# Ammonia Slip – Measurement vs. Calculation

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# Ammonia Measurement Difficulties

- Ammonia ($NH_3$) is difficult to measure due to its solubility and reactivity with coexisting water and gases in flue gas.
- Because it is so soluble, sample cannot be dried prior to analysis.
- Permitted limits typically are on a dry basis.

# Ammonia Reactions

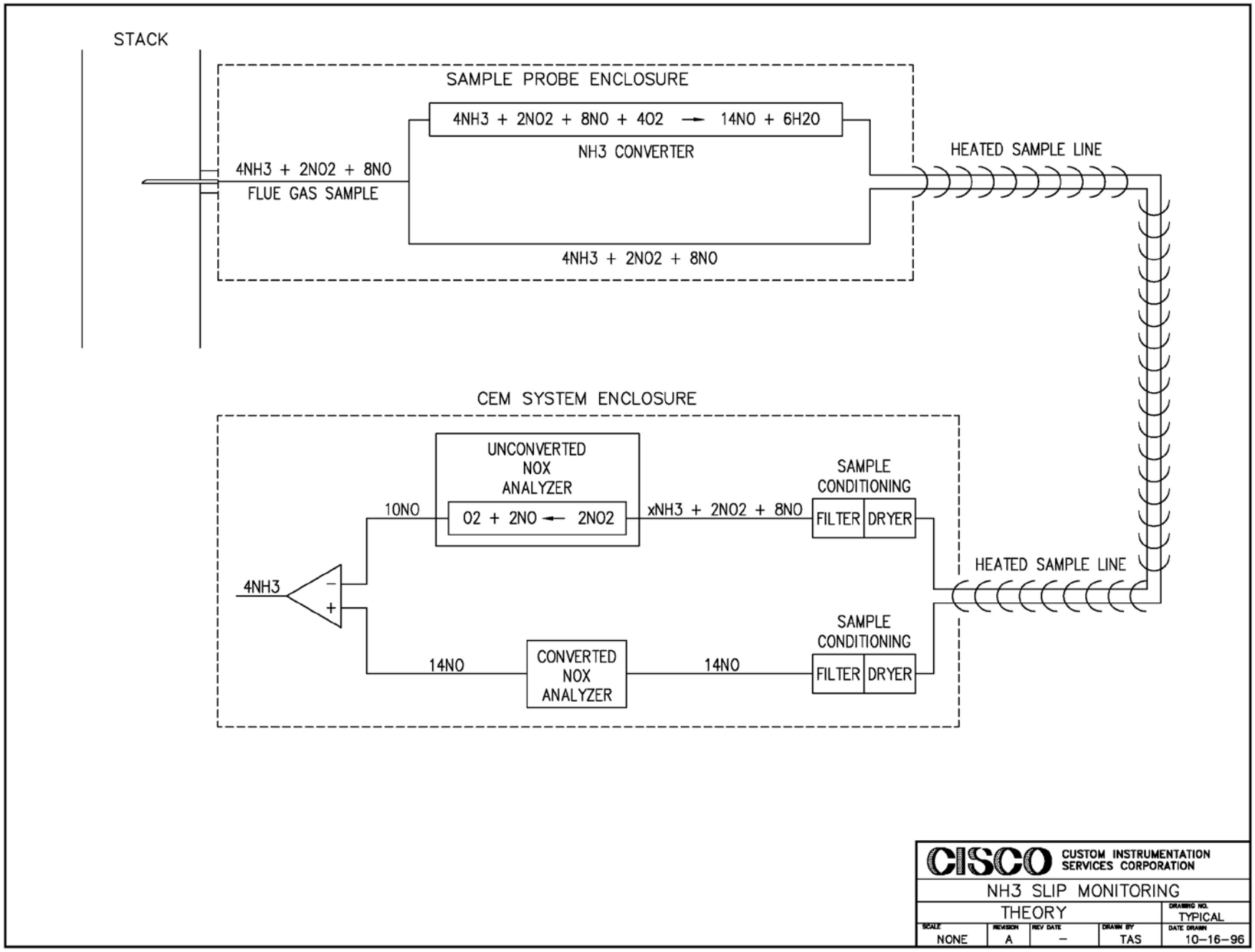
- $NH_3$ reacts with $CO_2$, $NO_2$, and $SO_2$ to form ammonia salts as temperature drops. These are all present in flue gas.
- Ammonia salts will foul sample systems.
  - CiSCO uses $NH_3$ scrubbers to prevent ammonia salts from fouling analyzers.
- Transporting $NH_3$ sample therefore is not advisable.

# $NH_3$ Reporting Methods

- CiSCO uses two methods to successfully report $NH_3$ slip on a continuous basis for compliance purposes:
  - Determination
  - Calculation
- Another option exists:
  - Tunable Diode Laser (TDL)

# Determination Method

- Also known as the Differential $NO_X$ method ($\Delta NO_X$)
- Process:
  - Two $NO_X$ analyzers
  - Two sample streams from single sample point
    - One sample with $NH_3$ slip converted to $NO_X$
    - $NH_3$ slip is determined from the difference between the two measurements.


STACK
SAMPLE PROBE ENCLOSURE
4NH3 + 2NO2 + 8NO + 4O2 → 14NO + 6H2O
NH3 CONVERTER
4NH3 + 2NO2 + 8NO
FLUE GAS SAMPLE
4NH3 + 2NO2 + 8NO
HEATED SAMPLE LINE
CEM SYSTEM ENCLOSURE
UNCONVERTED NOX ANALYZER
O2 + 2NO ← 2NO2
10NO
xNH3 + 2NO2 + 8NO
SAMPLE CONDITIONING
FILTER
DRYER
HEATED SAMPLE LINE
4NH3
14NO
CONVERTED NOX ANALYZER
14NO
SAMPLE CONDITIONING
FILTER
DRYER
CISCO
CUSTOM INSTRUMENTATION SERVICES CORPORATION
NH3 SLIP MONITORING
THEORY
DRAWING NO.
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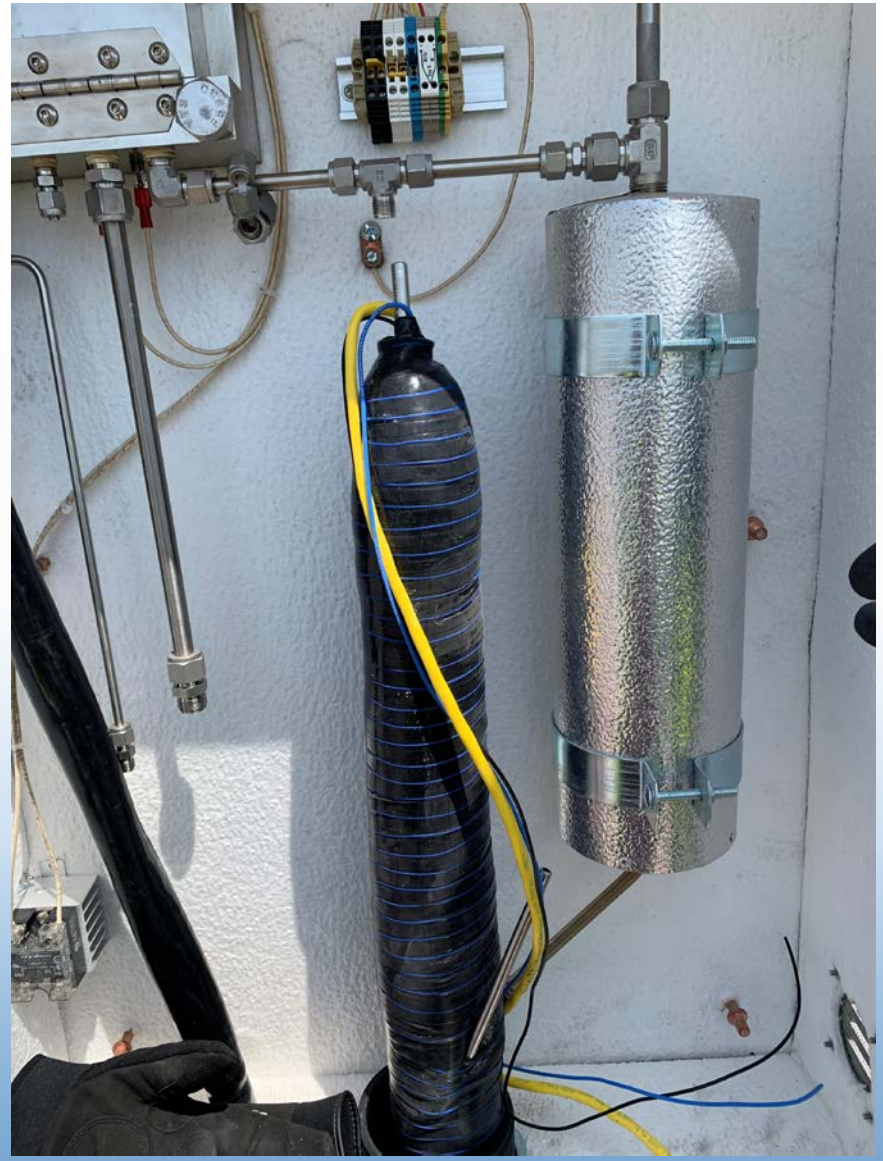

# Determination Method

- Up-front cost approximately $70k to add the required analyzer and sample handling equipment and material.
  - Does not include the stack $NO_X$ analyzer and associated sample handling system.
- Calibrate with NO gas – similar to $NO_X$ analyzer
- Annual replacement of the $NH_3$ converter, approximately $2k

# Determination Method

- Consideration should be given to the range of the converted $NO_X$ sample analyzer.
- The range needs to be high enough to capture the $NO_X$ in addition to the converted $NH_3$.
- The range should not be too high, which would prevent calibration using the Stack $NO_X$ calibration gas.
  - Example:

    Stack $NO_X$ analyzer range 0-10 PPM

    $NH_3$ ($NO_X$) analyzer range 0-16 PPM

# Calculation Method

- $NH_3$ slip = $NH_3$ injected – $NH_3$ consumed
- $NH_3$ consumed = $NO_X$ @ SCR inlet – $NO_X$ @ stack
- Requires a sample point to measure $NO_X$ at the inlet of the SCR

## *$NH_3$ Slip ppmvd (San Joaquin Valley Air Quality Management District)*

To calculate $NH_3$ ppm (slip) for the San Joaquin Valley AQMD.

$$R = \frac{\left( \frac{F_{NH3}}{17} - \left( \frac{\frac{F_{Stack}}{29} \times (A - B)}{10^6} \right) \right) \times 10^6}{\frac{F_{Stack}}{29}} \times CF$$

Units: ppm

Reference: San Joaquin Valley Air Quality Management District.

CiSCO Formula ID SJVAQMD $NH_3$ Slip

- R = Stack $NH_3$ concentration in ppm
- $F_{NH3}$ = $NH_3$ injection rate in lbs/hr
- $F_{STACK}$ = Stack flow in lbs/hr
- A = SCR $NO_x$ ppm
- B = Stack $NO_x$ ppm
- CF = Correction Factor (User Setting)

# Calculation Method

- Does not typically require certification
  - One exception: Pennsylvania
- With the addition of a correction factor, the CEMS value is corrected to match the source test value
  - Correction can be significant
  - Correction value is based on tested operating conditions

# Calculation Method

- Up-front cost approximately $70k to add the required analyzer and sample handling equipment and material.
- SCR Inlet $NO_X$ analyzer can be used to control $NH_3$ injection as well (not done in the CEMS).
- There are many CiSCO systems using this method.
  - Required in some areas
- Various agencies have their own formula.

# Alternative Option – In Situ TDL

- Approximately $70k cost for the analyzer itself
- Performs $NH_3$ measurement across the stack using a laser
- Measurement on a wet basis
  - Analyzer can also measure $H_2O$ to allow correction to dry basis if required for reporting.