SNCR System
Design, Installation, and Operating Experience

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The Basic Process

- SNCR is a gas phase reaction between ammonia radicals and NO to form N2 and water in the absence of a catalyst.

$$NH2^{-} + NO + 1/2O2 \rightarrow N2 + 2\ H2O$$

- Strong Temperature Dependence

The First Patent

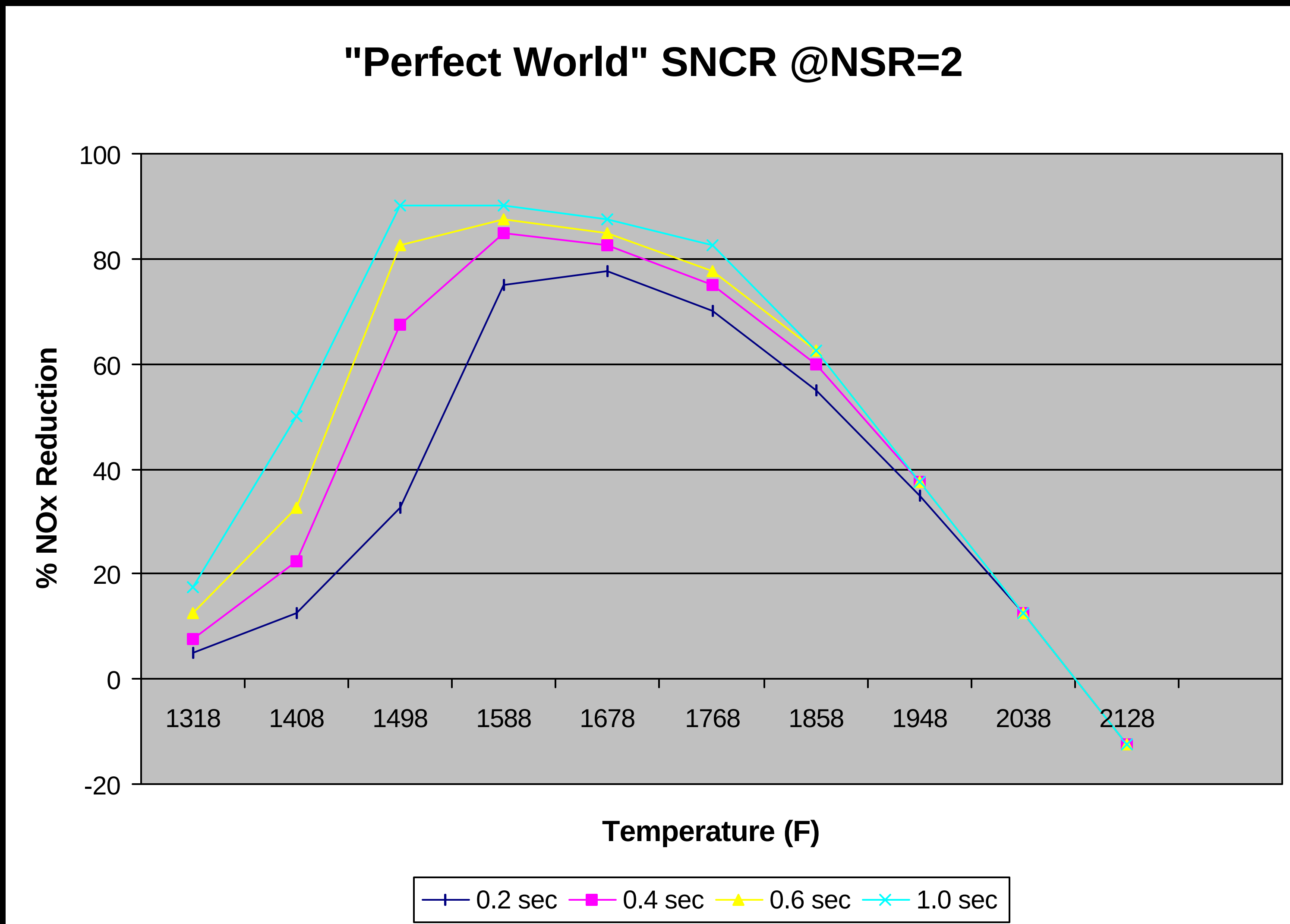
- First patented by Exxon for use on combustion effluents in 1975, using ammonia.
- Established required temperature range and stoichiometry/performance.
- Patent expired in 1990.

Other Patents

- EPRI was soon thereafter granted a very similar patent , using urea, in 1980.
- EPRI furthered the art by patenting SNCR in excess of 2000 degrees F in the absence of oxygen.
- Commercialized in the late 80's.
- The original two EPRI process patents have expired as well.

The Perfect World

- In laboratory conditions (insulated tubular reactor with perfect mixing and unlimited residence time), NOx reduction greater than 90% has been demonstrated.
- Ideal Conditions – Temperature of 1800F, Residence time greater than 0.5 seconds.

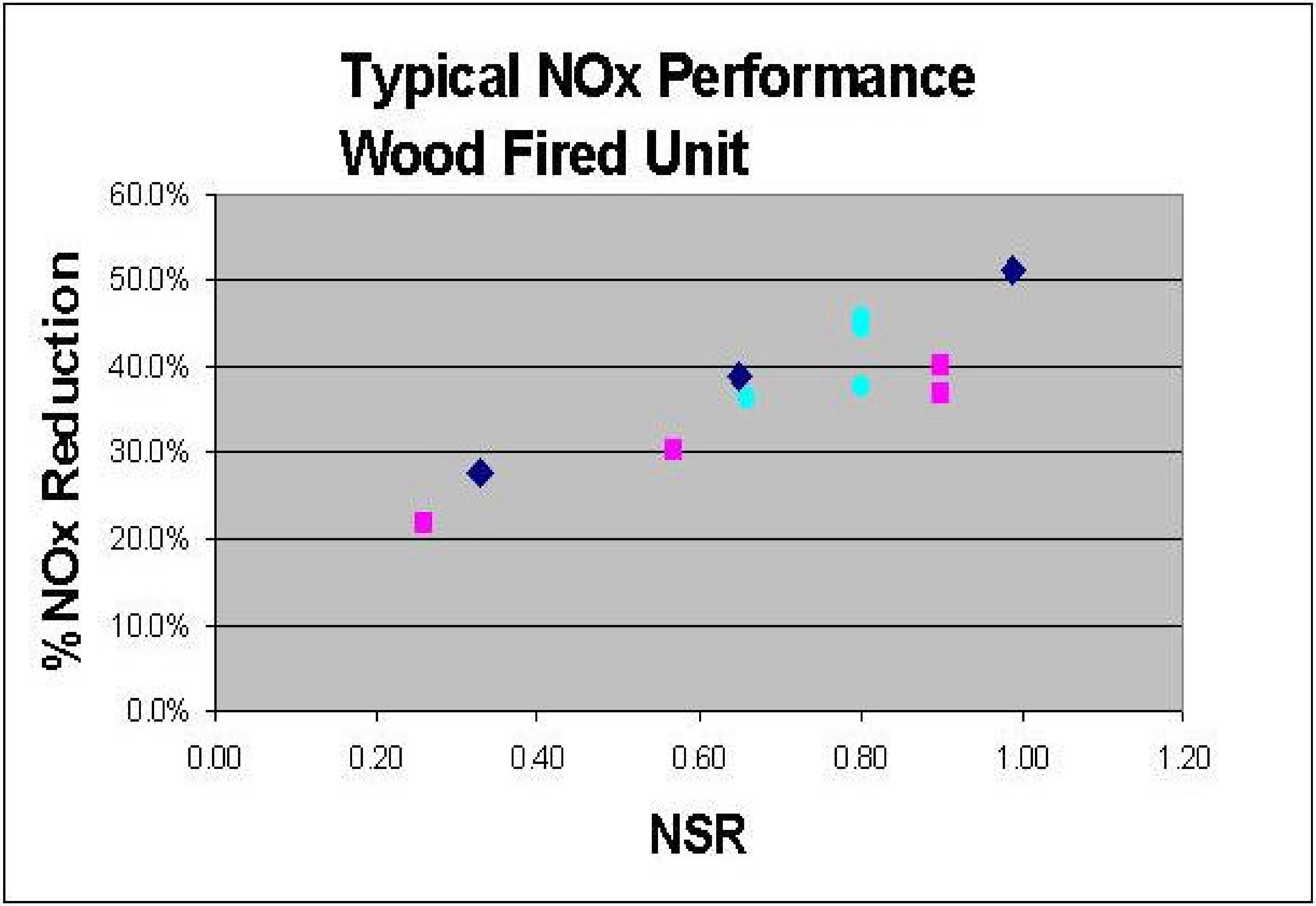

"Perfect World" SNCR @NSR=2
% NOx Reduction
100
80
60
40
20
0
-20
1318
1408
1498
1588
1678
1768
1858
1948
2038
2128
Temperature (F)
0.2 sec
0.4 sec
0.6 sec
1.0 sec

The Real World

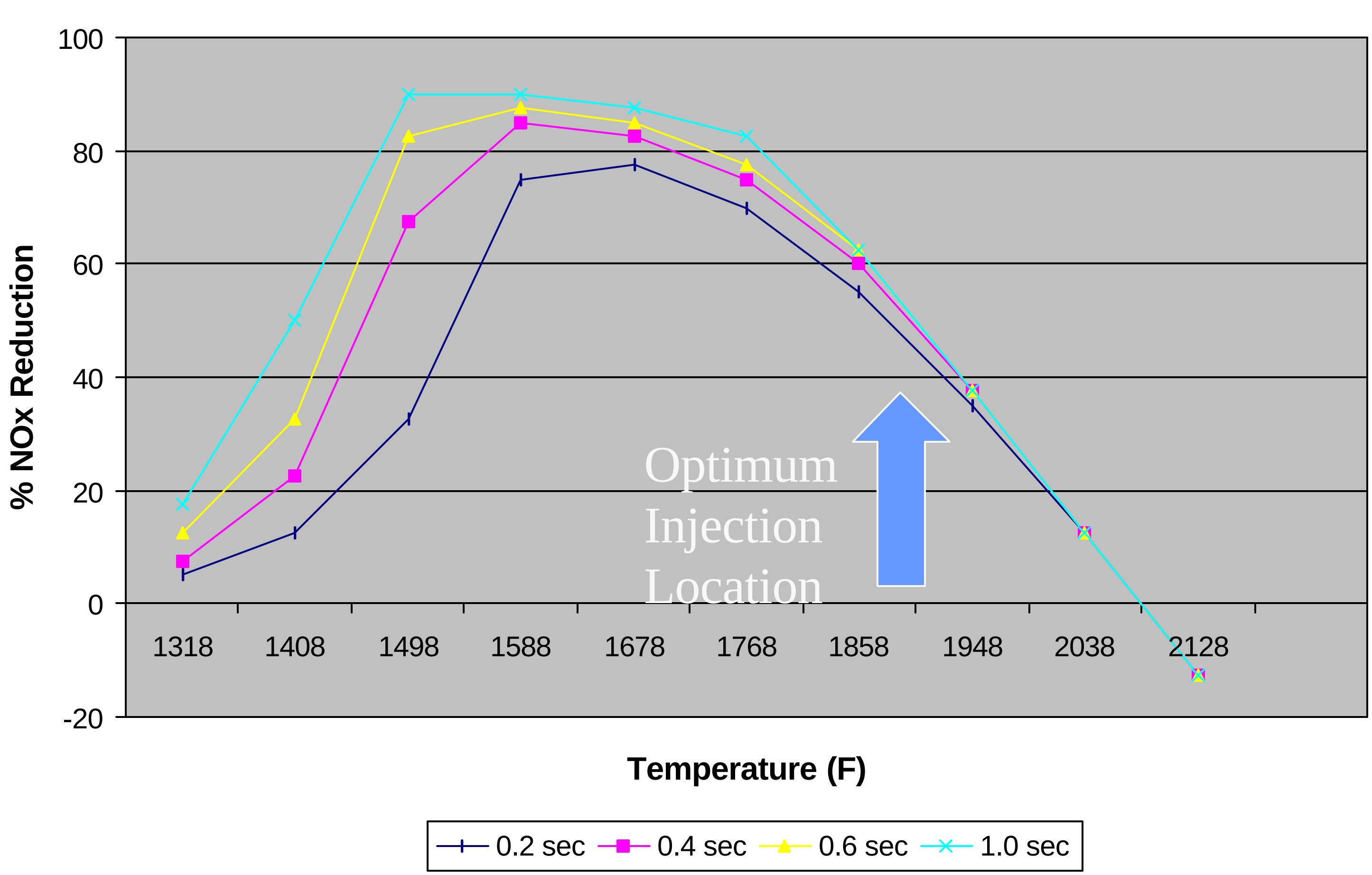
- Rapidly declining temperatures
- Access limitations
- Imperfect mixing
- Liquid evaporation time delay
- Load swings
- Operator indifference
- Carbon Monoxide
- Ammonia Slip is Important

Closest to Perfect

- Waste Incinerators, Wood/Bark Boilers, CFB's, some PC Boilers.
- All are characterized by reasonable furnace plan dimensions, well defined gas profiles, and adequate residence time prior to first convective surface.
- Common performance is 50% reduction at NSR = 1.0 and ammonia slip L.T. 10 ppm.


Typical NOx Performance
Wood Fired Unit
% NOx Reduction
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0.00
0.20
0.40
0.60
0.80
1.00
1.20
NSR

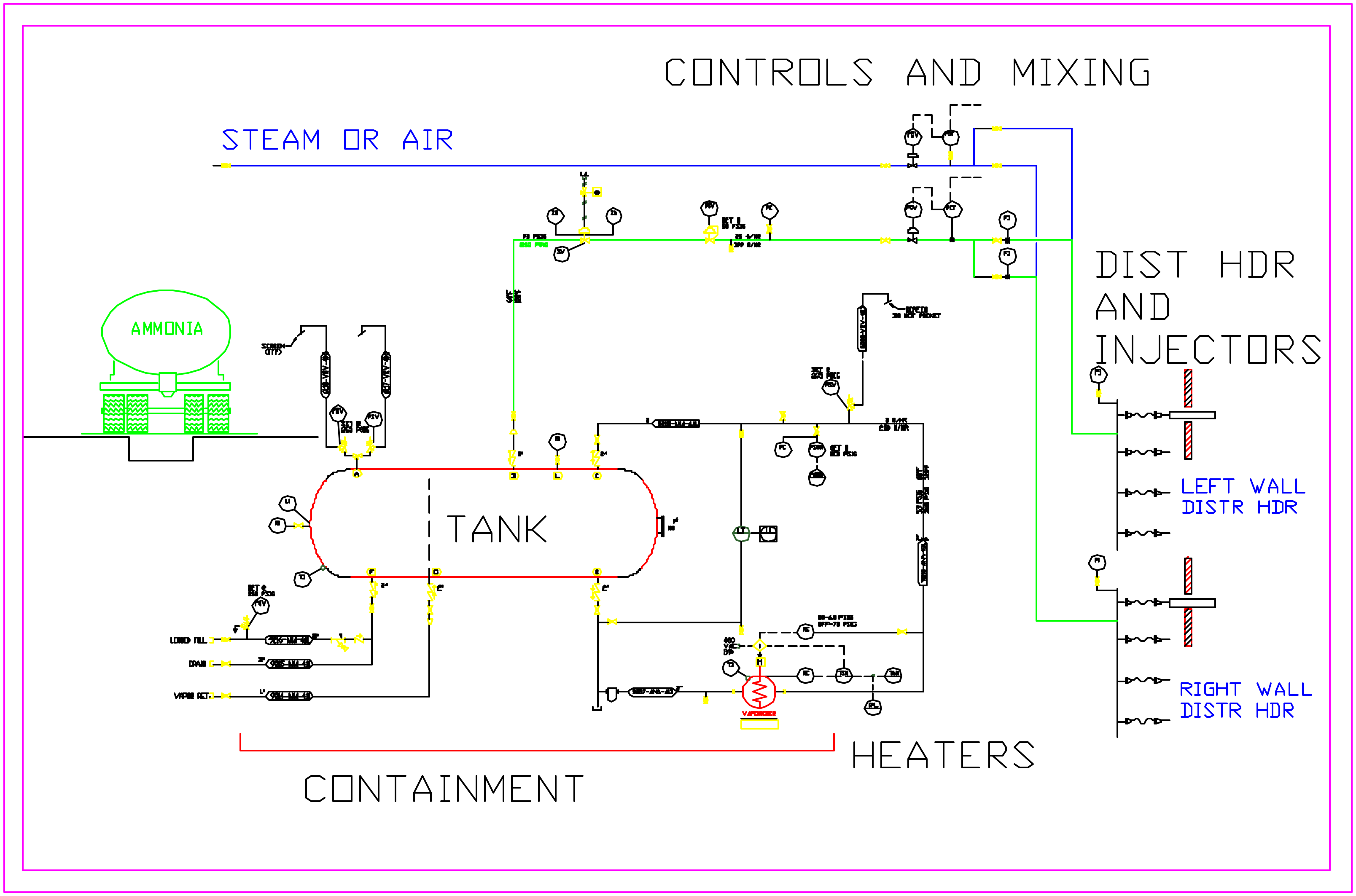
"Real World" SNCR @NSR=2



Ammonia Process

- Simplest and least expensive* approach.
- Gaseous injection.
- Anhydrous ammonia has lowest delivered cost.
- Storage and Handling issues.
- Low boiler corrosion risk.

* - Assumes typical tank/containment.

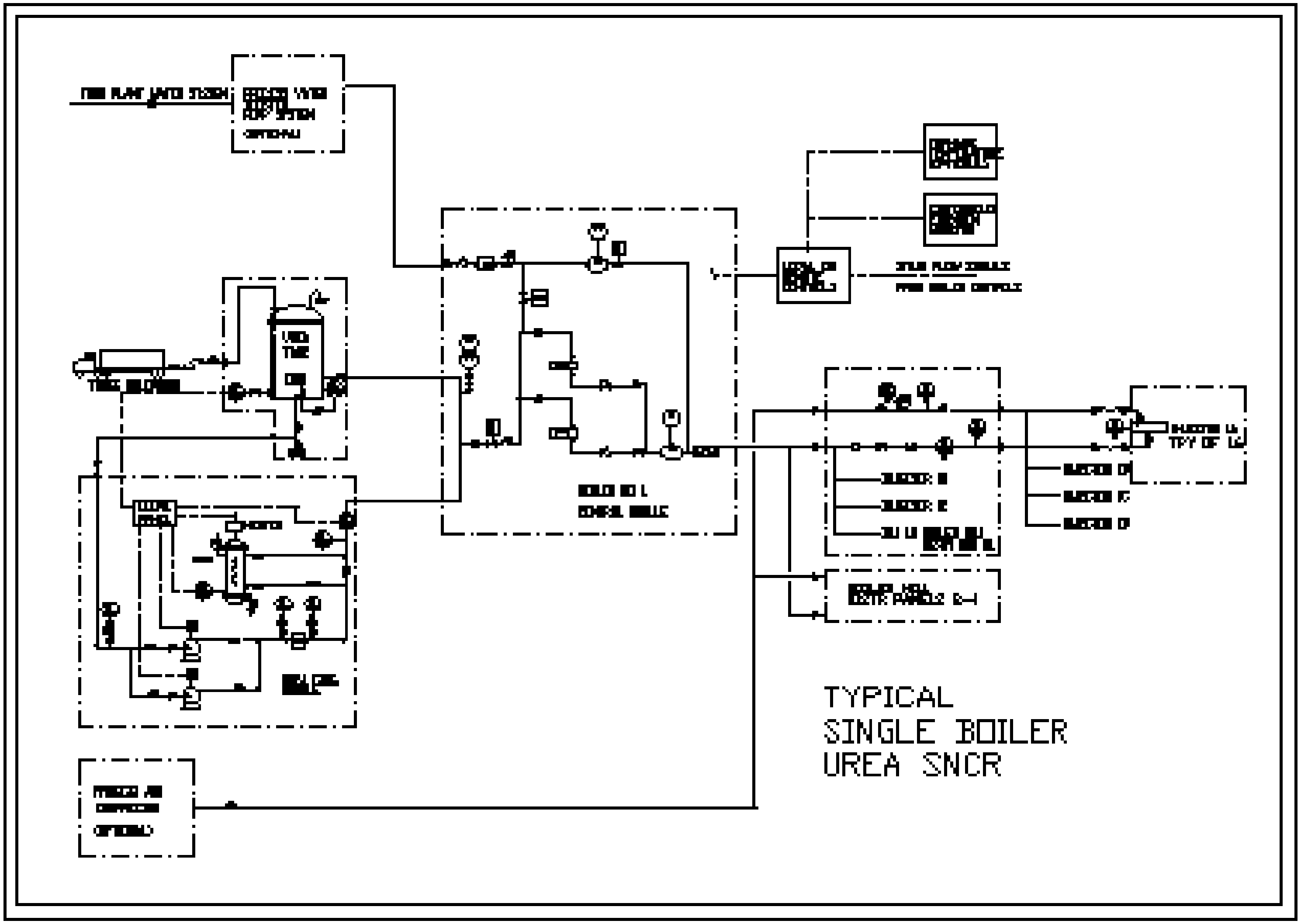

CONTROLS AND MIXING
STEAM OR AIR
DIST HDR AND INJECTORS
AMMONIA
TANK
LEFT WALL DISTR HDR
RIGHT WALL DISTR HDR
HEATERS
CONTAINMENT

Urea Process

- Liquid Reagent, with or without atomization.
- Higher reagent costs, but friendlier chemical.
- Equivalent performance and stoichiometry.
- More difficult to distribute reagent equally.
- Local boiler corrosion common.

Design Considerations

- Heat or Dilute
- Load Range
- Injector Location
- Injector Number, Location, and Sizing
- Controls
- On-Site Urea Dissolver?

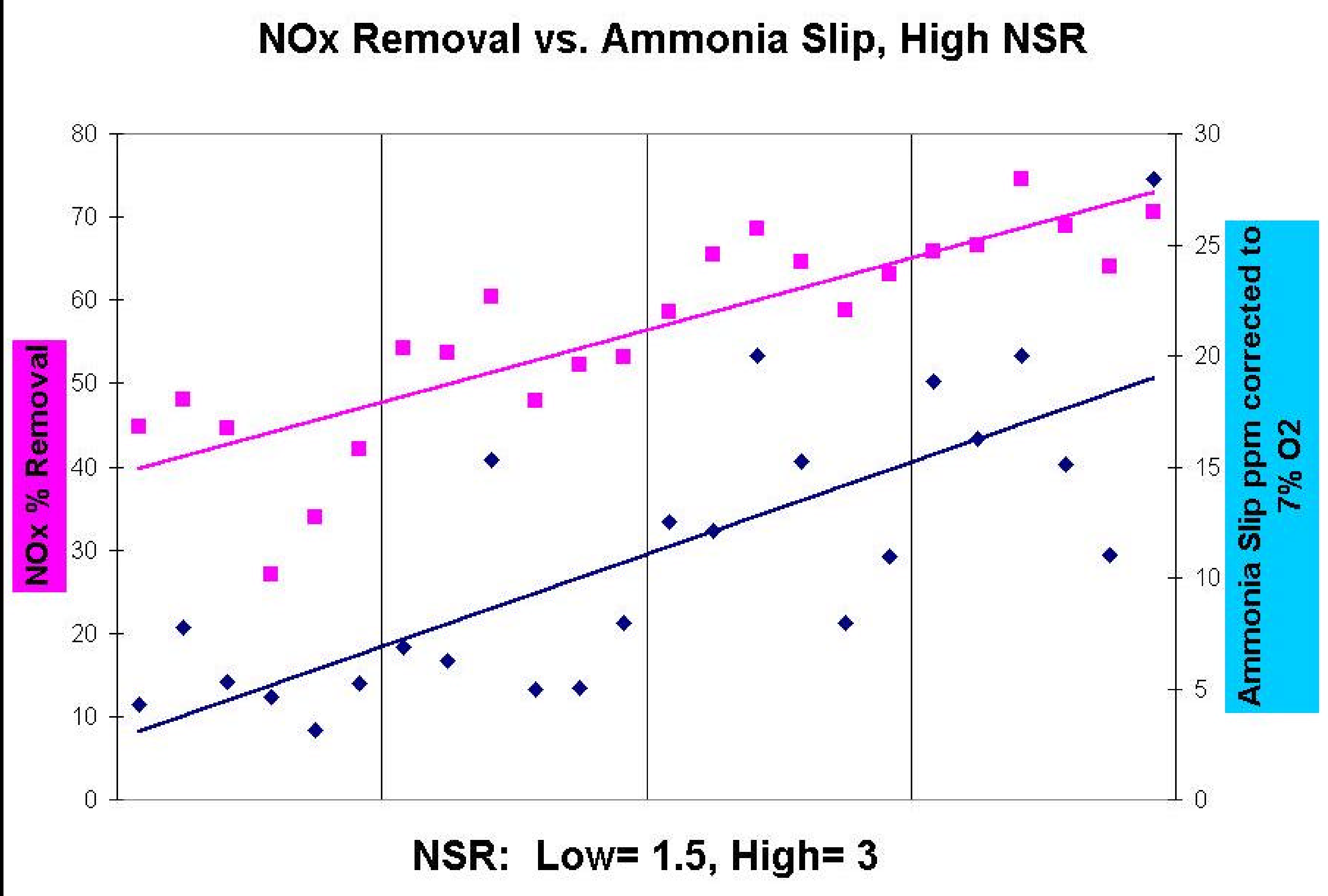

TYPICAL
SINGLE BOILER
UREA SNCR

Economic Summary

- Installed Cost – Utility scale $5-10/kW
- Installed Cost – Industrial $15-20/kW
- Negligible Outage Costs
- Operating Cost - $500-750 per ton NOx removed using urea

Optimization

- The more injectors the better.
- Use flat pattern nozzles if possible.
- Check flow balance once per day.
- Secondary dilution water quality is an issue.
- Pull and inspect injectors once per week.
- Generic reagent works fine.



NOx Removal vs. Ammonia Slip, High NSR
NOx % Removal
80
70
60
50
40
30
20
10
0
Ammonia Slip ppm corrected to 7% O2
30
25
20
15
10
5
0
NSR: Low= 1.5, High= 3

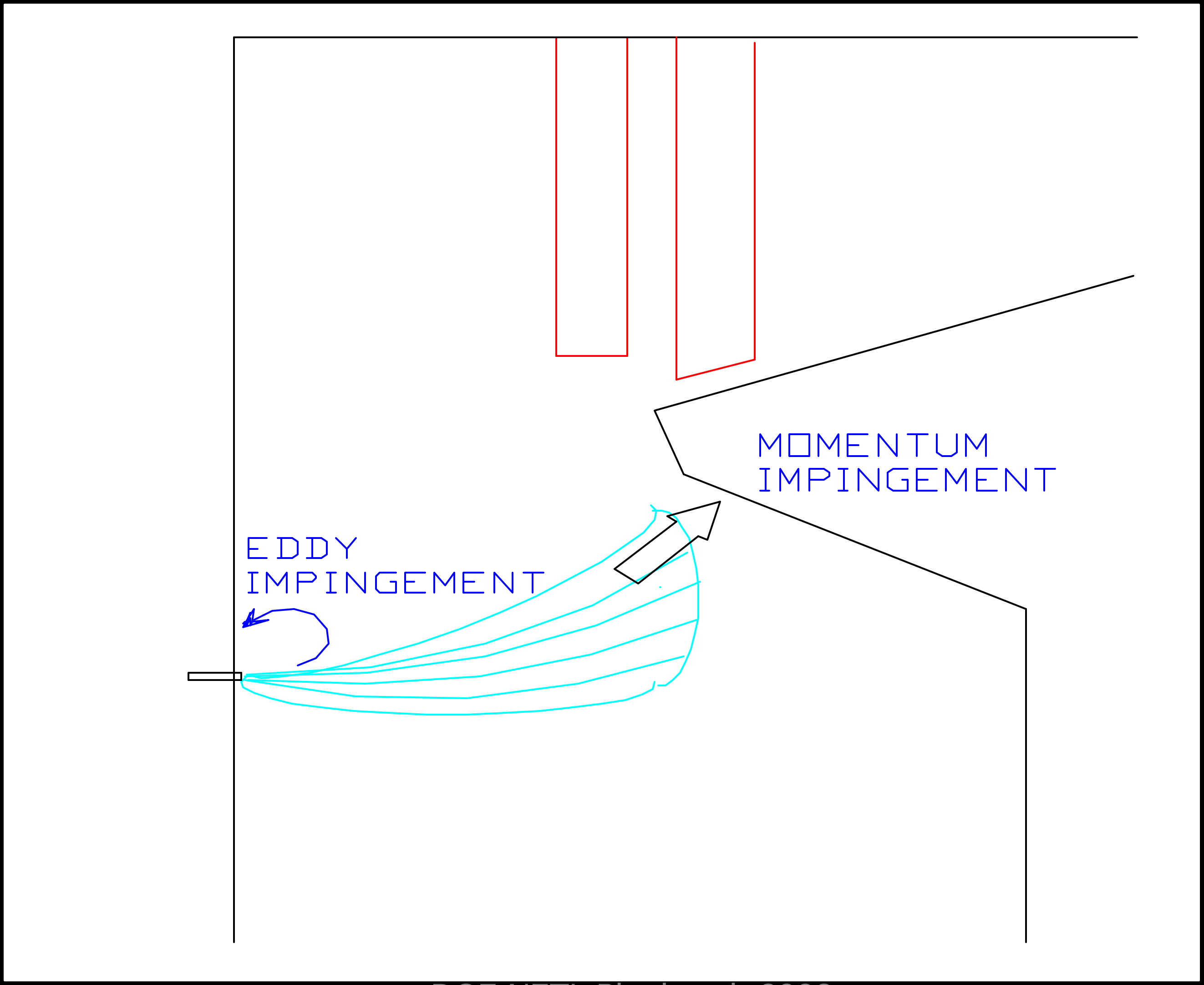
Operational Issues

- Corrosion
- Detached Plume Formation
- Air Heater Pluggage
- Nozzle Failure

Corrosion

- Localized corrosion at liquid injected SNCR facilities is a problem.
- Generally located in immediate vicinity of injector ports, or on opposite walls of narrow boilers.
- Especially problematic for fuels with high chloride and sulfur.

LOCALIZED CORROSION



Short Term Corrosion Fixes

- Reduce liquid impingement
- Extended wall injectors
- Higher air pressure/flow
- Lower water flow
- Inconnel overlay

Long Term Corrosion Fix

- Evaporate solution prior to injection.
- OTA (Once Through Ammonia) System
  – Patent Pending.
- Simpler, Cheaper, Smaller.
- Demo in 2002.

Plume Issue

- Quite common in non-scrubbed flue gas
- Most often detached from the stack
- Caused by condensation/combination at lower temperatures.
- Ammonium chloride, ammonium bisulfate, +?

Plume Suppression

- Slip reduction – keep less than 10 ppm
- Nozzle orientation/operation key.
- Get good stack and operational data.
- Ammonia monitors recommended for non-scrubbed facilities.

Not so fast

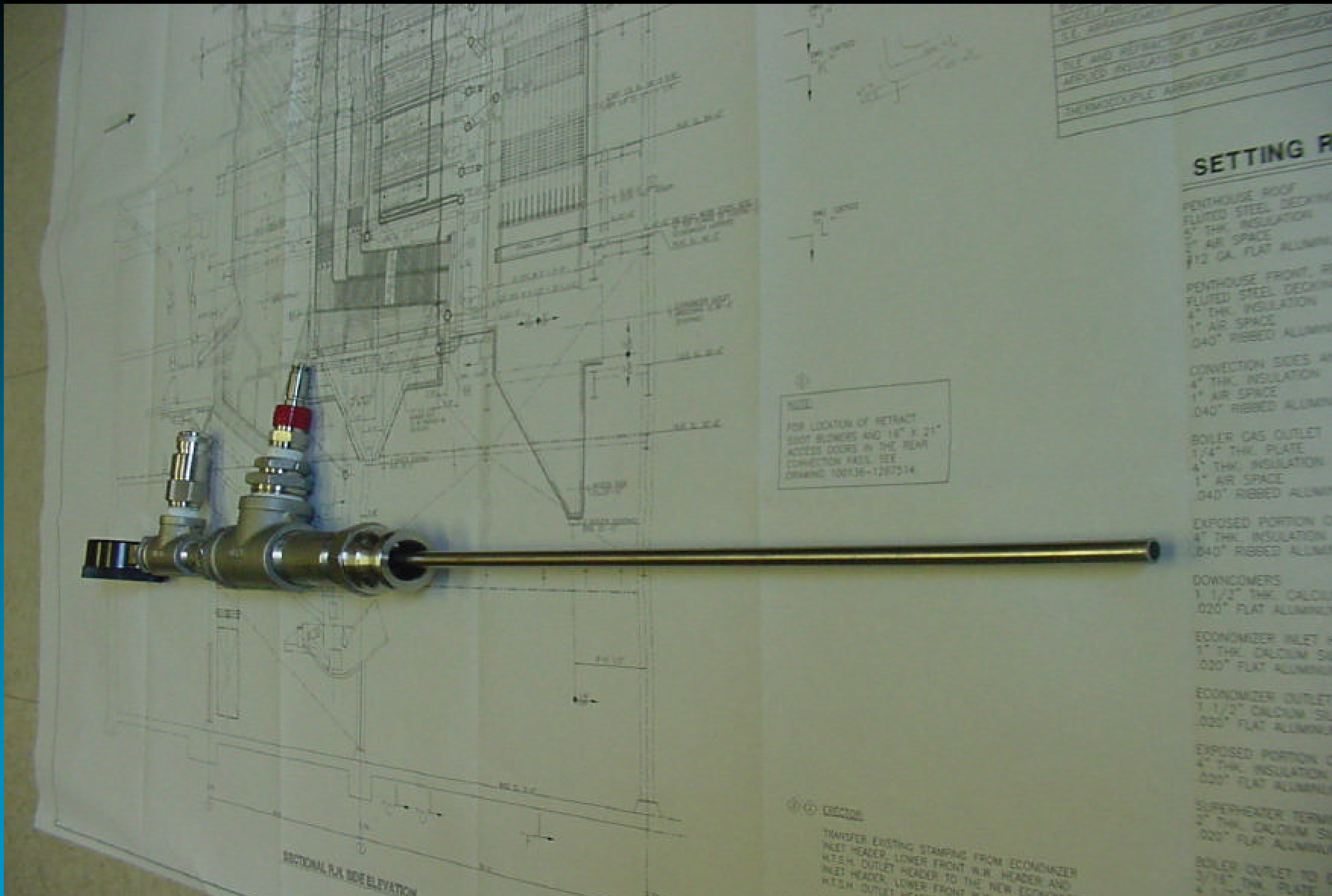
- Detached plumes can be difficult to diagnose and solve.
- Plumes observed at near zero slip
- Plumes not observed at high slip
- Not obvious from manual sampling analysis.

Air Heater Plugging/Corrosion

- Ammonium Bisulfate is a liquid above 300F
- Sticky material - difficult to remove.
- Not a problem with low sulfur fuels
- Again, minimize slip
- Another good reason for an ammonia monitor.

Injector Burn-out

- High Temperature Corrosion
- Erosion
- High alloy with heavy wall thickness
- Interchangable lances


SETTING

Combination Technologies

- Very compatible with combustion controls.
  - Low NOx Burners
  - OFA Injection
  - Gas Reburning
- NOx reduction approaching that of SCR at lower capital cost - $30/kW, 60-80% reduction.

SNCR Summary

- Mature Technology
- Fuel Indifferent
- Low cost alternative for first 50% reduction.
- Easily retrofitted
- Compatible with combustion modifications for High NOx removal