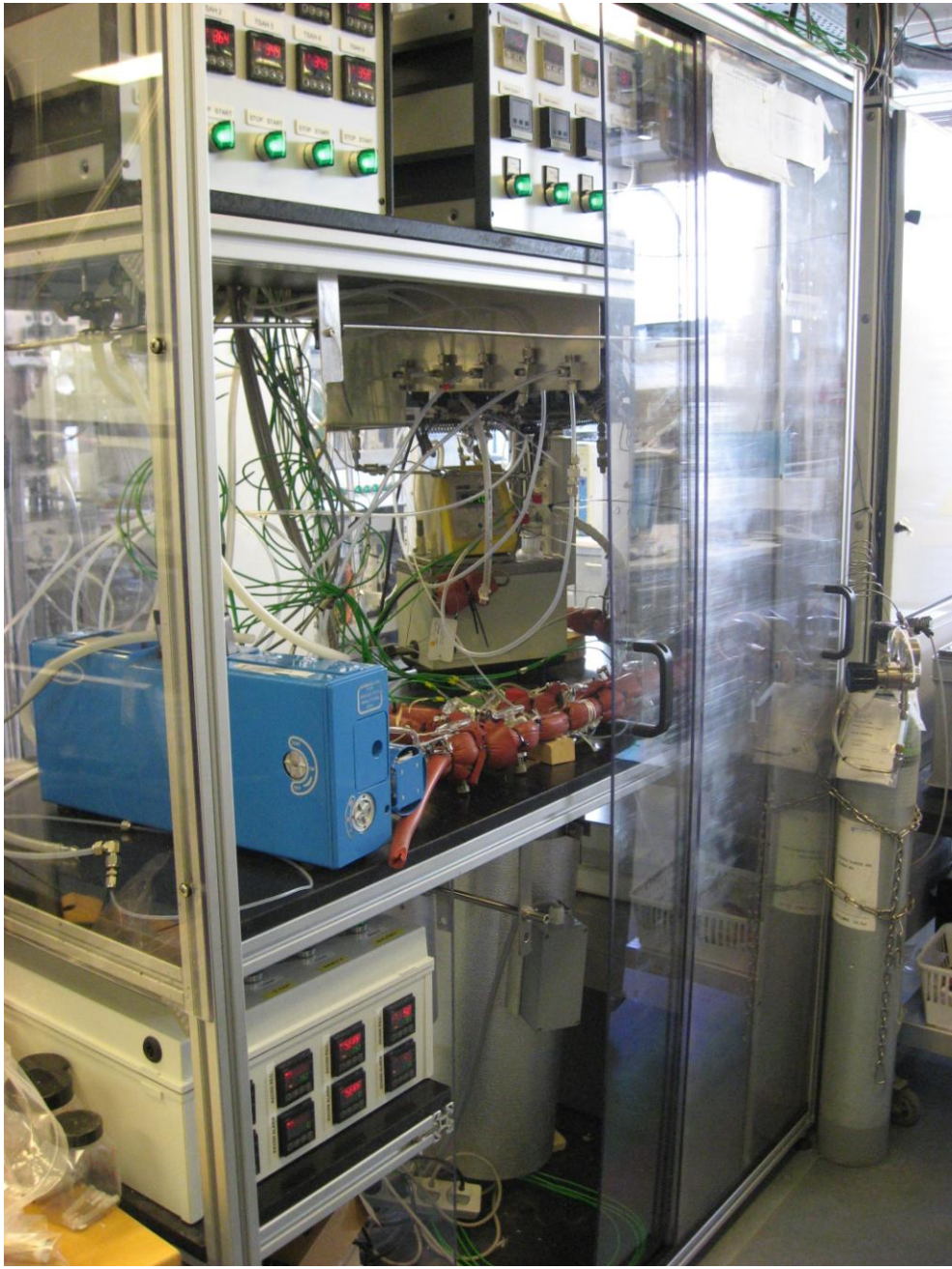
Kinetic study of Hg^0 oxidation

Laboratory setup for testing commercial SCR catalyst:

- 1-4 monolithic channels of catalyst of length L=4-50 cm
- Gas matrix:

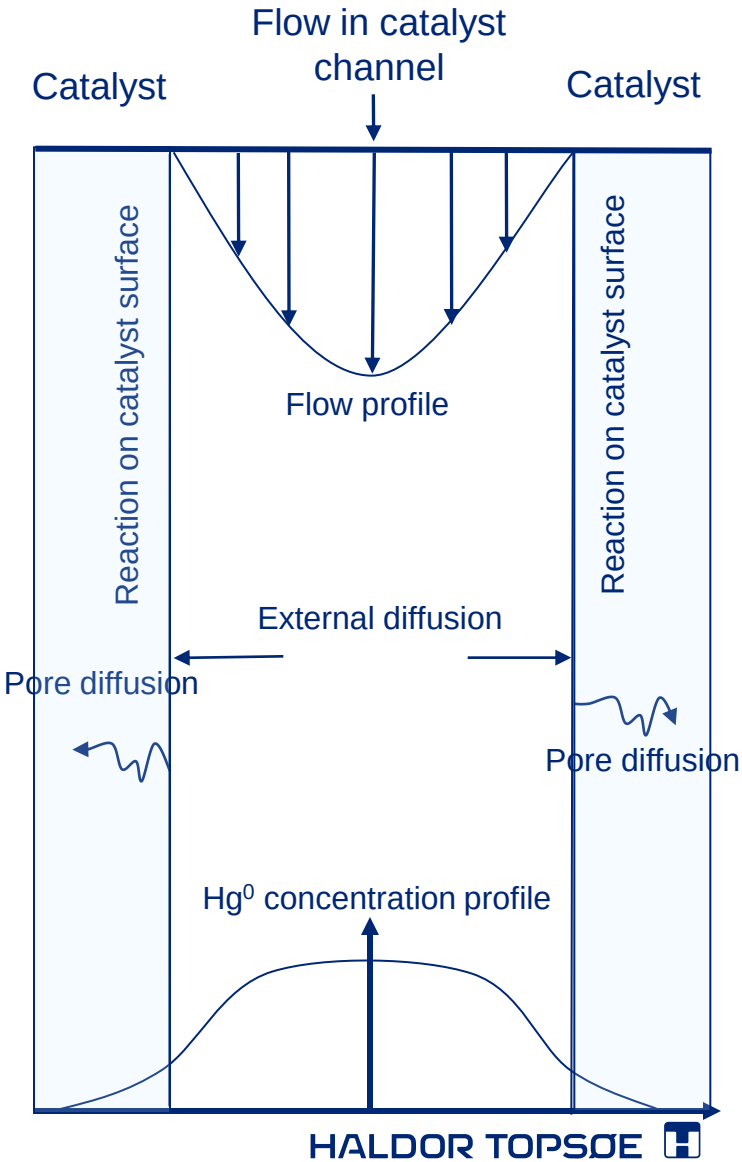
  Hg^0, HCl, O_2, H_2O, N_2, SO_2, NO, NO_2 and NH_3

- T=250-450ºC (480-840ºF)



The kinetic regimes: Mass transfer and reaction

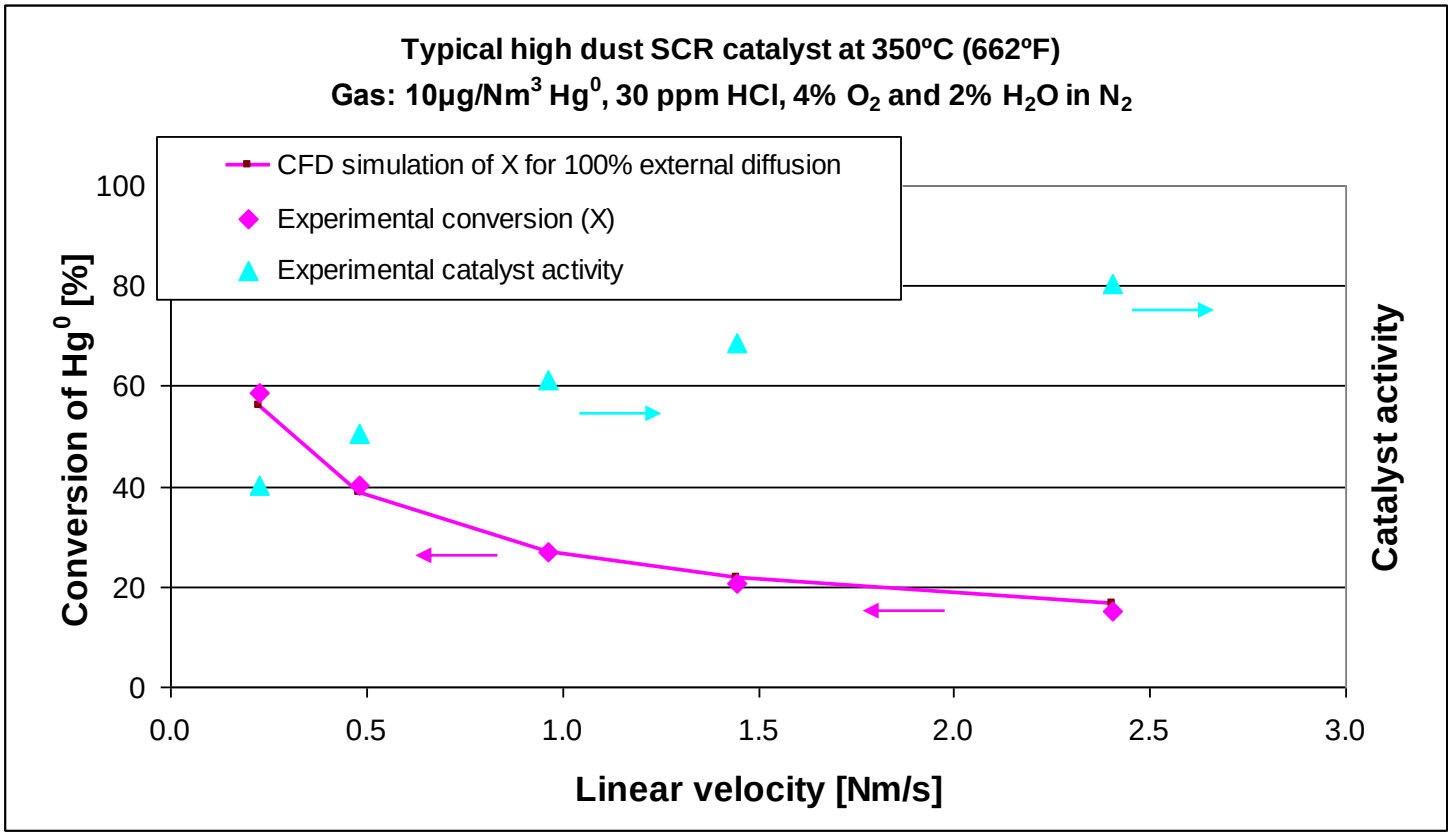
- Mass transfer
  - 'External diffusion' of reactants from the bulk gas to the catalyst surface
  - 'Internal diffusion' of reactants in the catalyst pores to the internal surfaces
- Reaction
  - On the external and internal surface of the catalyst material



Study of the external diffusion

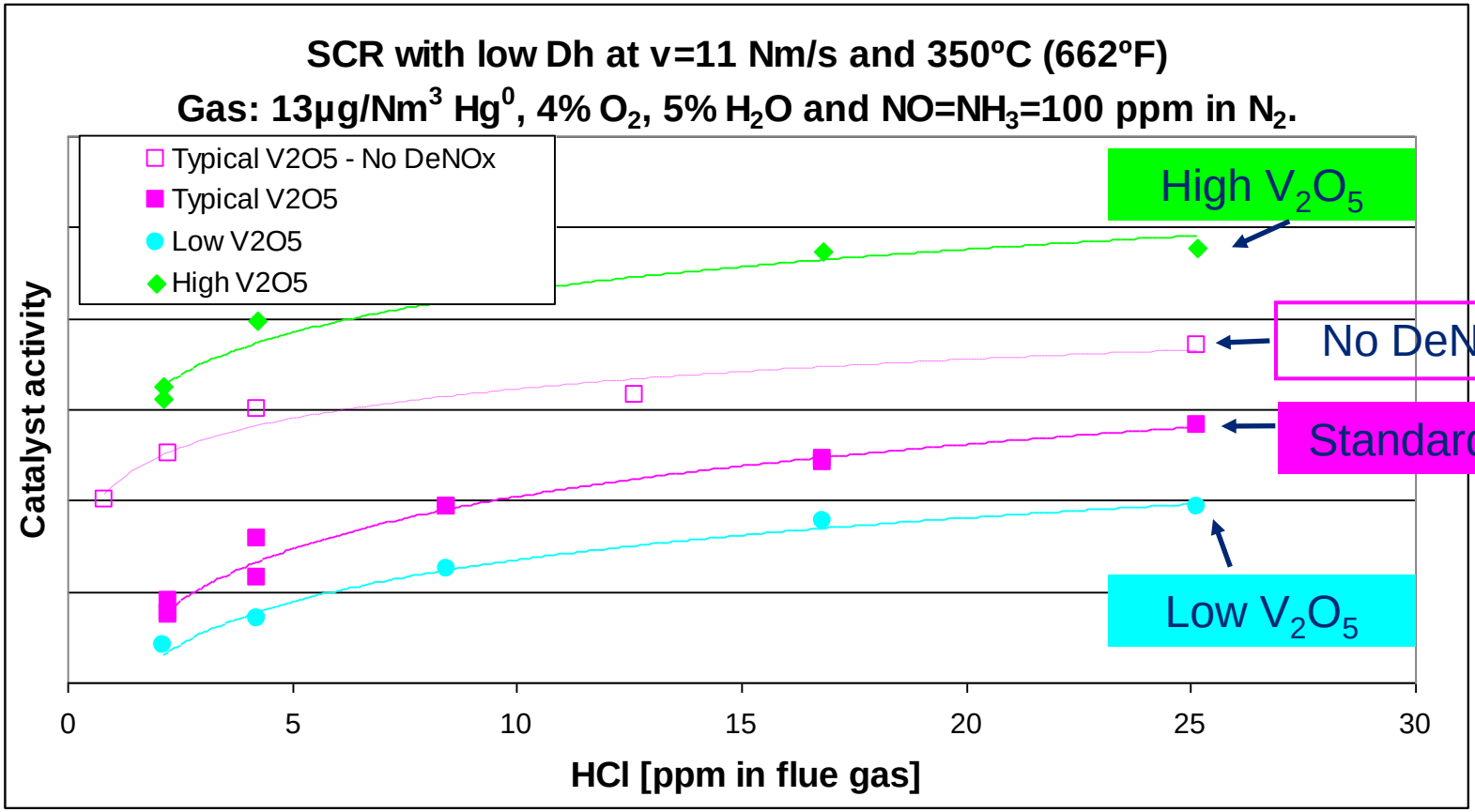
- Measurement of Hg^0-oxidation in favourable gas matrix *(high HCl, no DeNOx, low H_2O)*

Example set of data:

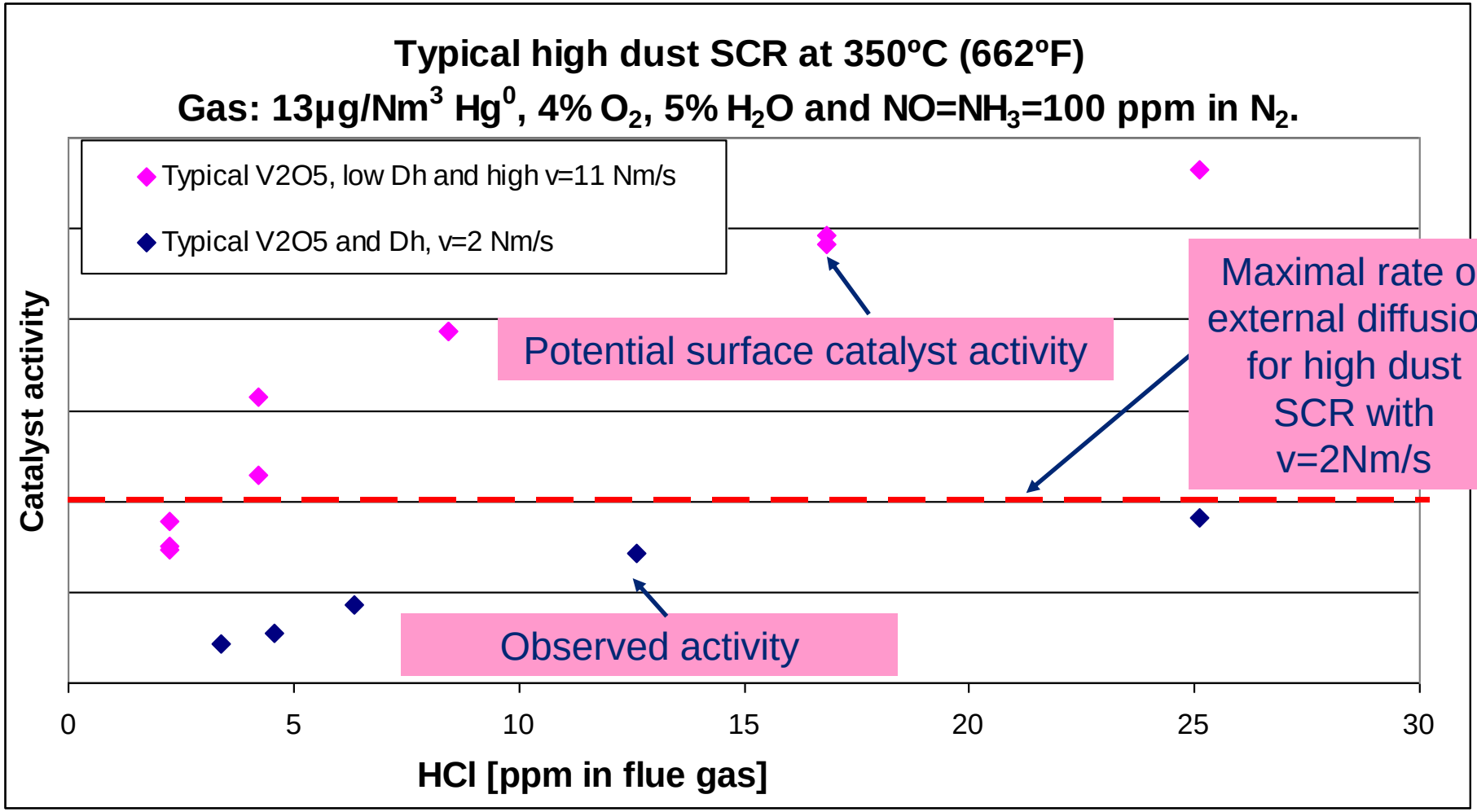


Study of the catalyst activity: Surface reaction and pore diffusion

- The catalyst activity for Hg^0-oxidation is measured at a kinetic regime where external mass transport is not limiting
  - At high linear velocity (v=11 Nm/s) and low hydraulic diameter (Dh)



Study of the observed catalyst activity at industrially relevant conditions



Conclusions from laboratory study

- External diffusion resistance is the major limiting factor governing Hg^0 oxidation in high dust SCR's at typical operating conditions
  - Properties such as formulation (e.g. V_2O_5 content) and porosity of existing SCR catalysts provide a very high surface activity for Hg^0 oxidation
  - The geometry of the catalyst and linear velocity determine mass transfer to the catalyst surface and thereby observed activity for Hg^0 oxidation

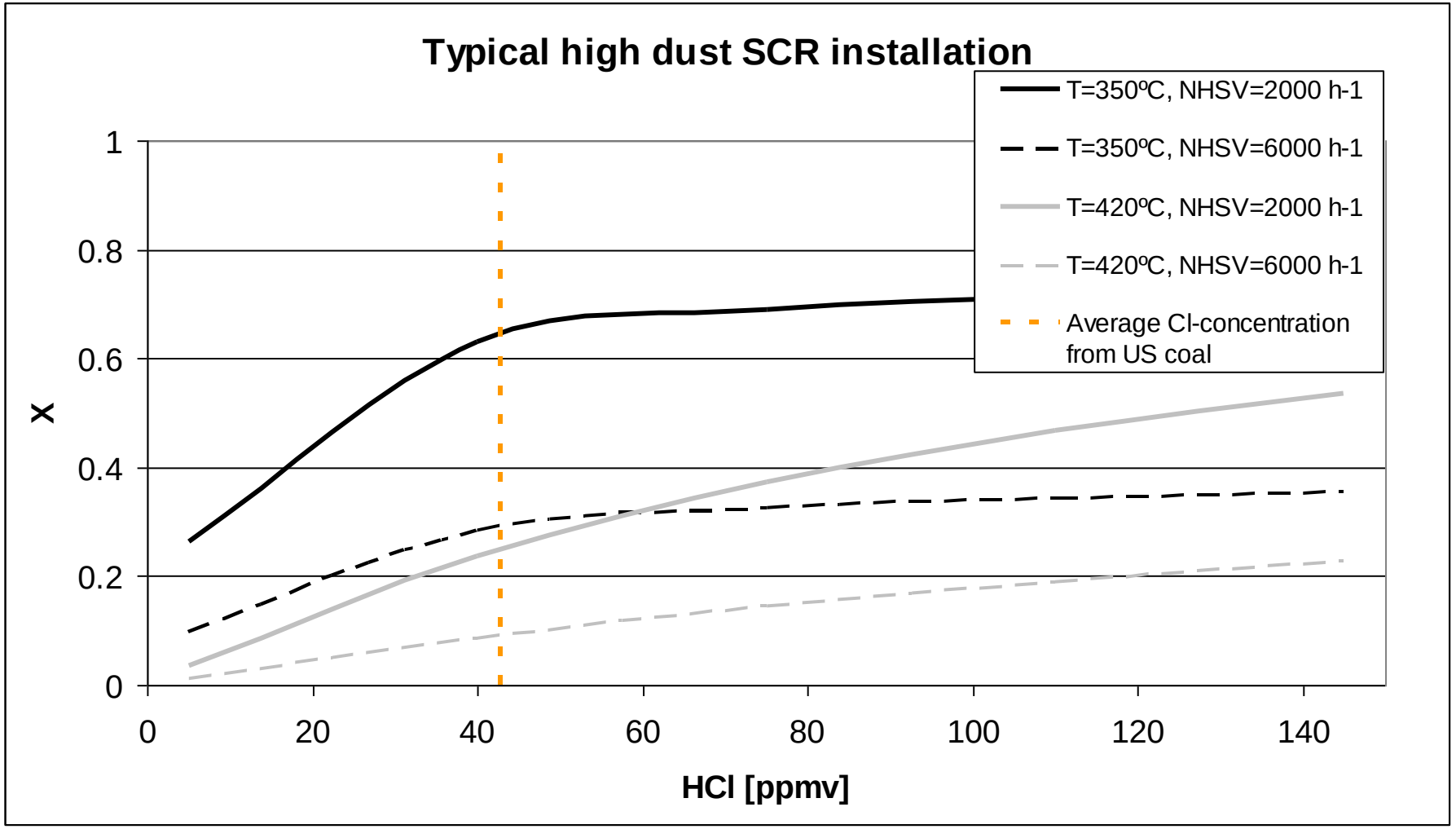
Hg^0 oxidation in full-scale

- The fraction oxidized mercury at the SCR inlet varies from day-to-day (15-95%) due to influence from e.g.
  - Unburned carbon and calcium in the fly ash, presence of acid gasses and time - temperature history.
- SCR performance can be described by the conversion of Hg^0 (X) (and is independent of inlet speciation):

$$X = \frac{\Delta Hg^0}{Hg^0(in)}$$

= >The total oxidized mercury leaving the SCR is a function of both inlet speciation and SCR performance!

Predictions for Hg^0 oxidation across the SCR in full-scale



Conclusions on fate of Hg in full-scale

- Up to 90% Hg^{2+} is achievable in full-scale at the SCR outlet depending on the inlet Hg speciation and the chlorine concentration
- > 91% mercury removal is achievable using existing control devices, but requires the combination of the SCR-FGD strategy with a particulate control device, e.g: