Perma Pure LLC

Low-NOx Fallout: Ammonia in Your Sample System

EPRI CEMS User Conference

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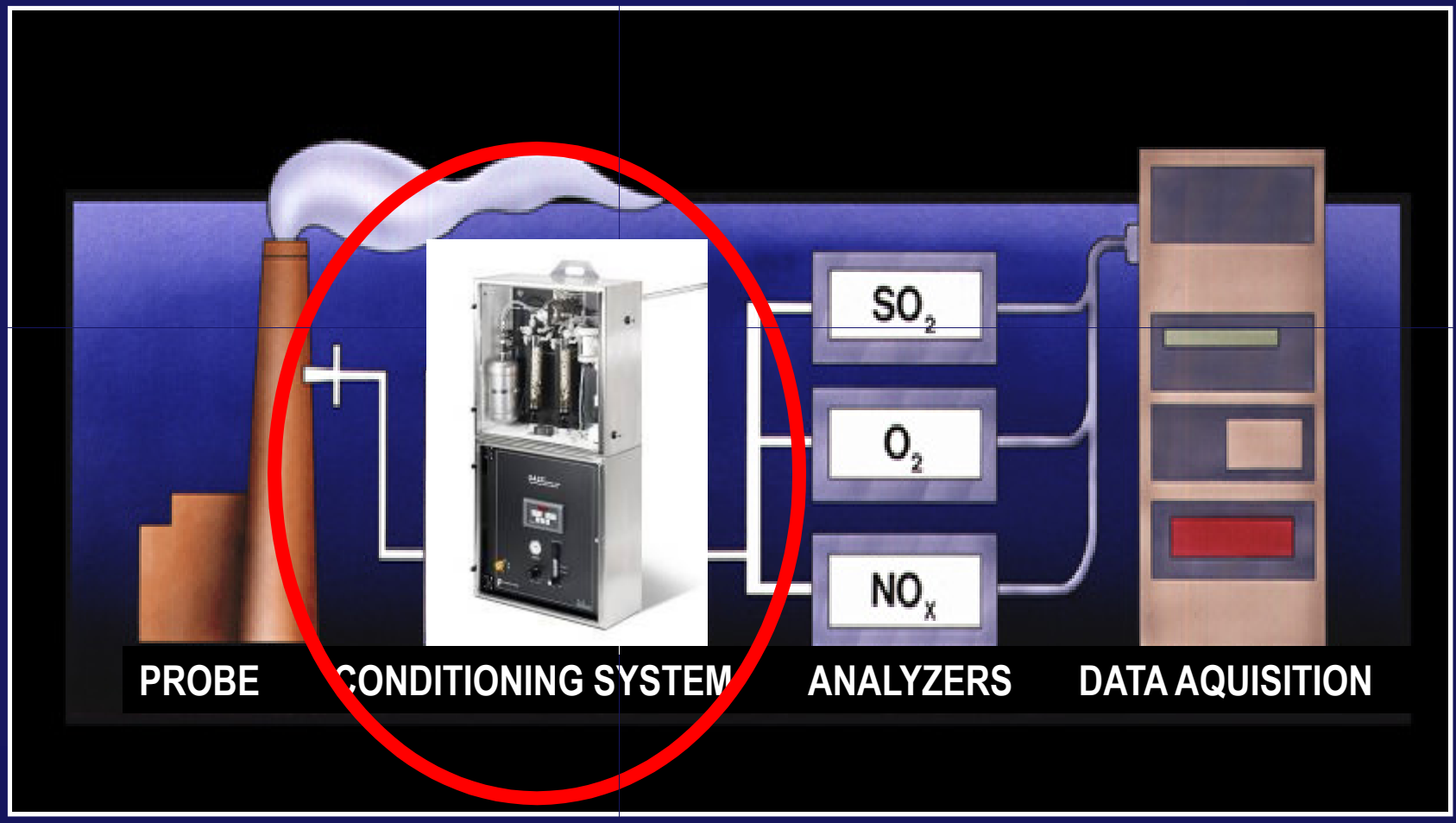
Sample Handling – Critical Path for CEMS



Perma Pure – Gas Sample Handling

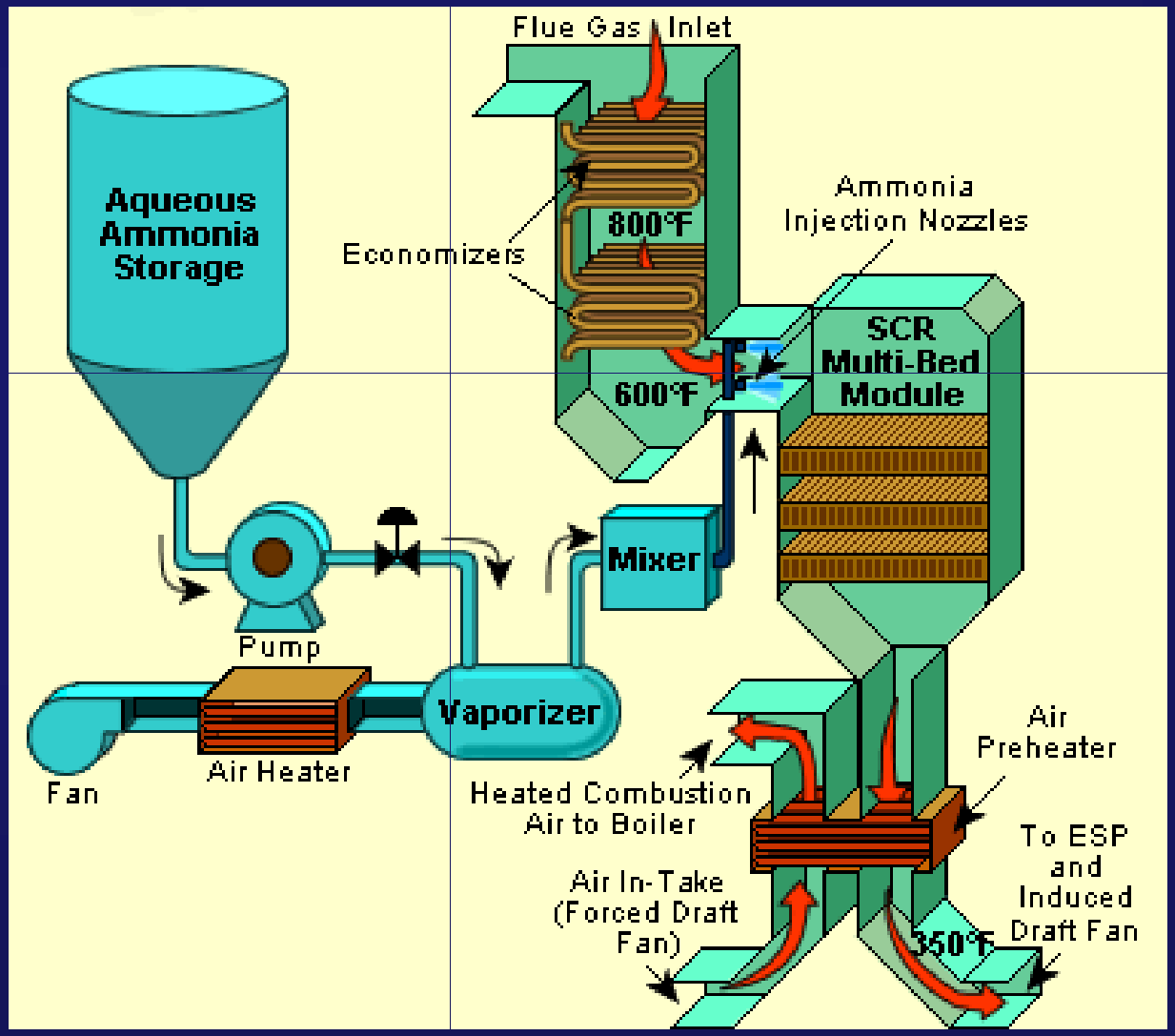
3 Technologies:

- **Dilution Probes**
  - Wet measurement
- **Baldwin™ brand Thermoelectric Coolers**
  - Water removal through flash condensation
- **Nafion® permeation dryers and systems**
  - Water removal at the stack through unique membrane dryer technology
- **Plus probes, filters, scrubbers, accessories**

Selective Catalytic Reduction (SCR)

- **Reduction of NOx by injection of ammonia**
  - NH_3 and O_2 react with NO and NO_2 to form N_2 and H_2O
- **Or, by injection of urea**
  - $(NH_2)2CO$ and O_2 react with NO to form N_2, H_2O and CO_2
- **Similar Processes hold for SNCR**

SCR System for NOx Control in a Boiler



The Fallout: Ammonia Slip

- **When unreacted ammonia is released into the flue gas stream. Causes:**
  - Added ammonia is never entirely consumed
  - Catalyst temperatures are not in the optimum range
  - Too much ammonia is used
- **Can be mitigated by "slip catalyst"**

Ammonia Slip

- Range: 1 ppm up to 200+ ppm
- 5-20 ppm is a typical measurement
- In many cases, release of NH_3 is not regulated or even reported
- Unfortunately, Analyzer Shop does not control the rate of ammonia injection
- Process operators are often not concerned about ammonia slip

Unwanted Consequence #1

- **NH_3 is a catalyst in the formation of SO_3 from SO_2 and O_2**
- **As vapors condense, you also get:**
  - $SO_3 + H_2O \rightarrow H_2SO_4$ (Sulfuric acid)
  - $NH_3 + H_2SO_4 \rightarrow NH_4HSO_4$
    (ammonium bisulfate – ammonia salts)

Unwanted Consequence #2

- **Downstream formation of ammonium bisulfate – "ammonia salts"**
  - due to sulfur content of the fuel source
  - white and powdery when pure, it forms "large rhombic prisms" as it condenses
  - collects and fouls solid surfaces in flues, probes, filters, sample lines and inside analyzers
  - forms in tight spaces, eg. O_2 analyzer paramagnetic mirror

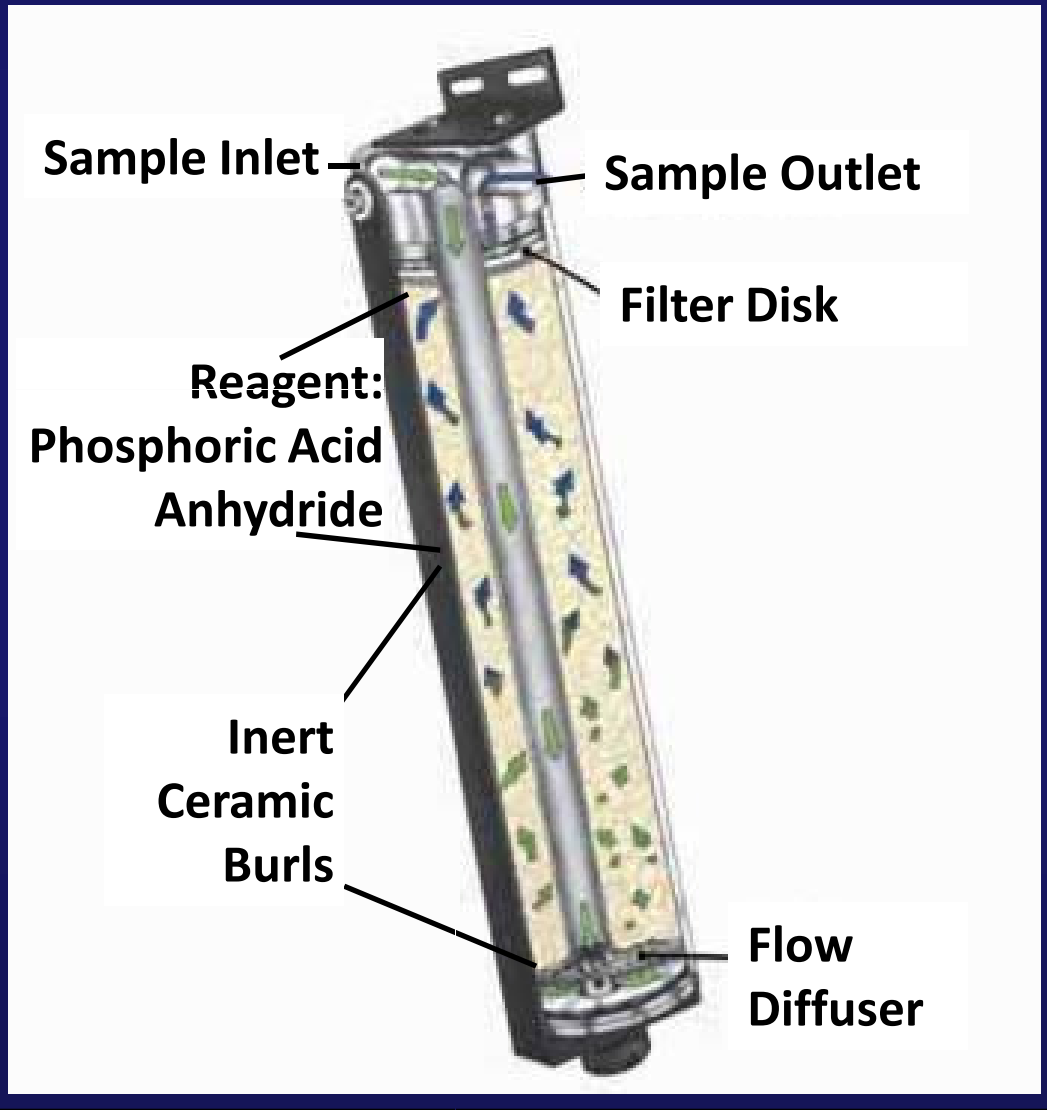
Unwanted Consequence #3

- **Conversion of NH_3 back to NO**
  - can happen even at lower temperatures
  - can artificially inflate NOx readings
  - when every PPM counts, can cause a failed RATA
  - are you paying for NOx, but not NH_3, emissions?

Ammonia Scrubber

- **Protects analyzers and downstream components**
  - Eliminates ammonia salt deposition
- **Very selective reagent**
  - Phosphoric acid removes only bases
- **Very high corrosion resistance**
  - Housing: stainless steel, polysulfone
  - Element: H_3PO_4 on inert ceramic
- **Reliable and low maintenance**
  - No moving parts, only periodic refills

Scrubber Flow Schematic



Hot, Wet Chemistry

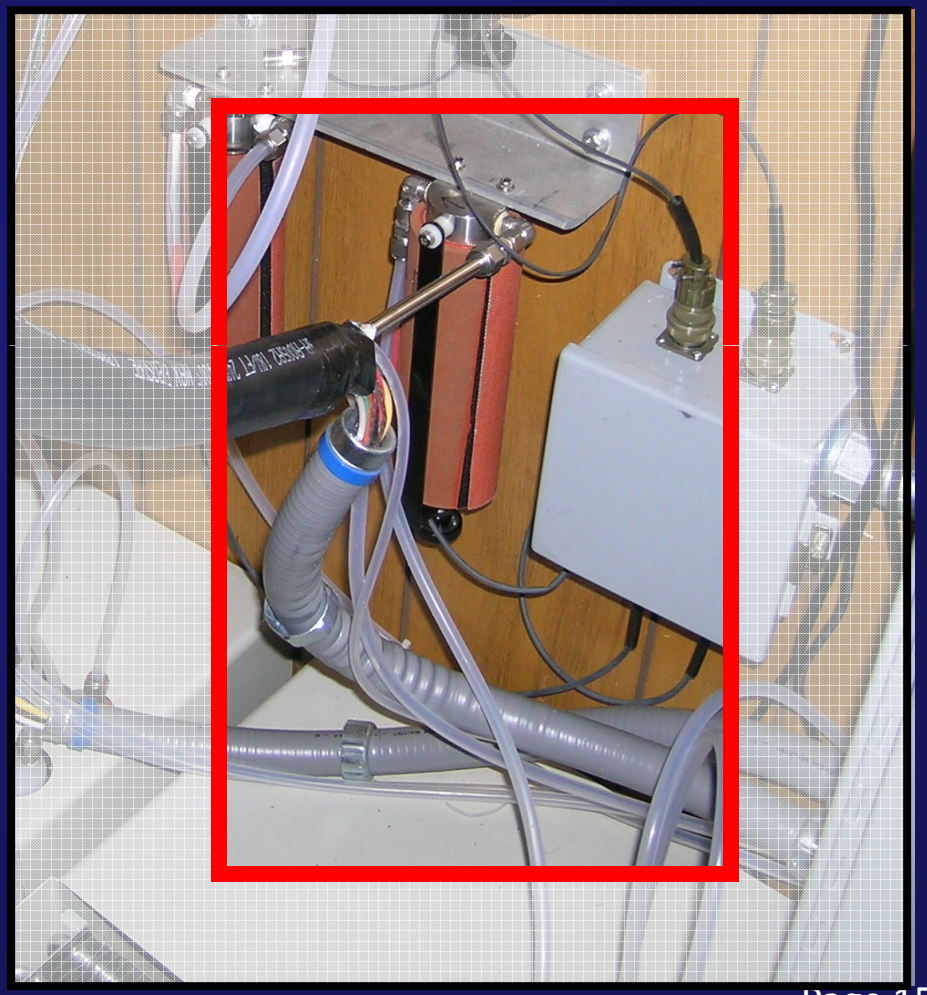
- **Target Temperature 80-90°C**
- **Ammonia reacts in vapor form**
- **Water remains in vapor form**
  - Otherwise, the bottom fills with liquid
  - Heater blanket maintains 90°C
- **Or, maintain 80-90°C in heated enclosure**

Hot Wet Chemistry

- **1st Stage Reaction: Phosphoric acid anhydride must be wetted**
  - Install upstream of cooler or Nafion® sample conditioning system
  - If downstream of cooler, spray with de-ionized water when refilling reagent
- **2nd Stage Reaction: Formation of ammonium phosphate – salts**
  - Collect on the inert ceramic burls at bottom of scrubber

Sample Installation

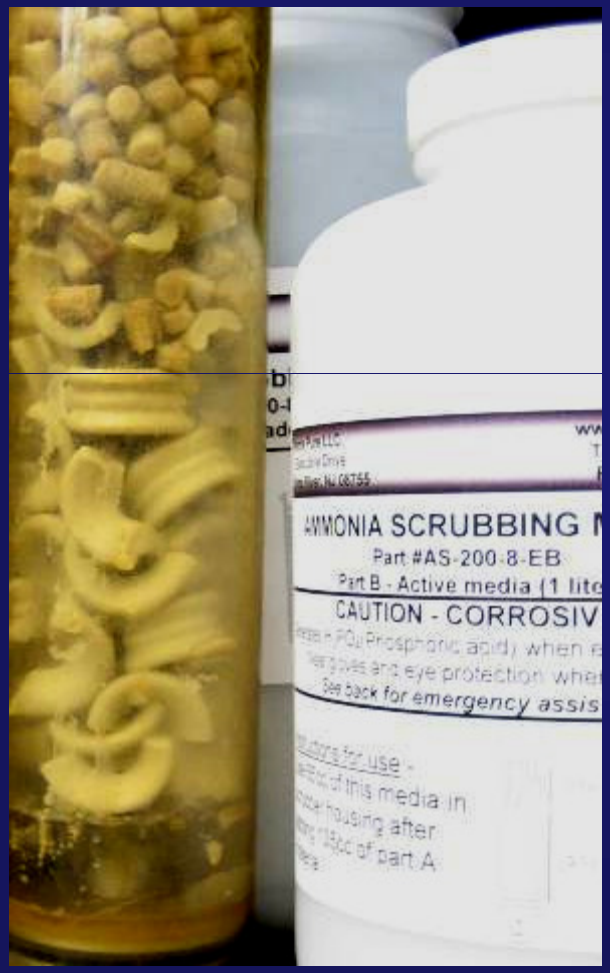
- Sample line feeds first to ammonia scrubber, then to cooler



Spent Ammonia Scrubber

Note: Scrubber should NOT be mounted horizontally, as this one was

Maintenance



- Refill media every 40,000 liter/ppm/hours
- Hand tighten mounting screw
- Example:
  - Flow rate = 10 lpm
  - Slip = 5 ppm
  - Change Media every 33 days