Building Emission Measurement

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www.AgAirQuality.com
Purdue Methods Project
2001-2002

- QAQC-based contract
- Large vane anemometers
- Small vane anemometers
- FANS tests on fan outlet
- BESS tests of removed fans
- Effect of fan degradation on flow
- Spatial, temporal variations
- Bypass pumping
- GSS flow and pressure meters
- Sampling period 5-10 min
- Cal gas inputs into gas probes
- Analyzer comparisons
  - Nt vs. auto modes on 17C
  - OP-FTIR, CL, EC, PIR
- TEOM pilots (TSP, PM10, PM2.5)
  - Collocation of four TEOMs
  - Test 30 vs 50 C
  - Effect of cleaning, filter changes
- Odor sampling in barn vs lab
- Wireless ISP, web publishing
- “Pilot test for APECAB”
Ammonia emission = k x 186 m³/s x (25.3 – 1.6) = 11,267 g/d
Two federal projects ‘01-’04

- Mechanically ventilated livestock buildings
- Continuous emission monitoring (source)
  - Multiple gas sampling points
  - Gases (NMHC, CH4, NH3, H2S, traces)
  - PM10, TSP, PM2.5
- Grab samples (bags, traps, canisters)
- Reliable emission measurements

Control of Air Pollutant Emissions from Swine Housing
CAPESH (funded by EPA and Premium Standard Farms)
Aerial Pollutant Emissions from Confined Animals Buildings
Tunnel-ventilated finishing houses with flushing in Missouri

- Obtain baseline emissions
- Test soybean oil sprinkling
- Test essential oils
- Test “biocurtain”
- Available summer 2003

Control of Air Pollutant Emissions from Swine Housing
Single-Speed Fan Airflow

- Fan performance curve, degradation
- Fan removal and test at BESS lab
- FANS tests (AMCA transfer standard)
- Small vane anemometers
- Fan operation (go downstream)
- Fan static pressure

FANS, an AMCA transfer standard (spot measurement)

BESS Lab (AMCA-Standard)

Small vane anemometer AMCA transfer standard (continuous measurement)
Airflow of Variable Speed Fans

- Fan removal and test at BESS lab
- Fan operation
- FANS tests to calibrate flow devices
- Full impeller anemometers (direct) in chimney
- Small vane anemometers (direct)
- Indirect method for belt drive fans
  - Static pressure
  - Impeller rpm
- Ancillary information
  - Fan performance curve
  - Speed control signal
  - Motor voltage

![Graph showing airflow and pressure data]

- **Airflow**
- **Pressure**

![Image of variable speed fan]

- **SVA**
Instrument Shelter

- Space for instruments usually unavailable
- Instrument protection and security
- Key to quality assurance
- Analyst comfort
- Mobile
Ammonia and Hydrogen Sulfide

Pulsed fluorescence (convert to SO₂)

Chemiluminescence (convert to NO)
Gas Sampling Probes and Locations

- Extractive sampling
- Filtered air
- All Teflon
- Random sampling
- Select primary representative exhaust fan (PREF)
- Maximize exhaust
- Minimize ambient
- Be willing to ignore exposure locations
Sampling Location Groups (SLG)

- Pit fans operated together as group
- Pit fans too far apart for one to represent others.

Primary representative exhaust fan (PREF) for wall fan group
NH₃ Concentrations by Location

November 8, 2002
CAPESH Site

NH₃ Concentration, ppm

Time of Day, h (Nov. 8, 2002)

Barn A
Sampling cycle
Ambient

Barn B
Relative humidity/temperature probe
TEOM sampler for PM10
Air sampling
Static pressure port
Temperature sensor
Odor sampling location

Floor plan (61 m x 13.2 m)

Barn 7

Barn 8

End view

End view

Fan #

South

Background air sampling

Instrument trailer

Instrument trailer

Summer air inlets

Attic

Pens

Shallow pit with recycle flush

Exhaust air sampling

Diffusers

Anemometer (SVA)
- Multiple locations (24)
- Prevent condensation
- Monitor pressure (0-1 psi)
- Monitor flow (0-10 L/min)
- Bypass pumping
- Proper surfaces (Teflon)
- Low residence time (< 60 s)
- Regular leak tests
- Grab sampling provision
- Calibration gas provision
- Provide for additional analyzers
Sampling probes, 10-115 m long

Bypass pumping circuit

9.5 mm OD, 6.4 mm ID Teflon

M1

7.9 mm OD, 4.8 mm ID vinyl

P1

22.2 mm OD
15.9 mm ID vinyl

M2

26-solenoid manifold

Pressure sensor

M3

Exhaust

9.5 mm OD, 6.4 mm ID Teflon

Exhaust

6.4 mm OD
3.2 mm ID vinyl

Analyzer

NH₃

H₂S

CO₂

CH₄/VOC

Cal gas circuit

Bag fill port

Flow restrictors

Mass flow meter

6-port diluter (5 L/min)

Sampling probes, 10-115 m long

Barn 7 calibration

Barn 8 calibration

Leak test circuit

Air valve

Rotameter

Jar

P4

P4

P: pump

S: solenoid

M: manifold

F: filter

M: manifold

P: pump

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6-port diluter (5 L/min)
Odor Sampling

- Use gas sampling system
- Freeze fans during sampling
- 2-3 replications
- Flush and precondition bags
- Include background
Microweighing Technology

Sampling Inlet

Vacuum Pump

Flow Splitter

Flow Controller

Aux. Flow

Main Flow

Control Unit

Sensor Unit

Filter

13.67 l/min

3.00 l/min

Critical venturi

Filters

Multi-point gravimetric filter sampling

Pressure monitor

Vacuum pump

Source: Wang et al. (1999)

Source: Hinze et al. (1999)
Collocated TEOM PM10 in Layer House (baseline test)

TEOM TSP data in Missouri swine Houses (abatement test)
Collocated PM10, PM2.5, TSP
Process Monitoring

- Animal activity
- Heaters
- Evaporative cooling
- Curtains
- Feeders
- Flushing
- Oil sprinkling
- Traffic
- Weather

![Graph showing H2S Concentration, TSP Activity, and Flushing events over time.]

![Graph showing Oil pressure and RH B7 over time.]

![Graph showing Concentration, µg/m³ over time.]

![Graph showing Time of Day, h (Nov. 8, 2002).]
Data Acquisition Systems

- State of the art hardware, software
- On-line data inspection
- Alarm emails
- Automatic backups
- Automatic calibration
- Instrument interfacing
- Sample line control
Other Measurements

- Naturally ventilated houses.
- Nitrogen mass balance.
- Sulfur mass balance.
- Carbon mass balance
- Simultaneous downwind measurements.

J. Sweeten
Summary

- Protocol for air emission measurements is well established for MV barns.
- Seven barn emission sites underway in U.S.
- QAQC is critical.