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The clear path to operational excellence

TDLS200 TruePeak

TDLS200

NH_3 Slip Measurement

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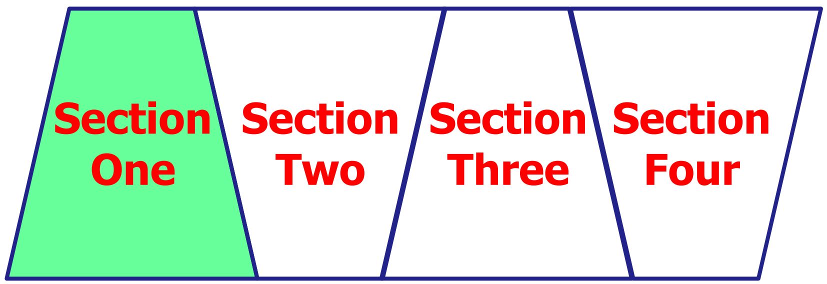
Background



Gas-Fired Installations

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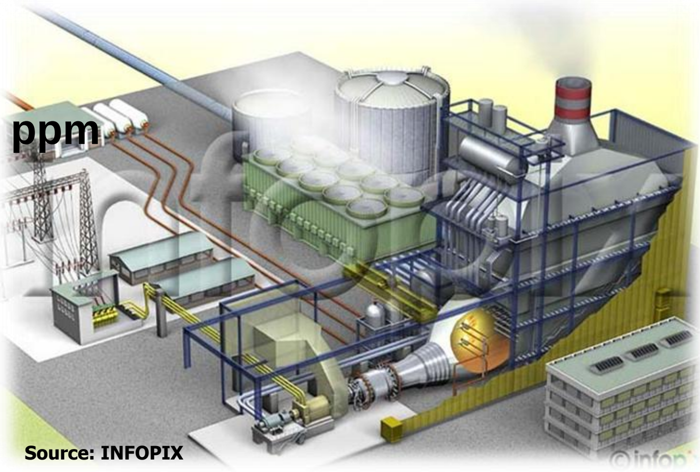
The SCR control system must be able to perform in a range of conditions

Flue gases from gas-fired installations that SCR systems are exposed to are:

- **Gas temperatures up to 800º F for boilers**
- **Gas temperatures up to 1200º F for turbines**
- **Inlet NOx concentrations ranging from 15 to 1000 ppm**
- **Outlet NOx emissions as low as 0.5 ppm**
- **Outlet NH3 emissions between 1 and 10 ppm**
- **SO2 concentrations between 0 and 2 ppm**
- **Dust concentrations up to 0.02 gr/dscf**



Source: INFOPIX

Gas turbines produce 200 pounds of NOx per one million cubic feet of gas

Utility boilers generate 400 pounds of NOx per one million cubic feet of gas

Page Source: Guidance For Sampling Of NOx Concentrations For SCR System Control In Gas-fired Applications *Institute Of Clean Air Companies, Inc.*

Gas-Fired Installations …… and Turbines

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The main parameters that affect NOx formation are:

Temperature

Residence time

Excess air

Concentrations of the various species (N_2 & O_2)

The extent of mixing

Gas turbines can affect these parameters by:

Operating with a lean primary zone (pre-mixed) in the combustion chamber

This leads to **lower flame temperatures**

Reducing the primary combustion zone volume

This leads to **reduced residence time**

Increasing liner pressure drop

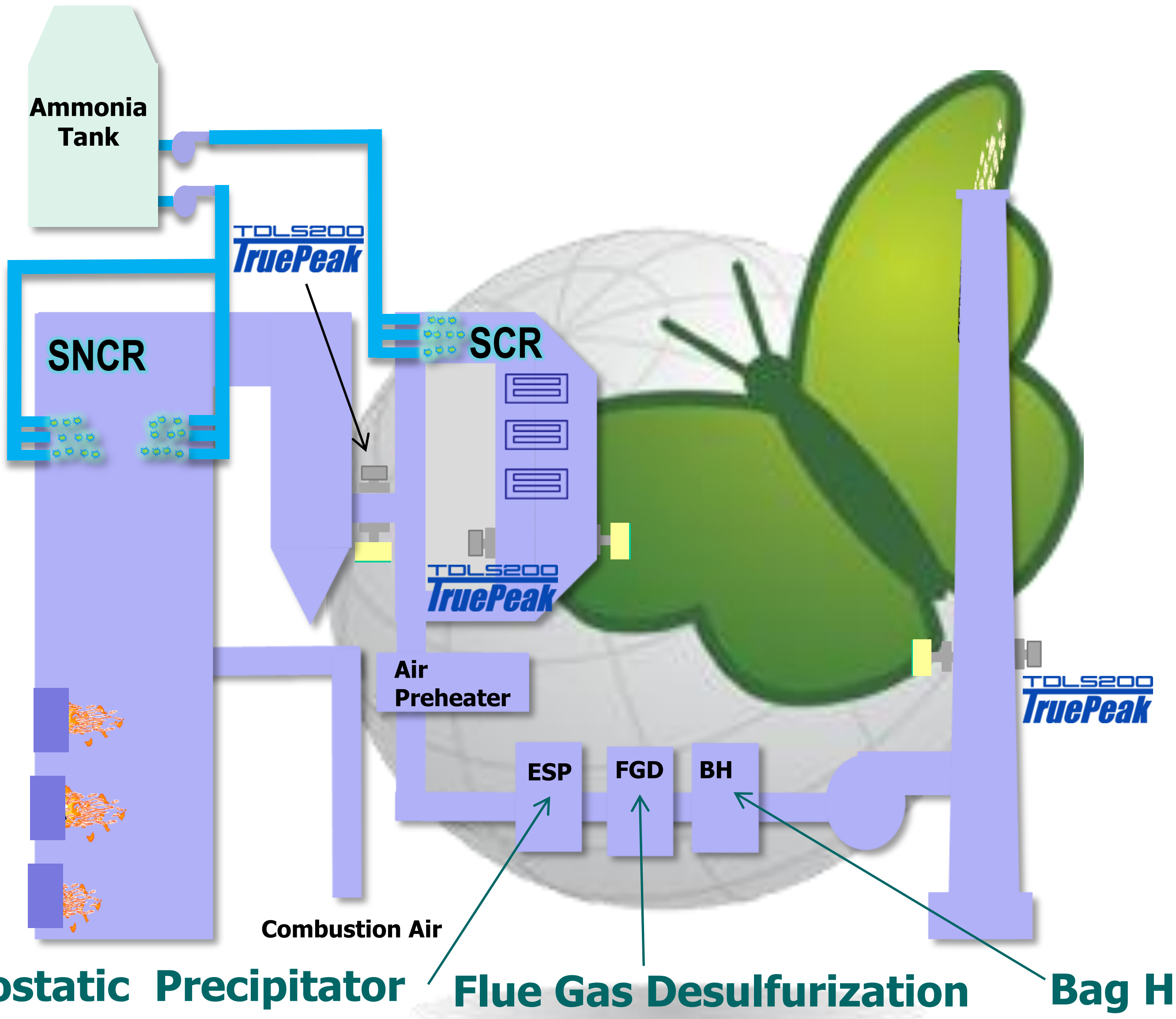
This leads to **increased turbulence & the elimination of hot spots**

Using water or steam injection

This leads to **lower flame temperature & a lack of oxygen required to form NOx**

Page Source: Guidance For Sampling Of NOx Concentrations For SCR System Control In Gas-fired Applications *Institute Of Clean Air Companies, Inc.*

TDLS200 Installation Locations for NH3 Monitoring



TDLS200 Installation Locations for NH3 Monitoring

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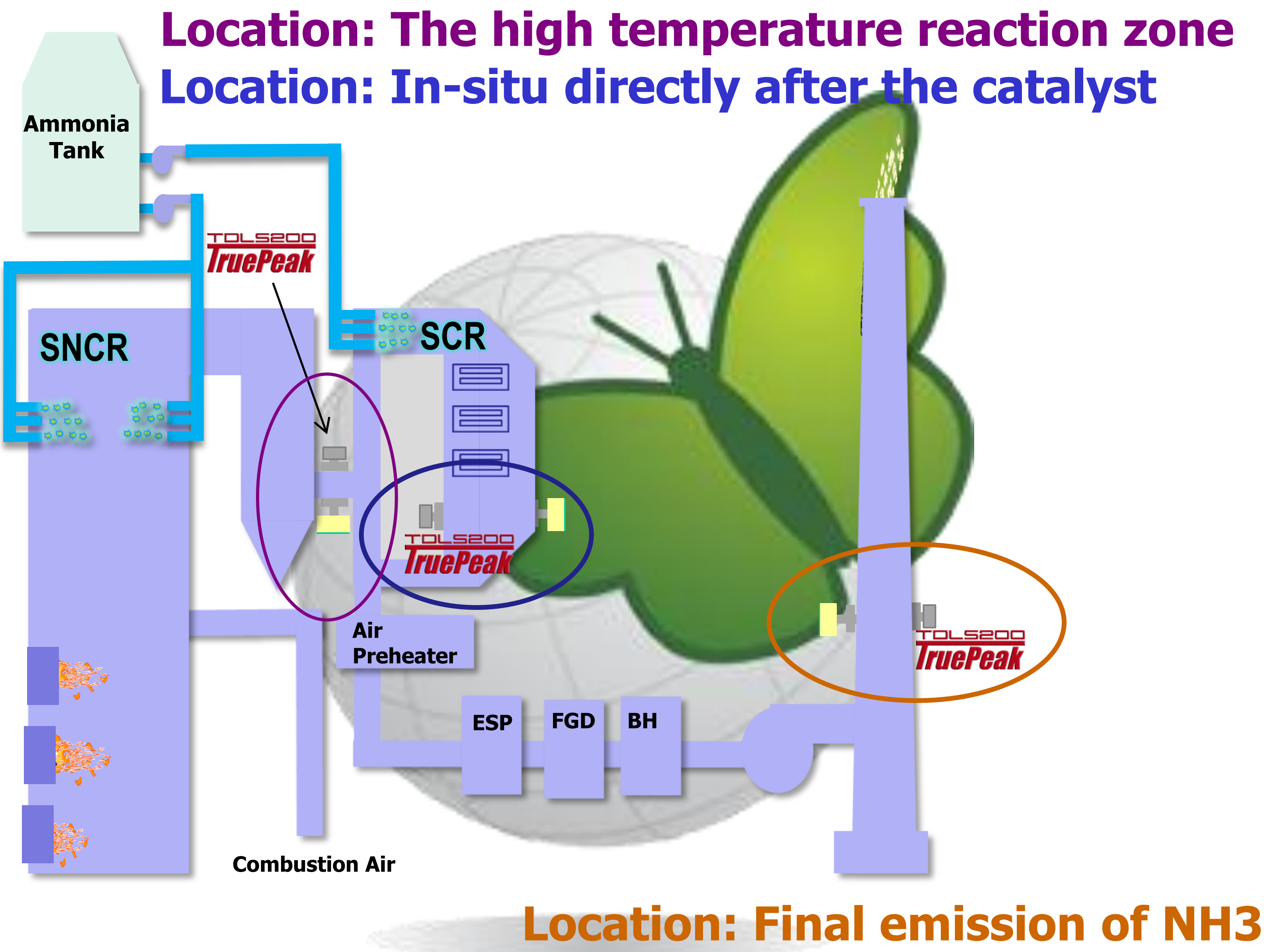

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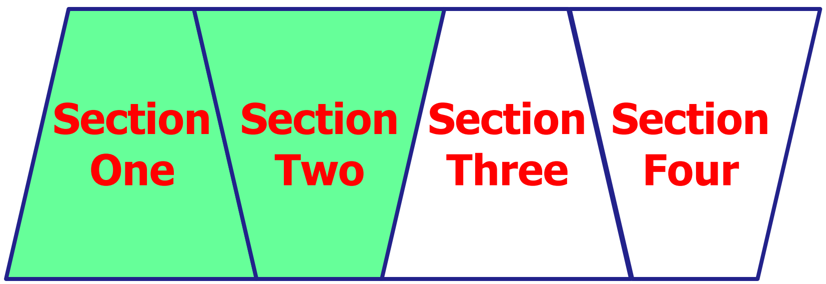
SCR and SNCR



For NOx Control

Ammonia Reduces Any NO Present

Nitric Oxide or NO is a toxic gas that is formed by the oxidation of nitrogen

NH3 reduces any nitric oxide present according to the reactions

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

This applies to either **Anhydrous** or **Aqueous** ammonia

Anhydrous = no water

Aqueous = solution of NH3 in water

Urea {CO(NH2)2}

The reaction for urea instead of either anhydrous or aqueous ammonia is:

4NO + 2(NH2)2CO + O2 → 4N2 + 4H2O + 2CO2

For industry use urea is produced from synthetic ammonia and carbon dioxide

There are specific user benefits associated with each chemical (reductant)

NOx Control with SCRs

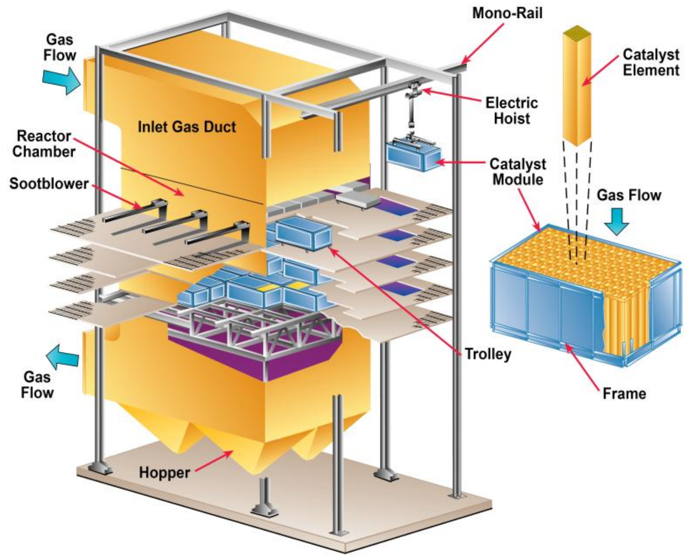
The Selective Catalytic Reduction (SCR)

The (SCR) process involves the:

Injection of ammonia into the flue gas

NH3 reacts with NOx in the presence of a catalyst

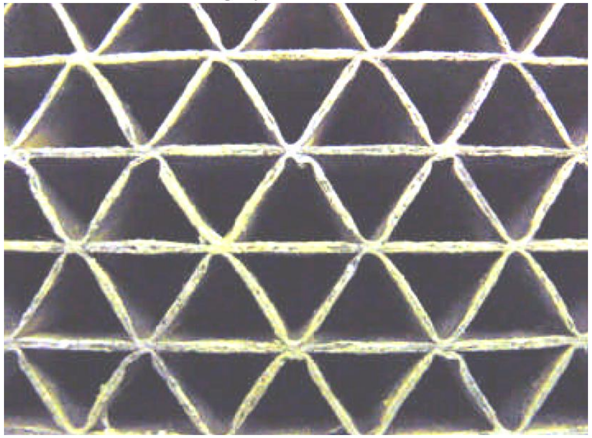
The reaction forms molecular nitrogen & water



Vertical-flow fixed-bed type reactor chamber

source: Southern Company 1995

Injector with air supply



New catalyst elements

Typical SCR System

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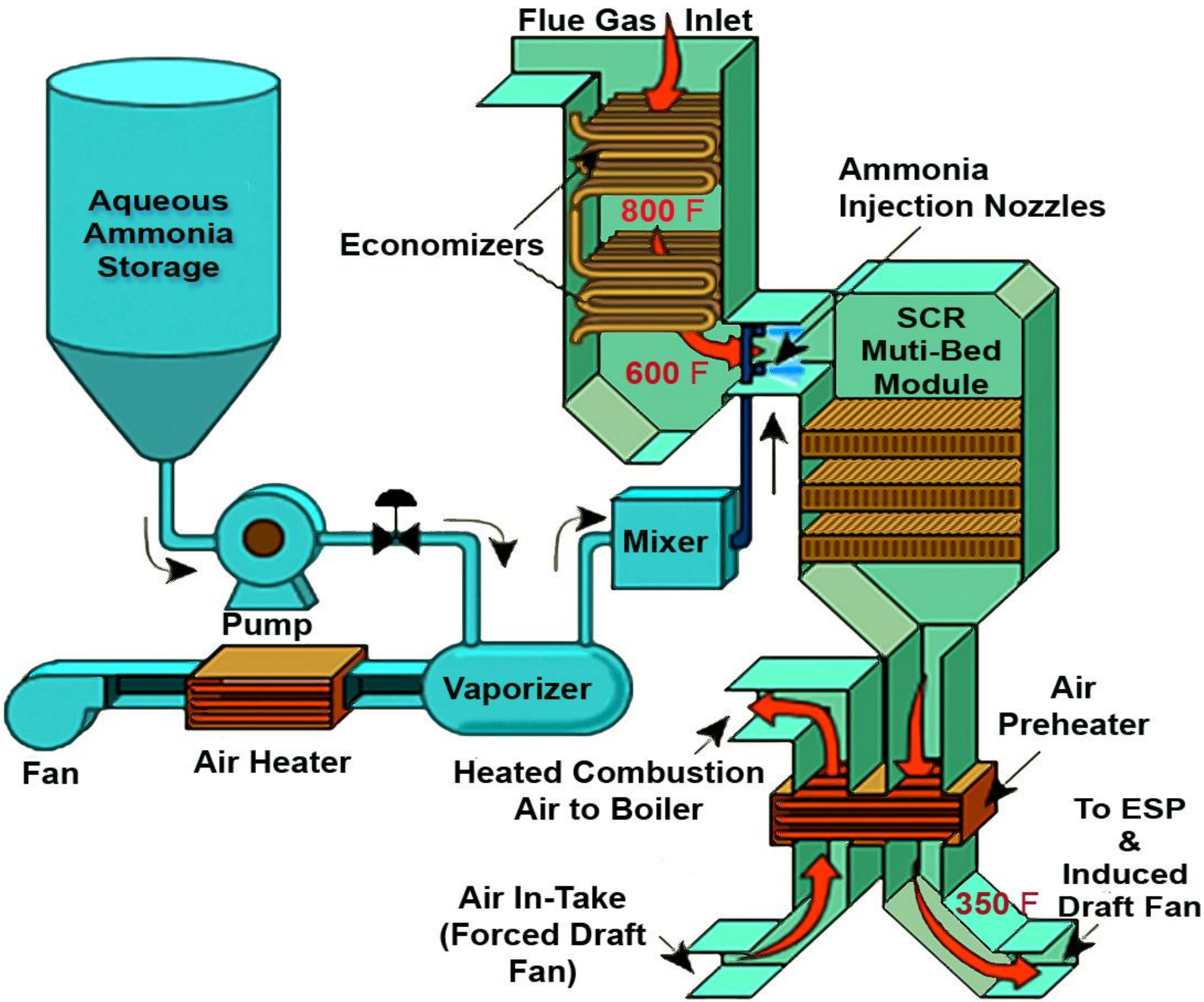

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Decreasing Catalytic Activity

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Ammonia slip can also occur due to:

Poor temperature control at the ammonia injection point

High fly ash concentrations in the flue gas

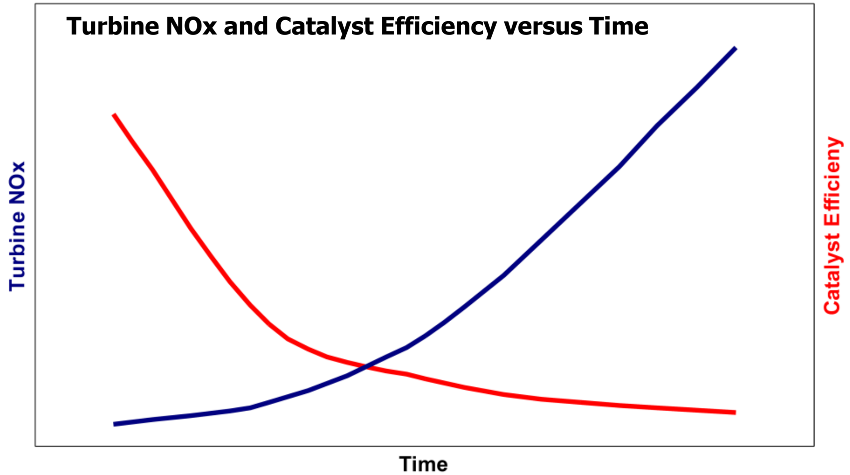
Ammonia slip rates start at very low levels and increase over time

Increasing Ammonia slip rates = decreasing catalytic activity

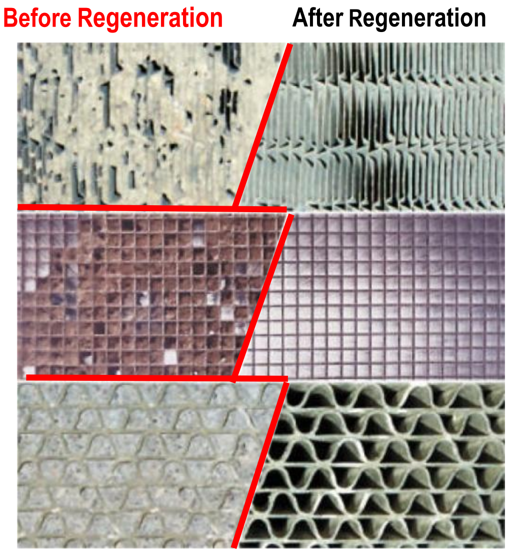
Note: Decreasing catalytic activity can be a result of **simple aging**

Highly important is the fact that it also can be due to fouling

Increasing NH3 slip is the **best indicator** of decreasing catalytic activity



Source: Operating Catalytic Emission Reduction Systems -Presented by Southern California Gas Company at Gas/Electric Partnership 2008 Workshop



Catalysts before & after regeneration

Note fly ash blockings in the various forms of catalyst design

Blockage by so-called popcorn ash

Blockage by concrete-like plug-ins

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SCR Operation ….Ammonia Slip

Un-reacted NH_3 in the flue gas downstream of the SCR reactor is NH_3 slip

It is essential to hold NH_3 slip to below **5 ppm, preferably 2-3 ppm**. Why?

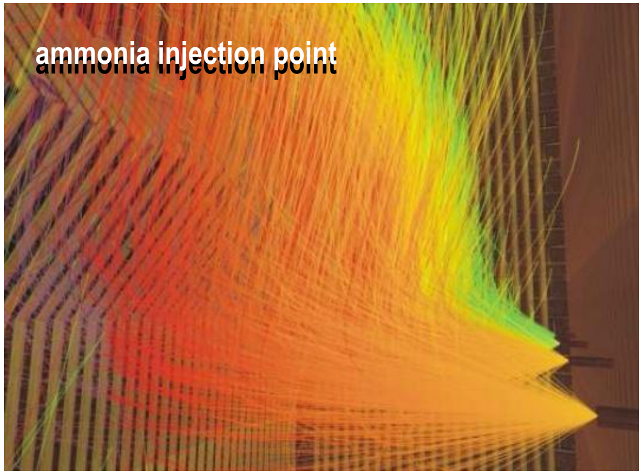
To minimize formation of ammonium sulfate [$(NH_4)_2SO$] & bisulfate (NH_4HSO_4)

These formations can cause plugging & corrosion of downstream equipment

This is a greater problem with high-sulfur coals, caused by higher SO_3 levels

Higher levels resulting from:

- Internal higher initial SO_3 levels due to fuel sulfur content
- Oxidation of SO_2 in the SCR reactor



Source: Lehigh Energy Update June 2001. SCR AND SNCR PROCESSES INCREASE RISK OF AIR PREHEATER FOULING

Difficulties in Control of the SCR

Measurement difficulties exist. This is particularly true of sampling

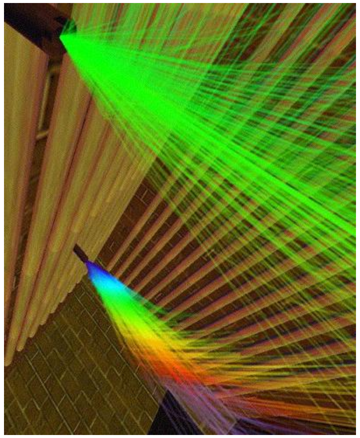
NOx analyzer difficulties commonly encountered are:

- **Unreliable <u>sampling system</u>** upstream of the SCR reactor
- **Slow ammonia reagent flow response time**
  - 5 to 10 minute lag in the NOx signal feedback from the stack CEM
- **Over-feeding ammonia reagent.** When?
  - When a step change decrease of NOx concentration at SCR inlet occurs
- Reagent flow reverts to default values during CEM calibration

What are the impacts of poor ammonia reagent flow control?

- **Increased reagent consumption**
- **High ammonia slip**

Summary of Benefits of Monitoring NH3 Slip



http://www.de-nox.com/

- Lower ammonia emissions
- Reduced particulate deposition, plugging and corrosion
- Reduced odor
- Reduced use of reagent
- Improved process efficiency
- Reduced catalyst costs
- Improved catalyst management

  "Utilities having installed an SCR system are faced with the question of how to monitor and assess the system performance. This becomes important especially when a catalyst management plan has to be developed. Such a catalyst management plan provides a forecast for future catalyst need and projected time when to install or exchange catalyst. **Taking into account that it may take some months for catalyst fabrication and delivery, it may become imperative to have this kind of information".#**

- Stack plume and visibility

  "The problem of ammonia slip fouling the air heaters, ammonia stack emissions and ash contamination are still unresolved and **will remain so until a reliable, continuous, in-situ ammonia analyzer can be identified." ****

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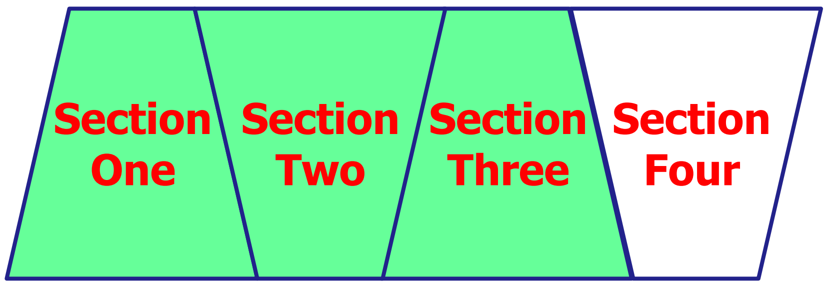
CURRENT PRACTICES FOR MONITORING AMMONIA SLIP FROM SCR PROCESSES, 1998 Conference on Selective Catalytic and Non-Catalytic Reduction for NOx Control, Department of Energy Federal Energy Technology Center May 21-22, 1998,

** REBURNING NOX CONTROL EXPERIENCES by New York State Electric & Gas Corporation (NYSEG)

NH3 Monitoring



Problems

The Results of Sample Systems Problems?

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Slower Response Time

Overcome by Increasing the Flow Rate

Resulting in Increased “Waste Gas”

Accuracy is Lost

Sample is altered by conditioning

Reduced Reliability

Plugged Filters

Required Maintenance

Modifying the Sample!!!!!

Increased Cost

Increased Maintenance

Modifying the Sample!!!!!

Increased Installation Footprint

Issues with catalyst management

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EPRI's Requirements for Ammonia Slip Analyzers

"Direct measurement of reactor outlet NH_3 will enhance the ability of the control system to trim or increase reagent flows during load transients or off-design operation.

To be part of a control system, the ammonia analyzer must meet the following criteria"

Measurement must be made at **high temperature** to avoid loss due to reaction with SO_3, flyash, or condensation in the sampling train

The gas sample should be **representative** of the whole flue gas stream

The instrument should **respond with a reading, in 30 seconds** or less

The probe must **operate on the high-dust side** of the precipitator (close to SCR exit)

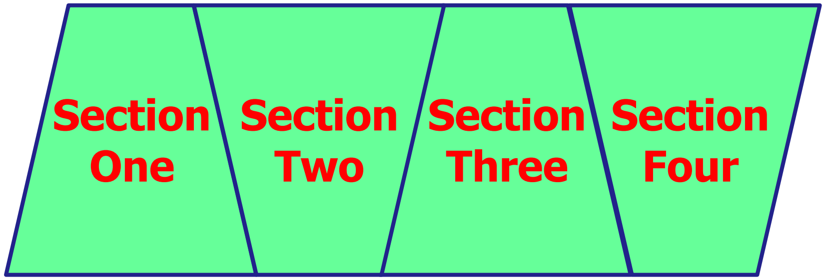
No interfering gas species

No ammonia can be lost in the sampling system; this implies that the instrument should be close-coupled to the sample port

Source IMPROVED SCR CONTROL TO REDUCE AMMONIA SLIP, ADA Environmental Solutions, LLC, Electric Power Research Institute, Orlando Utilities Commission

Section Four

TruePeak 200



Benefits

TDLS Process Control Benefits

Precise

Fast measurement of simple gaseous molecules (ex: ammonia)

Non sampling, low maintenance

Temp to 450° C for Ammonia

Space or path averaging

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Ammonia Measurement TruePeak Analyzer

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Interference free from water and other combustion products

In-situ. No sample handling or interface

- Ability to measure gas in process without removal or conditioning
- Ability to handle a reactive sample

≤ 5 second response

0.15 ppm detection limit (0-20 ppm range)

Direct measurement method……………. not inferred

No mechanical or mathematical separation required

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TruePeak Benefits of Monitoring Ammonia

Advantages TruePeak 200 Vs. Straight Extractive Or Dilution Extractive System

No gas transport

- Fast response time. 5 Seconds or less
- No loss of components in a sample system
- No filters, sample lines, pumps to clean

Lower planning expenses

- No support for heated sample gas lines
- No Analysis container
- No Disposal of sample gas and condensate
- Improved catalyst management

Lower installation and operation cost

- No Heated sample gas lines ($50/ft). **Mounts In-Line!**
- Smaller component Inventory
- Smaller replacement requirements
- Smaller cost for shelter or space in existing analyzer rooms

Direct measurement of NH3:
This can be done using several methods, both across the stack or duct measurement or Insitu probe type systems.

Typical across duct measurements use the Tunable Diode Laser method, or DOAS monitor.

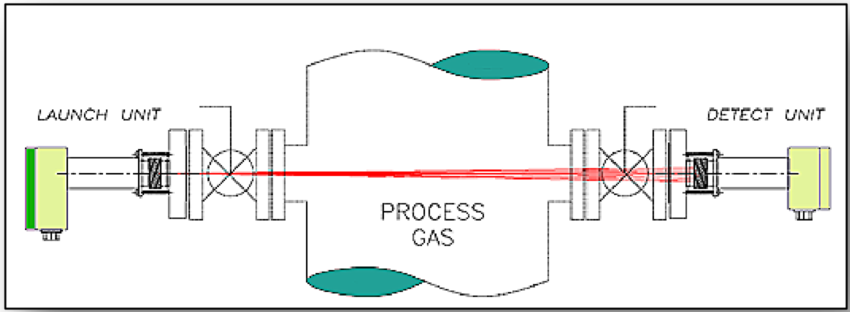
Photo from Yokogawa

Photo taken of the TDLS200 during its installation on a NH3 Slip application for a coal fired power plant in West Virginia.

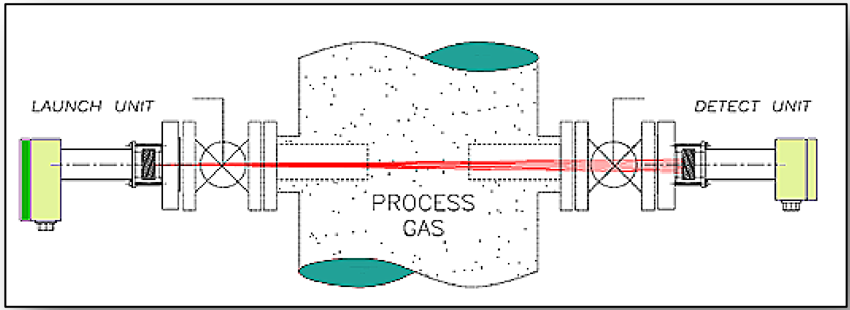
Insitu Alignment

The laser beam must pass from one side of the process to the other

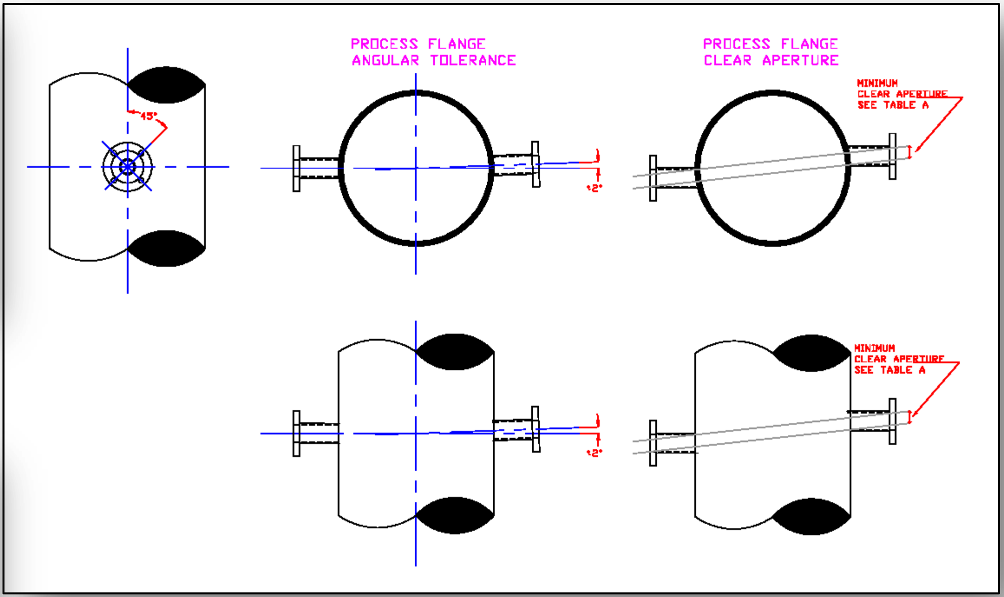
The flanges and nozzles must be within +/- 2 Degrees of center line



Standard Across the Process Mounting



Insertion Tube In the Process Mounting



What is the Holdup in using the TDLS?

“ The primary disadvantages of TDL methods are that there is little commercial experience for ammonia applications and that many of the suppliers are small, overseas firms. …Service and application support will be important features to users of these products”++

This used to a valid concern years ago

TruePeak is a “**Made In America**” product

YLAD has more NH3 Slip application experience than any other company

ASI (Now YLAD) has a hugh installed base of NH3 slip analyzers

TruePeak is completely field repairable

TruePeak is the only SIL rated TDL analyzer

TruePeak follows EPA Validation Guidelines Via Spiking

++ Source: Measuring Ammonia Slip from Post Combustion NOx Reduction Systems By James E. Staudt with Andover Technology Partners

TruePeak Benefits of Monitoring Ammonia…. Page 5

SCRs and Financial Considerations

Catalyst when new; can achieve greater reductions of NOx then later in life

While maintaining required ammonia slip levels

The catalyst loses its activity as a result of deposition

These are impurities from the fuel being used, ex: gas, coal

Note: NH3 for the NOx reduction does not impact the catalyst

HN3 does not cause catalyst degradation

At times there is an excess capacity of the SCR to reduce NOx

This is early in the catalyst life and has value. **When?**

Its valuable in the high ozone season. **Where?**

In the EPA Ozone Transport Regions. **Why?**

Emission reduction credits can be generated and traded

Does Anybody Have .... A ....