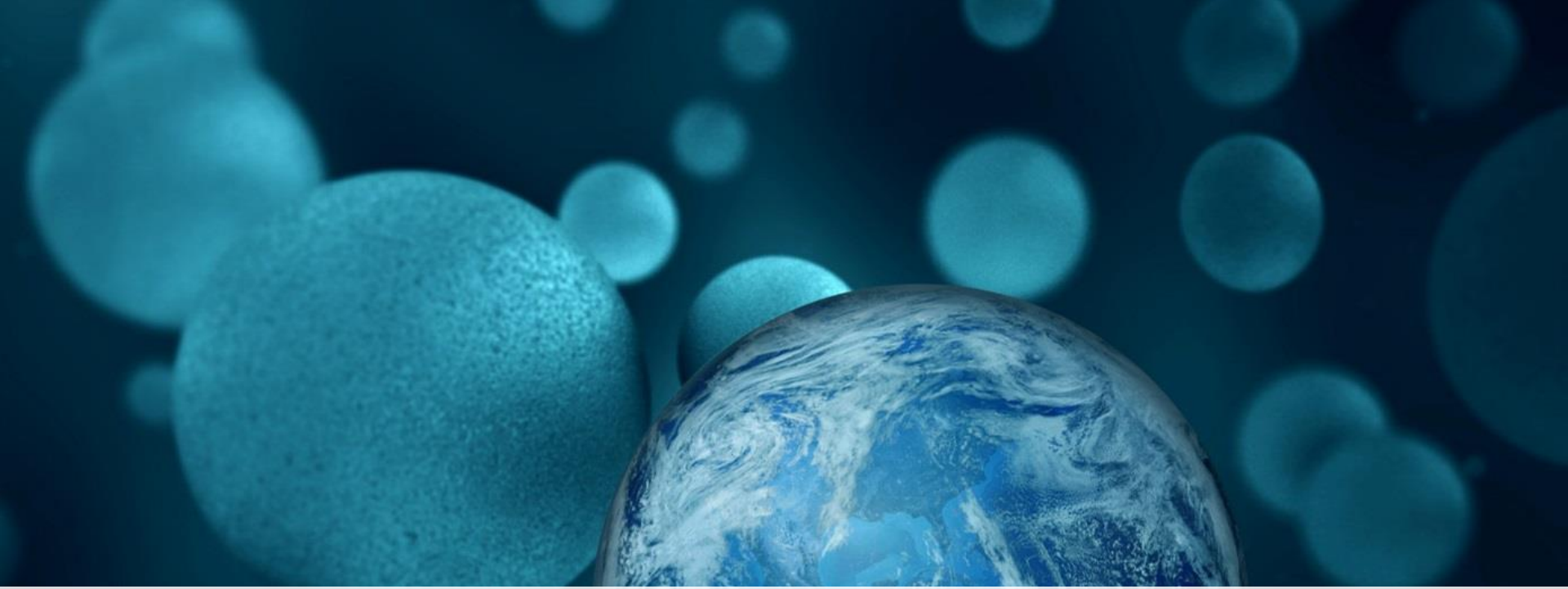

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Comparison/Contrast of NH3 Measurement Systems: TDL(Tunable Diode Laser) vs. Differential Chemiluminescence

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Clean Coal Conference. Houston June 2019

Agenda

- Define NH3 Slip
- What is a Selective Catalyst Reduction System?(SCR)
- Reasons for Monitoring
- Monitoring Techniques(Sample extraction types)
- Explain: “Grain loading” (dust loading)
- Chemiluminescence Differential system description
- “Dogs and Fleas” example
- Performance Specifications? PS-18?
- Conclusions

What is Ammonia SLIP?

- NH3 or “Ammonia” SLIP is unreacted NH3 that was designed to reduce NOx emissions.

- Ammonia slip is measured after the NOx reduction equipment. In circumstances where combustion sources experience a high level of ammonia slip, the excess un-reacted ammonia can contribute to increased corrosion, fly ash contamination, increased formation of ammonium salts on the air pre-heater and other downstream surfaces and emission of gaseous ammonia.

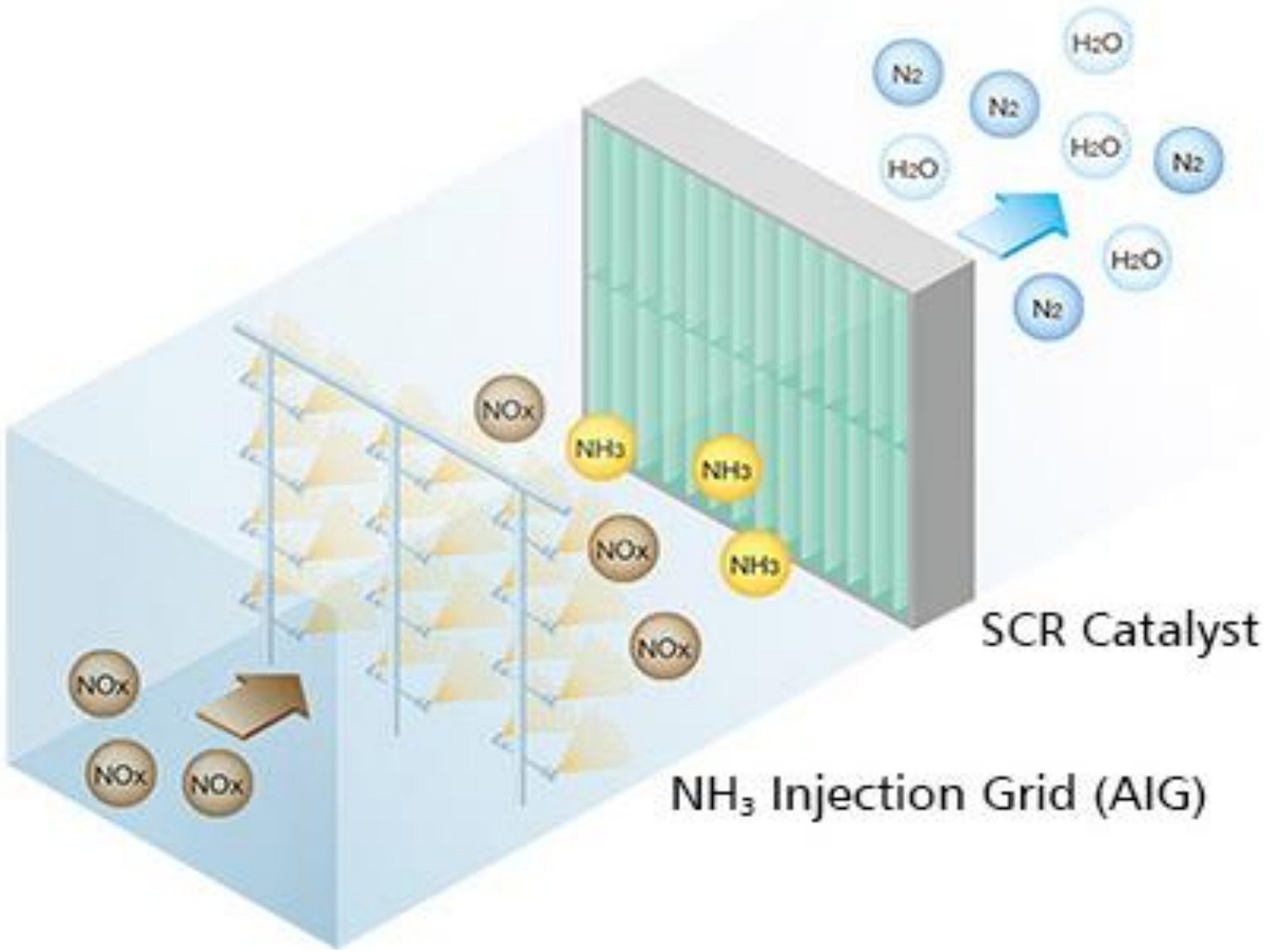
What is an SCR? (Selective Catalytic Reduction)

- In the SCR process, the reaction chamber contains a catalyst bed where NOx from the flue gas is reduced to nitrogen (N_2) and water (H_20) by the reaction of NOx and ammonia (NH_3). The SCR process is normally operating in the temperature range of 250˚- 400˚C. The primary reactions occurring in an SCR are given below:

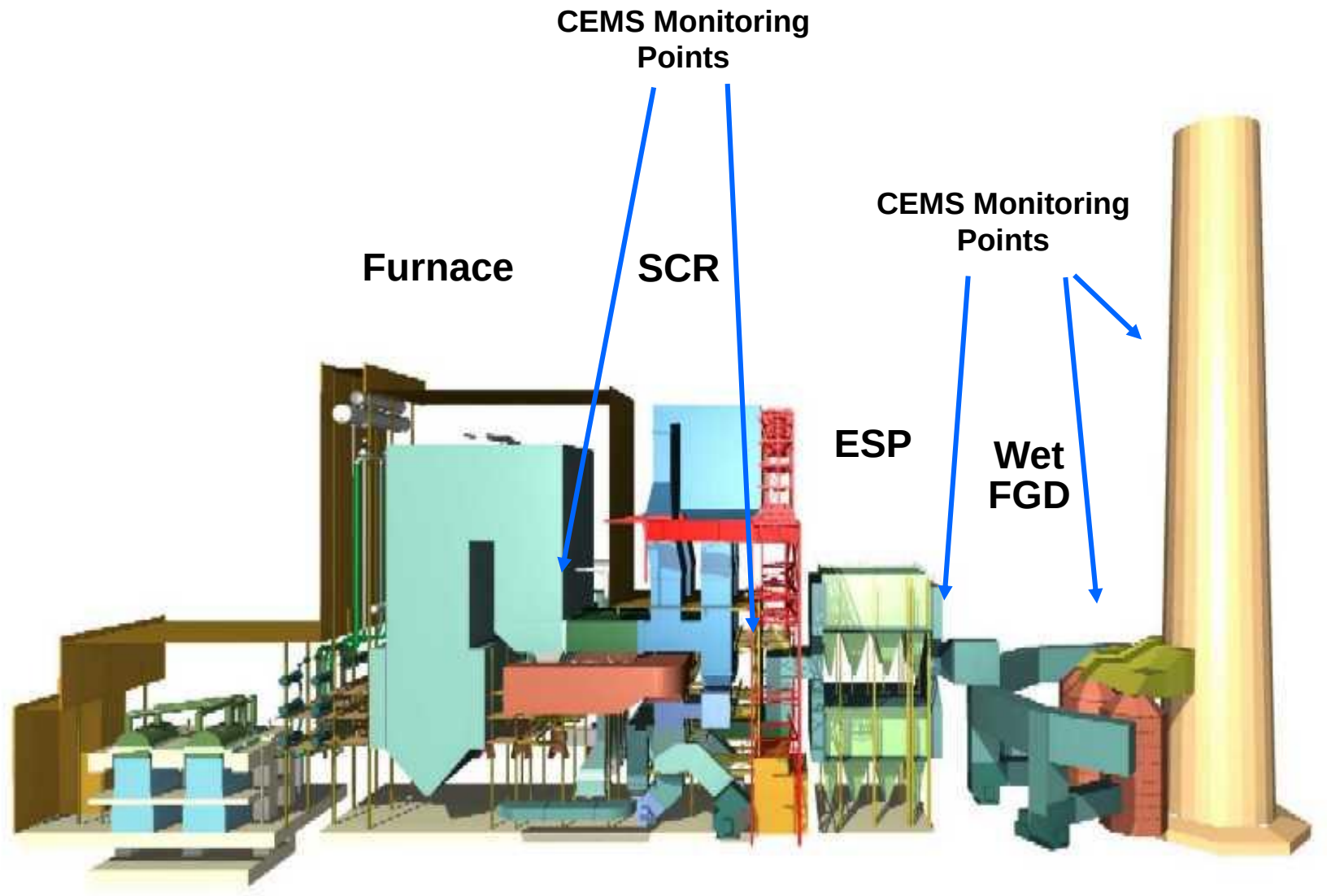
- $4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$

- $2\ NO_2 + 4\ NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$

Why Monitor the outlet of SCR on a coal fired unit?

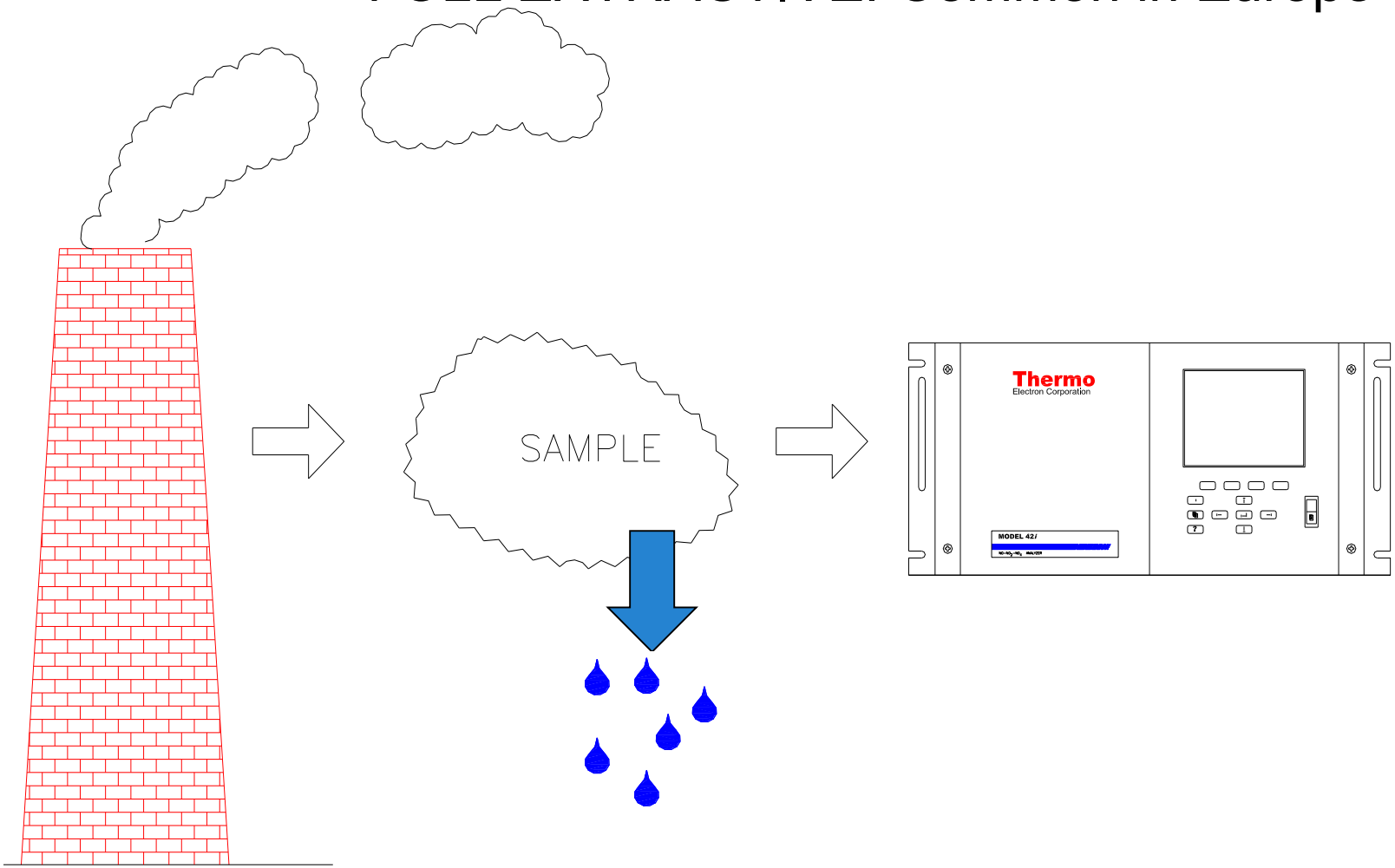


Typical Power Plant – CEMS Monitoring Points



Full Extractive- Dry Basis

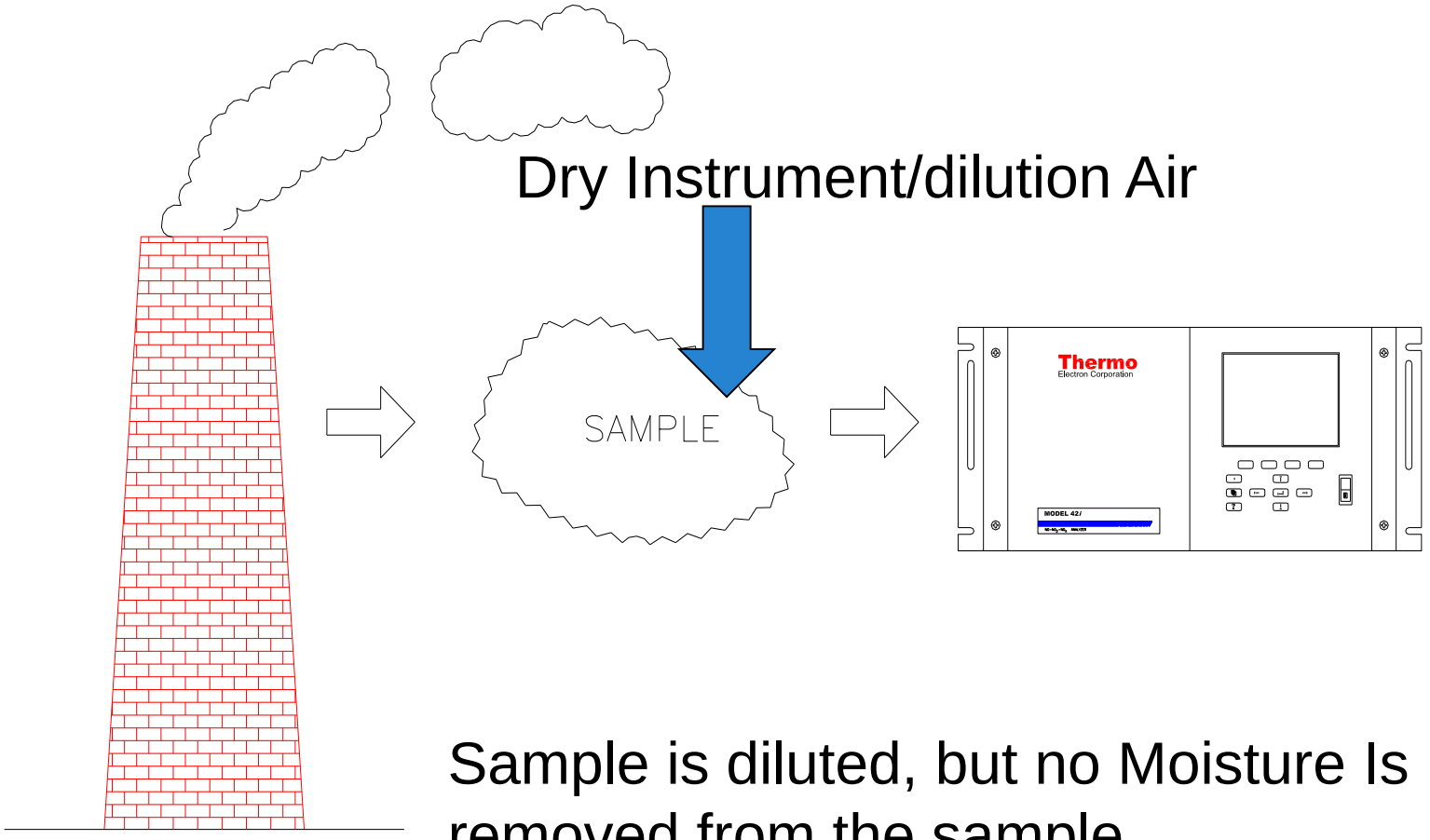
FULL EXTRACTIVE: Common in Europe



Moisture Removed by sample chiller

Wet Basis Dilution

DILUTION SYSTEM- Common in the United States



Sample is diluted, but no Moisture Is removed from the sample

Dust Loading? How much is “A lot of dust”?

Compare and contrast grains/dscf vs. grams/m^3. (7,000 grains= 1 lb) (DSCF means Dry Standard Cubic Foot)

- 0.0009 gr/ft³ ~2 mg/m³ *(Common output at final exit stack with good ESP/Fabric Filter and Wet Scrubber for SO2-FGD)*
- .022 gr/ft³ ~ 50 mg/m³ *(Common output for non-FGD system final exit stack loading with ESP and no Fabric Filter)*
- 1 gr/ft³ = 2,288 mg/m³ *-Reference point*
- 5 gr/ft³ = 11,441 mg/m³ *(A value BEFORE the ESP on low ash coal)*
- 10 gr/ft³ = 22,883 mg/m³ *-Reference point*
- 12 gr/ft³ = 27,460 mg/m³ *(A value BEFORE the ESP on HIGH ash Coal)*

NH3 Monitoring System

- **Chemiluminescence (Specified in RATA method 7E)**

The Model 42*i* operates on the principle that nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO_2 molecules decay to lower energy states. Specifically,

$$NO + O_3 \rightarrow NO_2 + O_2 + h\upsilon$$

Nitrogen dioxide (NO_2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO_2 is converted to NO by a molybdenum NO_2-to-NO converter heated to about 325 °C (the optional stainless steel converter is heated to 625 °C).

Typical Chemiluminescence NOx Analyzer Schematic

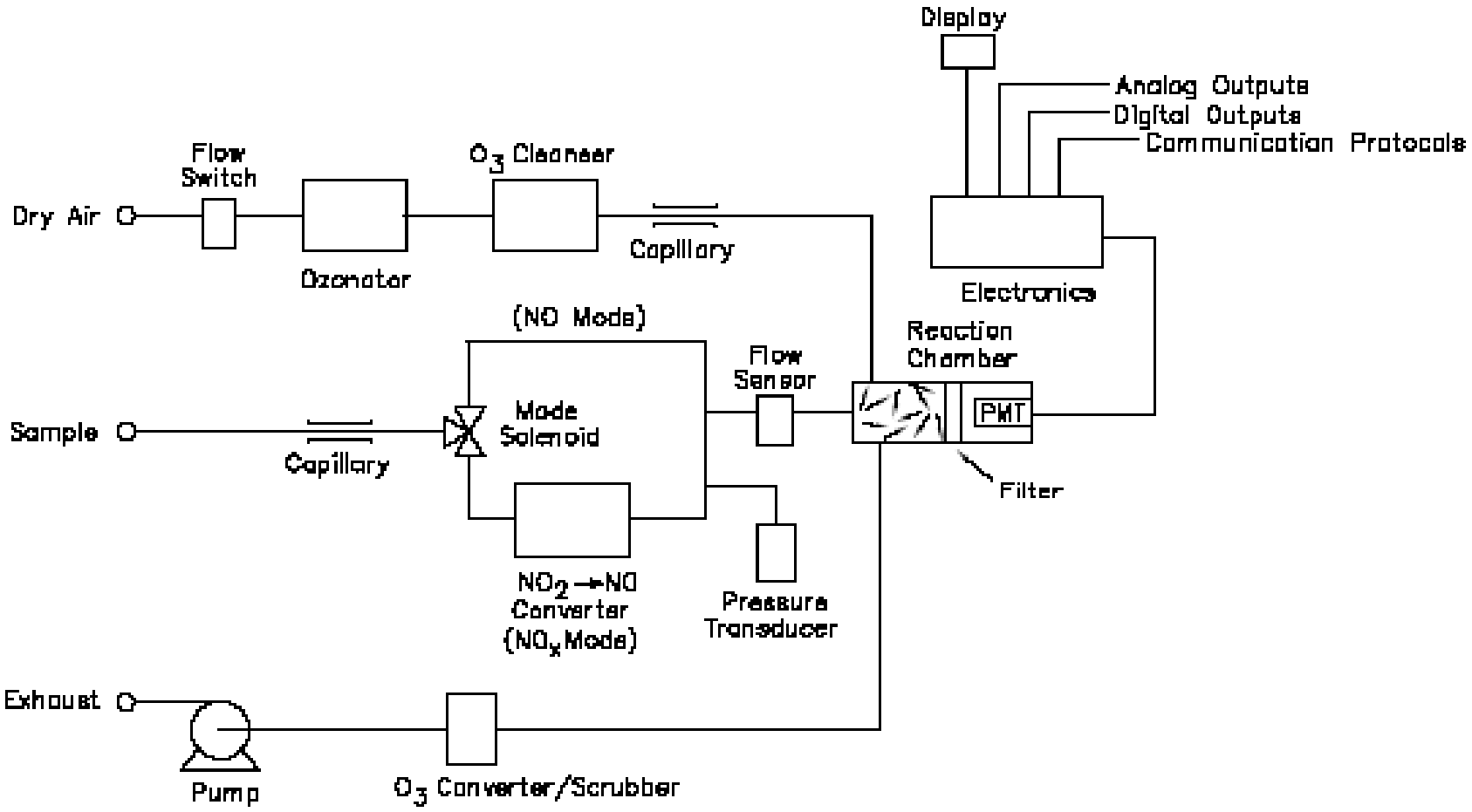


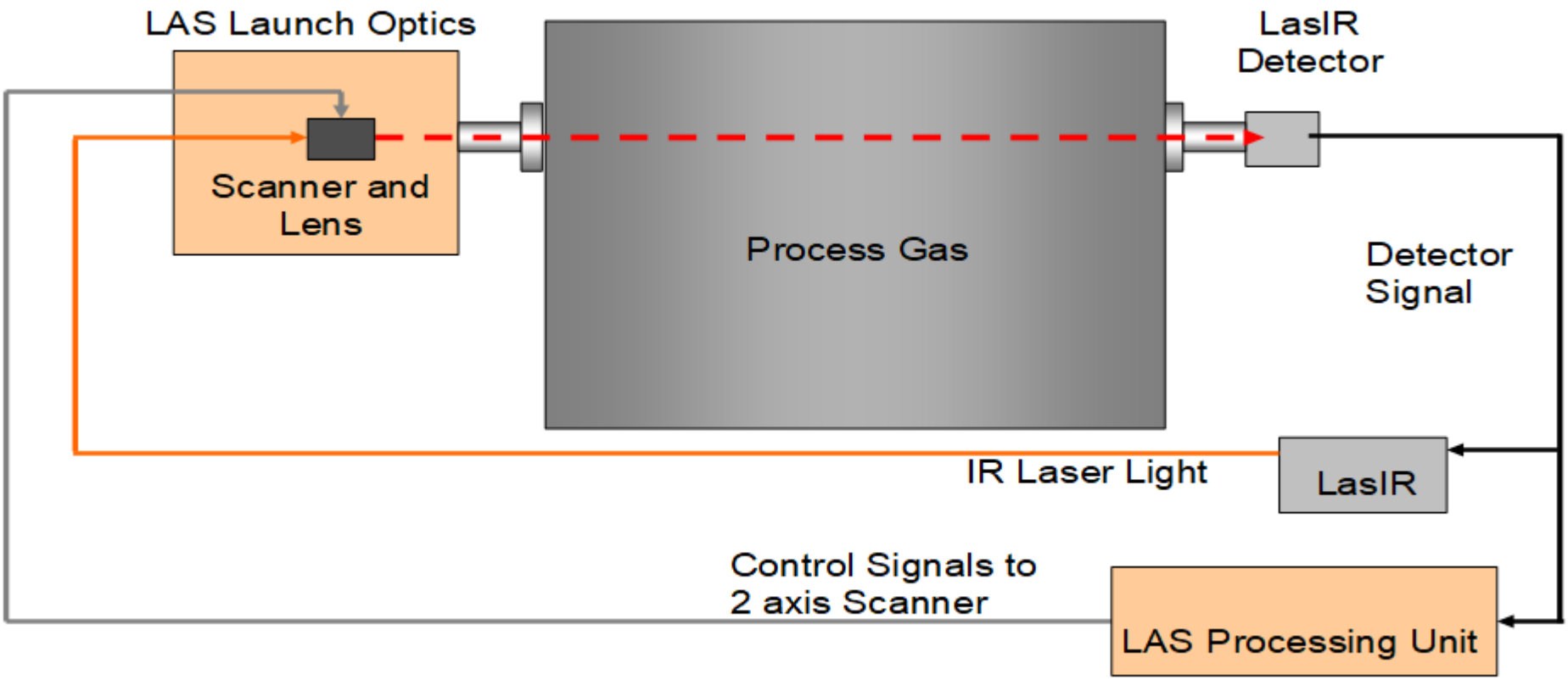
Figure 1-1. Model 42*i* Flow Schematic

NOx Differential Chemiluminescence Calibration Procedures

- Example: NOx range 0-30 and NH3 range 0-30 also.
- Always use NH3 calibration gas balance Air, not N2.
- Perform a calibration check with NO at 25 ppm. Check both the NOx and the NH3 analyzers and adjust to 25 ppm.
- After adjusting the NOx and NH3 analyzers (Both identical NOx analyzers), begin injecting the NH3 calibration gas.
- The NOx analyzer should drop to zero, due to the NH3 being scrubbed out at the sample conditioner. There is also an additional NH3 scrubber inside the NOx instrument ‘just in case’ there is a carryover.
- The NH3 analyzer (Identical to the NOx analyzer) should then reach over 95% of the value of the tag value of the NH3 cylinder. The difference between the response of the NH3 analyzer and the tag value can be recorded as ‘converter efficiency’ and stored in the PLC/datalogger.
- After returning to sample mode, the data system simply subtracts the NOx value response from the NH3 analyzer response and applies the ‘converter efficiency’ adjustment. The resultant is the NH3 slip value.

NH3 Tunable Diode Lasers

- Cross Stack Systems cannot be calibrated with NIST Traceable Gases.
- Extractive systems can be calibrated with gases
- We don’t believe that EPA HCL PS-18 applies to these systems.(Use caution)



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Key Conclusions

If you use Differential Chemiluminescence:

- NH3 is water soluble. You should convert it to NO before transport.
- Consider Dust loading and the use of Wet basis Dilution or full extractive, depending upon where you are sampling
- If you have more than 10 times NO vs. NH3, then consider TDL or other technologies. (Dogs and Fleas Example)
- If you have less than 10:1 NO:NH3, then Differential Chemiluminescence systems work well and are proven.

If you go with Tunable Diode Laser (TDL), consider:

- What is the dust loading on a cross stack system?
- Should we use an extractive system for a direct/filtered measurement?
- Can we calibrate with an actual gas standard?

IN EVERY CASE- do your homework FIRST:

- Perform an EPA method 7E test to see what the real values of NOx exist. https://www.epa.gov/emc/method-7e-nitrogen-oxide-instrumental-analyzer

- Perform an EPA Method 320 FTIR test to find out the real values of NH3. https://www.epa.gov/emc/method-320-vapor-phase-organic-and-inorganic-emissions-extractive-ftir

- Perform an EPA Method 5 test to find the dust loading in Grains/dscf or grams/m^3. https://www.epa.gov/emc/method-5-particulate-matter-pm

Power Plants are like people, their chemistry is unique and need to be treated accordingly

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