

Research, Progress and Regulatory Programs for Odor and Air Quality from Intensive Livestock and Feeding Operations in America




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Building Environment Research & Education

Agricultural and Biological Engineering

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Air Emissions from Livestock

- Odor
- Ammonia
- Hydrogen sulfide
- Particulate matter (dust)




Seminar Topics

- Environmental pressures on livestock producers
- Air emission research
- Proposed compliance agreement




Nuisance Suits

- Neighbors seek for:
 - Actual damages
 - Punitive damages
 - Injunction to close the operation
 - Court order for abatement of odor
- Iowa Supreme Court ruling in 1998

Cases in Iowa (3/03)

Defendant	Operation	Damages Suffering/Property
ISU 1990	200-sow farrow to finish Slurry tank	\$20K/-
Wolff 1994	800 finishers Earthen basin	\$45K/\$11.5K
Pork Xtra 2002	4000 finishers Deep pit	\$46K/\$50K
Pork Innovation 2002	4,170 finishers Deep pit	-\$76K
Iowa Select Farms 2002	31,500 finishers 2-cell lagoon, deep pit	\$962K/\$103K (appealed, confidential)

Sources: Miner, 1997; van Sickle, 2003; Lee, 2004


Nuisance Suits

- Neighbors seek for:
 - Actual damages
 - Punitive damages
 - Injunction to close the operation
 - Court order for abatement of odor
- Iowa
 - Supreme Court ruling in 1998
 - 14 lawsuits on the books
- Missouri
 - 52 neighbors v. Continental Grain: \$5.2M award
 - 60 nuisance suits against PSF since August, 2002
- Nebraska
 - 11 families v. Progressive Swine Technologies, 2004

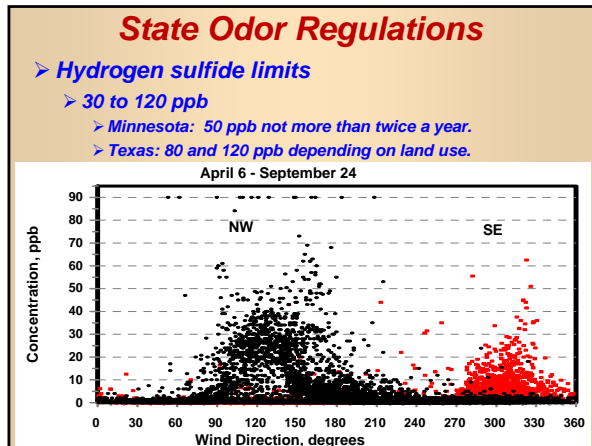
Sources: Miner, 1997; van Sickle, 2003; Lee, 2004

State Odor Regulations

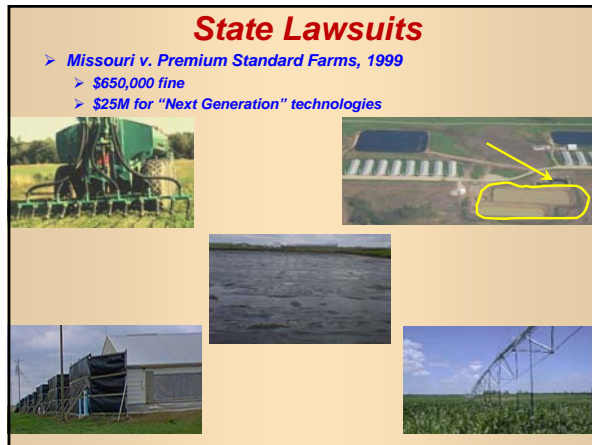
- Indirect Regulations
 - Permits (odor management plans)
 - Setbacks (minimum buffer distances)
 - Operator training (certification)
 - Land application restrictions (inject)
- Direct Regulations
 - 10 states (Redwine and Lacey, 2000)
 - Property line limits
 - Field olfactometry readings (2-8 D/T)
 - Gas concentrations (H₂S and NH₃)
- Lawsuits and consent decrees



NASAL RANGER
First Generation



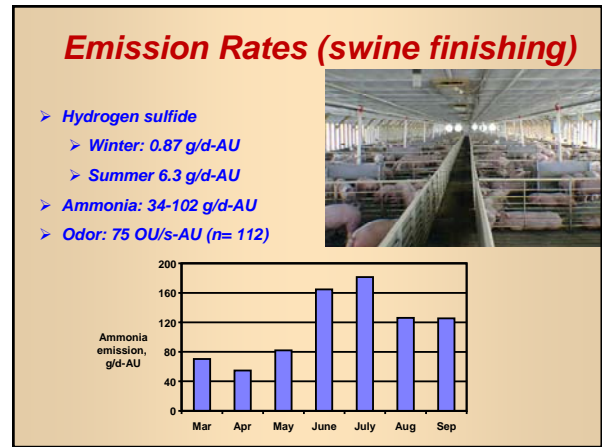
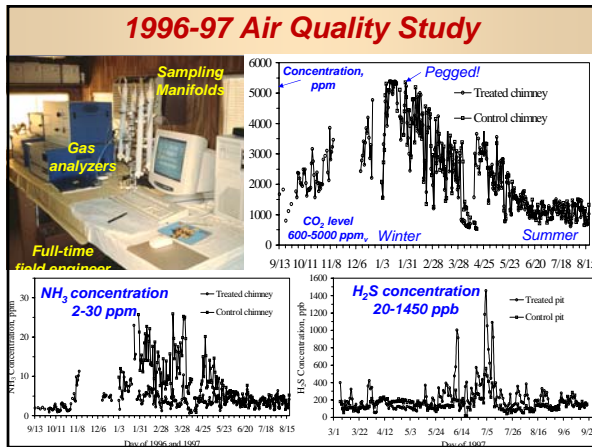
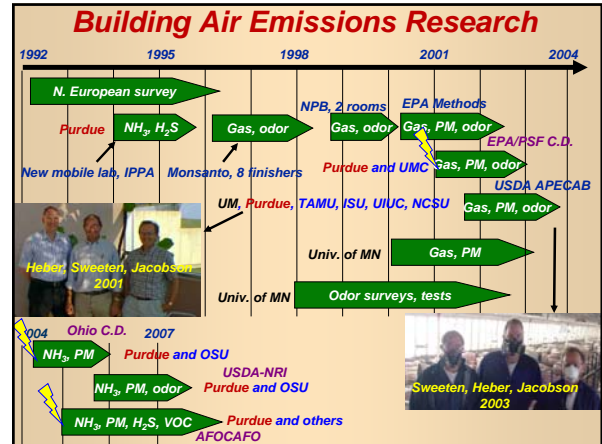
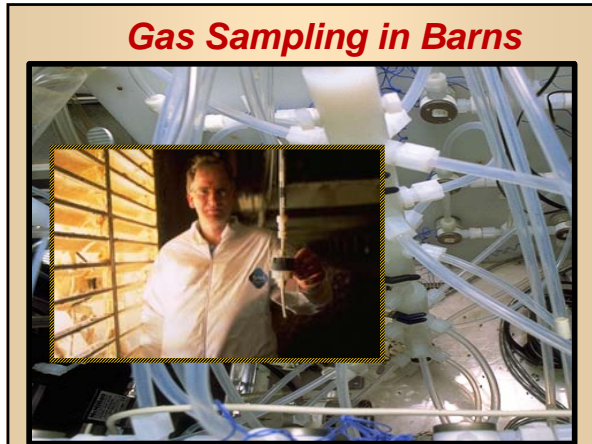
- ### State Odor Regulations
- Colorado: Farms > 364K kg live mass must:
 - obtain a permit
 - install covers on effluent ponds
 - adhere to setbacks
 - adhere to land application bans
 - implement odor control technologies and work practices
 - North Carolina
 - 7-year moratorium on new hog facilities
 - New odor rules in 2000
 - Odor management plans
 - Odor control if plan doesn't work
-



- ### State Lawsuits
- Ohio v. Buckeye Egg Farms
 - Must convert deep pit barns to belt-batteries
 - Revoked operating permits, July, 2003
 - Closed down one facility, November, 2003
 - California legislation SB-700
 - Dust
 - Ammonia
 - VOCs
-

- ### Federal Lawsuits
- Authority: U.S. Clean Air Act of 1990
 - 1. U.S. v. Premium Standard Farms, 2001
 - Air and water issues
 - \$350,000 penalty
 - Effluent pond emission monitoring
 - Barn emissions monitoring
 - Test soybean oil sprinkling
 - 2. U.S. v. Buckeye Egg Farms, 2004
 - Air issues
 - \$880,000 penalty
 - Barn emissions monitoring and controls
 - Test dust and ammonia abatement
 - Short term tests indicated 700 tons PM/yr > 250 limit!

- ### Influence of Science
- Regulations
 - Shaped by untimely political and societal pressures
 - Marked by simplicity, unfairness, arbitrariness, inaccuracy
 - Scientific knowledge will influence the regulations
 - USDA Agricultural Air Quality Task Force
 - Four university scientists are members
 - Task force reports to Secretary with white papers
 - White paper on livestock odor, 2000
 - National Academy of Science
 - Addressed accuracy of EPA emission factors
 - Published report in 2003
 - Referenced numerous times since publication



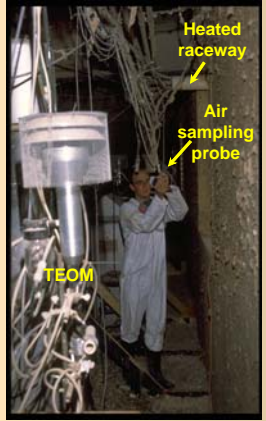
Manure Additive Study, 1999

- ✓ 7 of 35 products reduced NH₃ by 3-15%
- ✓ 7 of 35 products reduced H₂S by 23-47%
- ✓ No products reduced odor emissions

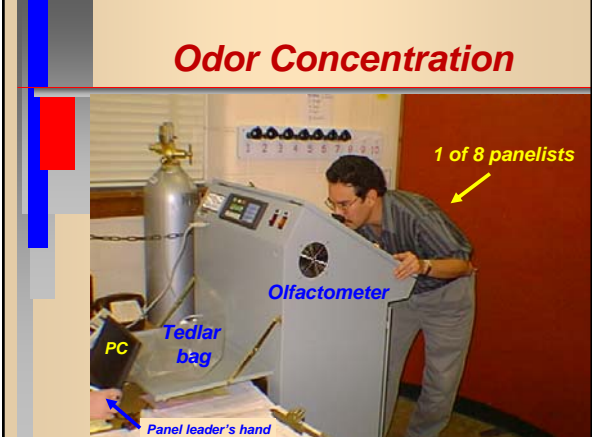
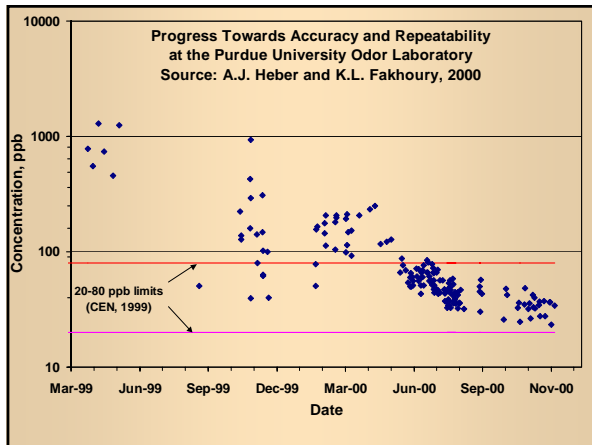
Real-Time Particulate Matter Monitoring

Purdue Methods Project 2001-2002

- > QAQC-based contract with EPA
- > 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 of sample lines
- > GSS flow and pressure meters
- > Sampling period 5-10 min
- > Cal gas inputs into gas probes
- > Analyzer comparisons
 - > Mt 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"




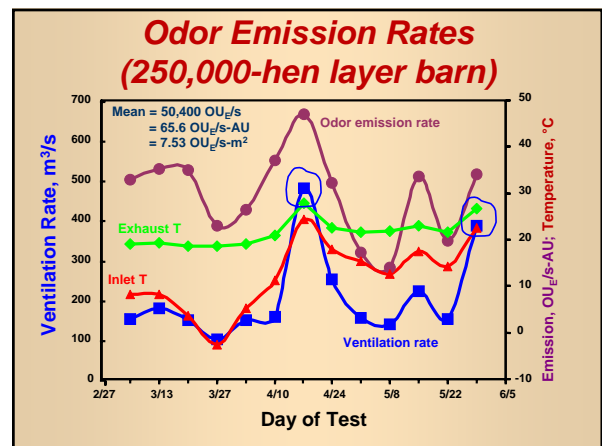
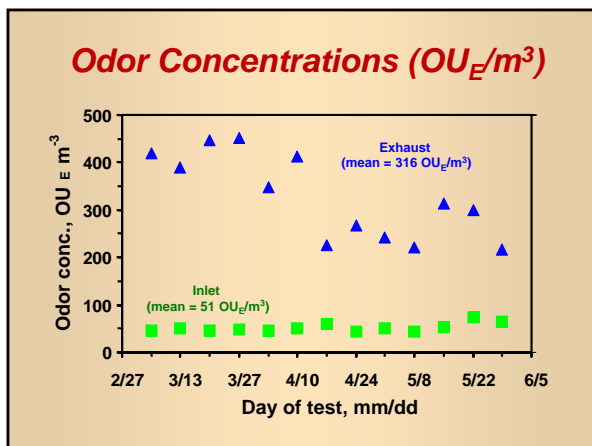
Odor Concentration

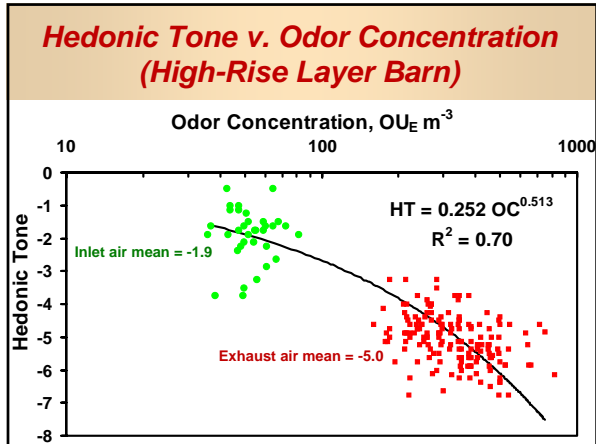



Physical Factors of Odor

Odor: Property or quality of a thing that affects, stimulates, or is perceived by the sense of smell.

1. Odor concentration, OU/m^3
2. Odor intensity
3. Persistence
4. Hedonic tone
5. Hedonic tone behavior
6. Character descriptions



Two emission projects '01-'04

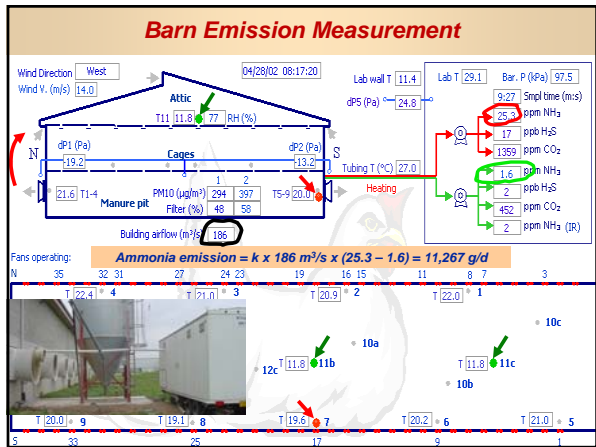
Control of Air Pollutant Emissions from Swine Housing
CAPESH (funded by EPA and Premium Standard Farms)

- Mechanically ventilated livestock buildings
- Continuous emission monitoring (source)
 - Multiple gas sampling points
 - Gases (NMHC, CH_4 , NH_3 , H_2S , traces)
 - PM_{10} , TSP, $PM_{2.5}$
- Grab samples (bags, traps, canisters)
- Reliable emission measurements

APECAB (IN site)

APECAB Project (USDA-IFAFS)

CAPESH Project (EPA and PSF)



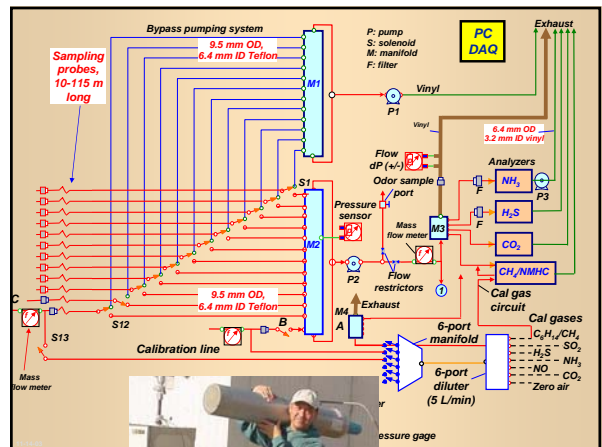
On-Farm Instrument Shelter

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

Top Quality DAQ Systems with Remote Access

Gas Sampling 2001 and 2002

- 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
- Can add analyzers



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

Two 250,000-Hen High-Rise Layer Barns

Building Layout and Sampling Locations

Two 1,100-hd Tunnel-Ventilated Swine Finishing Barns

Barn Ventilation Rates

Single-Speed Fan Airflow

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

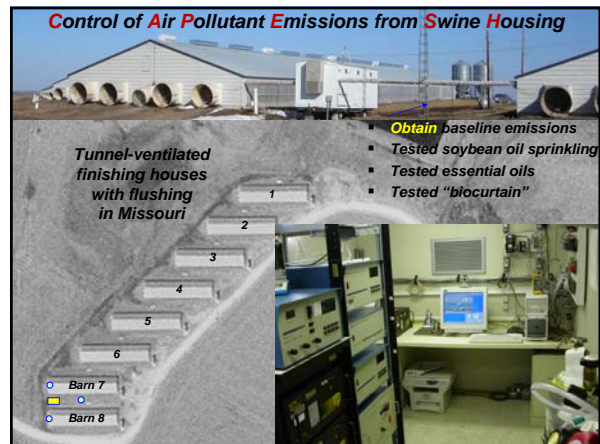
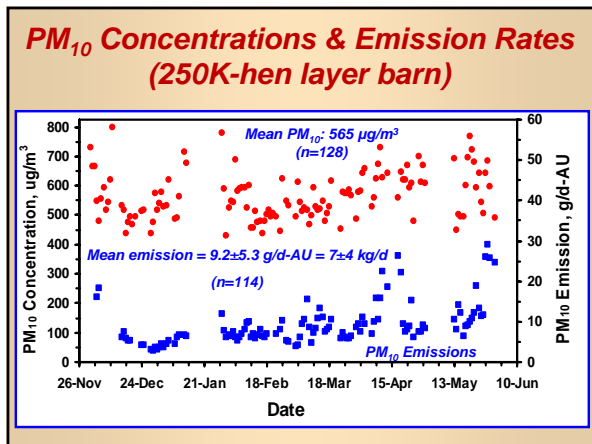
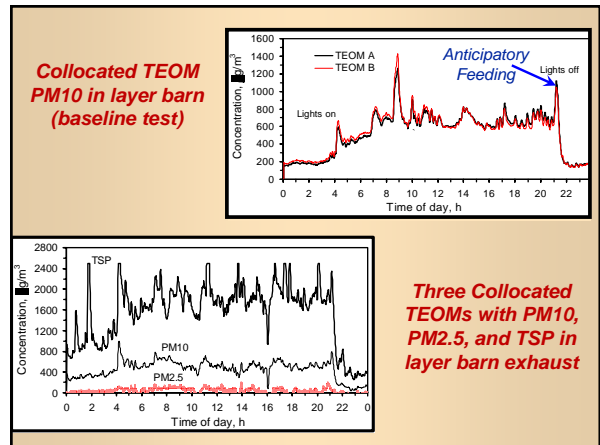
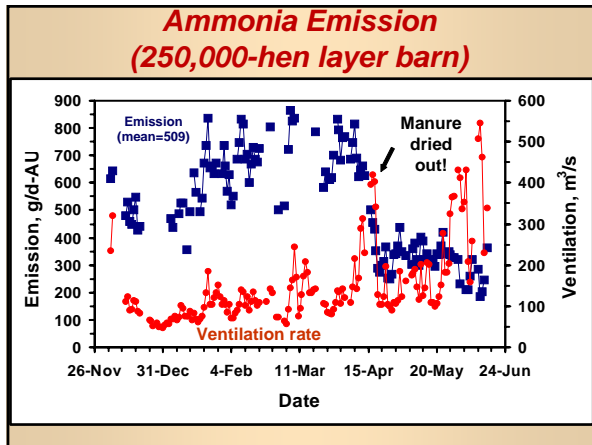
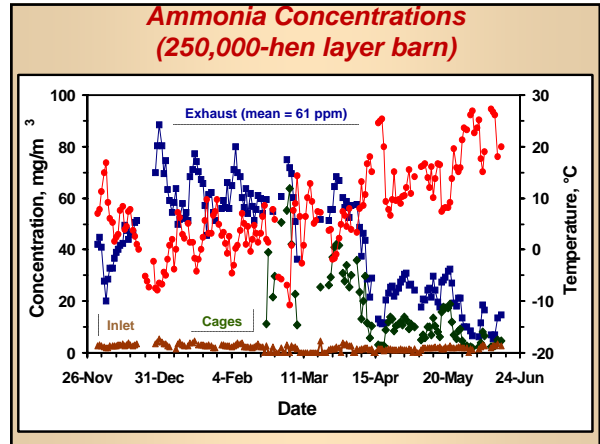
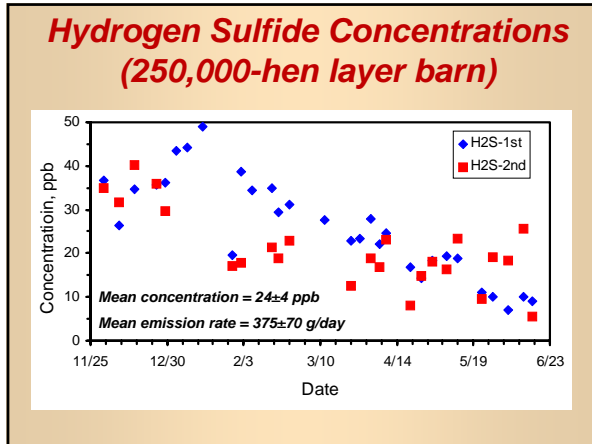
FANS, an AMCA transfer standard (spot measurement) (ARS/Kentucky method)

BESS Lab (AMCA-Standard)

Small propeller anemometer AMCA transfer standard (continuous measurement)


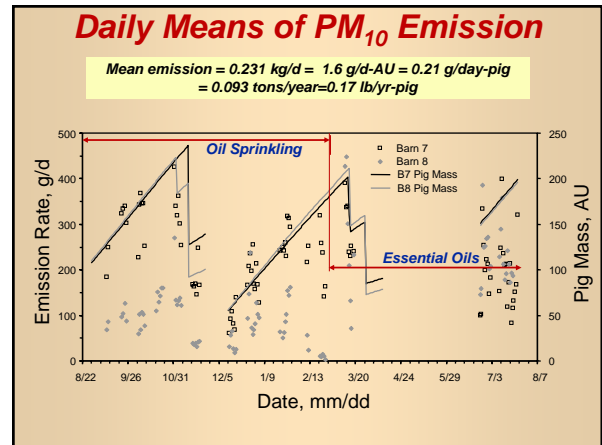
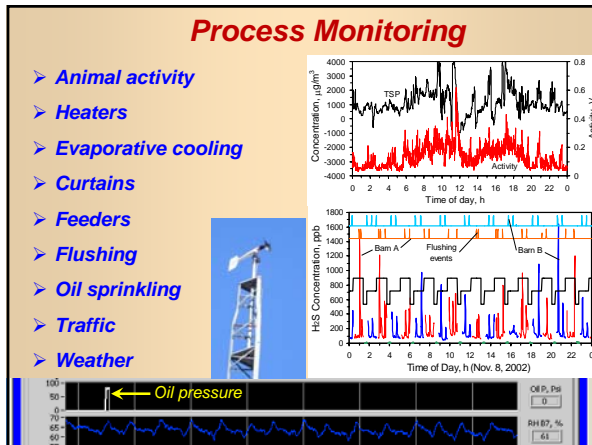
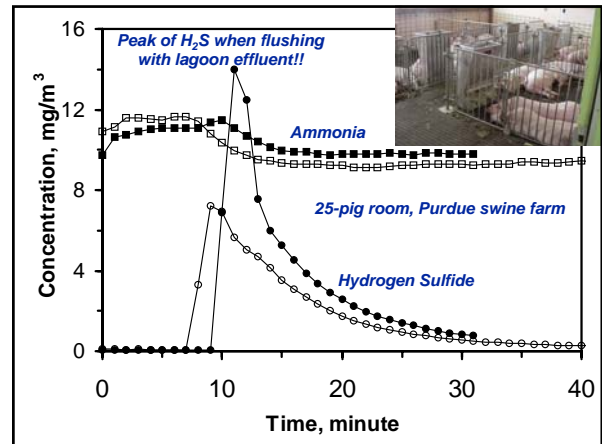
Airflow of Variable Speed Fans

- Fan removal and test at BESS lab
- Fan operation (vibration sensor)
- 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



Data Acquisition System

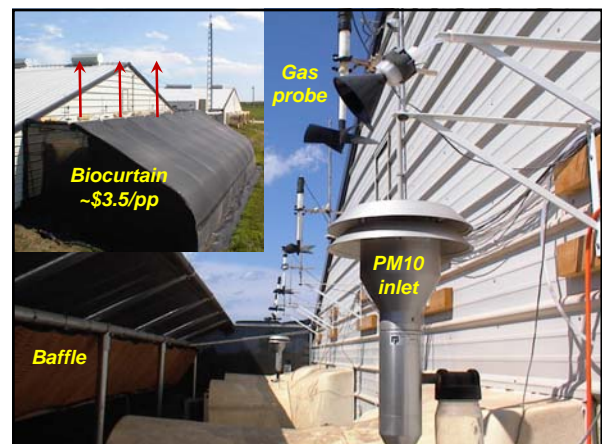
- State of the art PC-based hardware, software
- Sample line control
- Instant data display, no downloading
- On-line data inspection for remote surveillance
- Automatic/remote calibration
- Automatic data distribution and backup
- Alarm emails

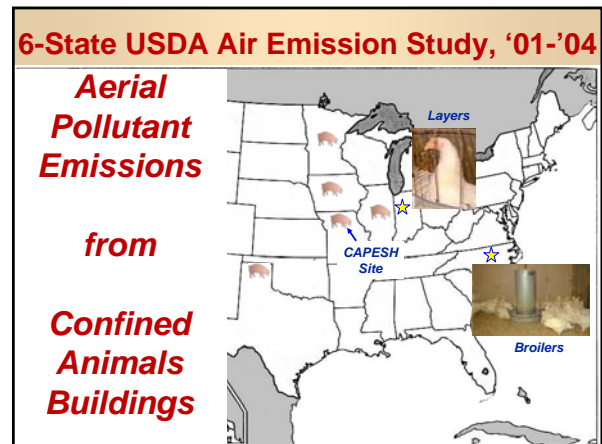
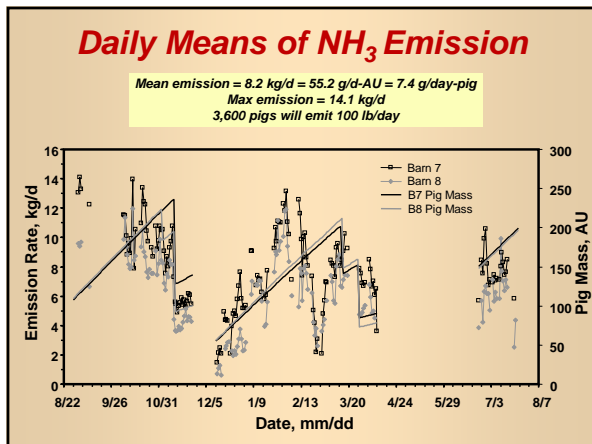
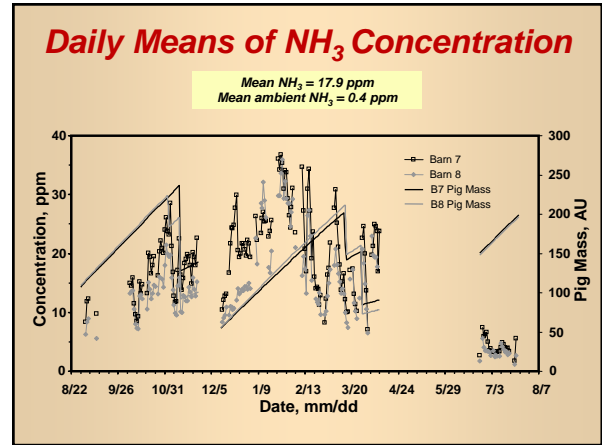
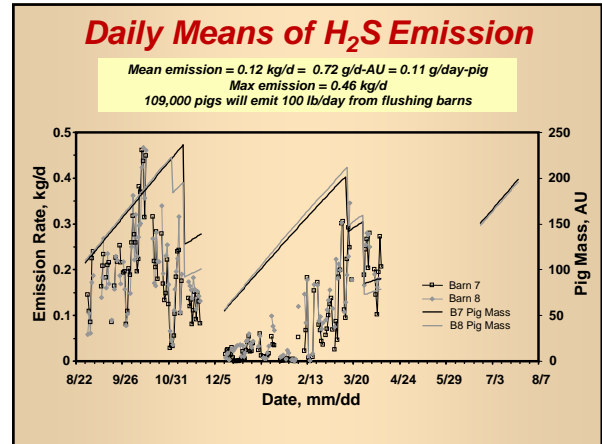
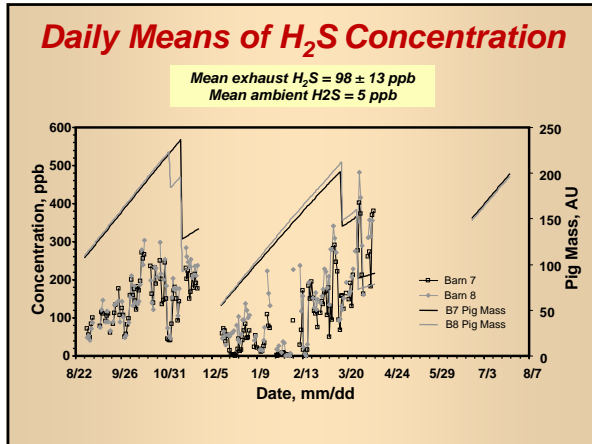



Treatment Effects on PM₁₀

Test	n	Control	Treated	Reduction
Soybean oil sprinkling	14	313 ± 33.4	106 ± 27.1	67%
Soybean oil sprinkling +	8	226 ± 58.9	75.4 ± 34.9	70%
Misting of essential oils	4	326 ± 101	346 ± 178	N/S
Misting of essential oils & water	20	196 ± 34.5	230 ± 27.2	N/S

All emission values in kg/day





**USDA National Research Initiative in Air Quality
(March 11, 2004)**

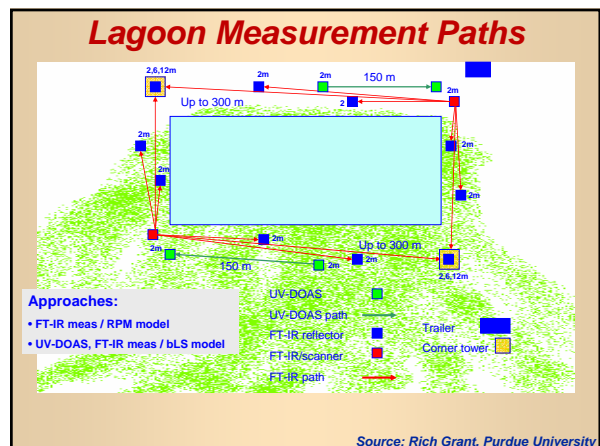
Cornell University, Ithaca, N.Y.	\$400,365
Florida A&M University, Tallahassee, Fla.	\$100,000
Iowa State University, Ames, Iowa	\$1,399,971 (3 awards)
Kansas State University, Manhattan, Kan.	\$477,775
Montana State University, Bozeman, Mont.	\$421,184
NASA Langley Research Center, Hampton, Va.	\$223,052
North Carolina State University, Raleigh, N.C.	\$479,818
Purdue University, West Lafayette, Ind.	\$460,000
University of Connecticut, Storrs, Conn.	\$466,130
USDA's ARS, Lubbock, Texas	\$196,646
USDA's FS, Seattle, Wash.	\$475,059
Total: \$5,100,000	

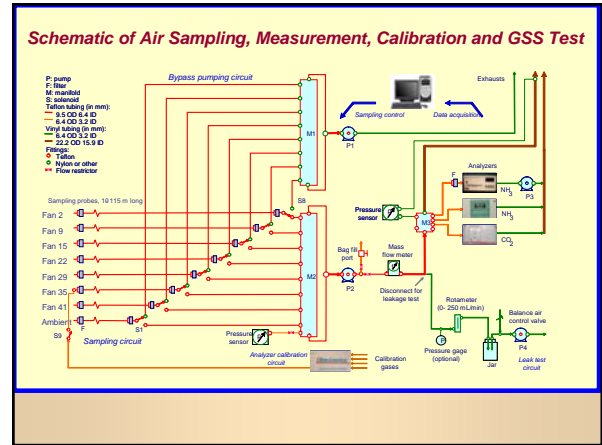
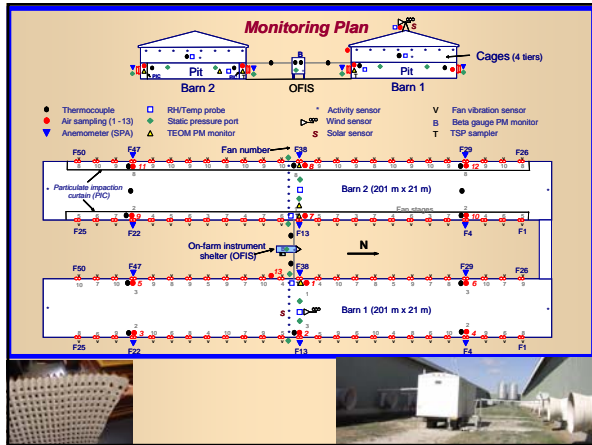
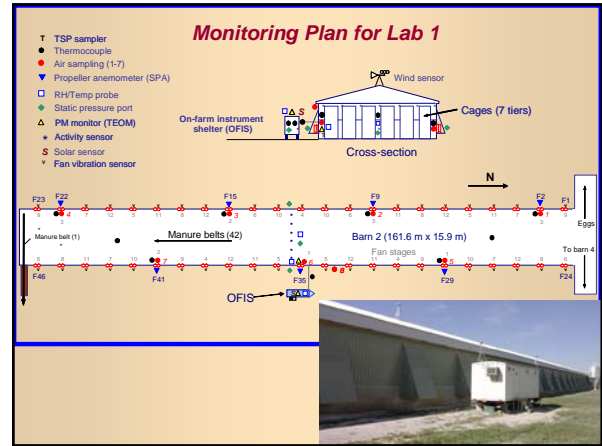
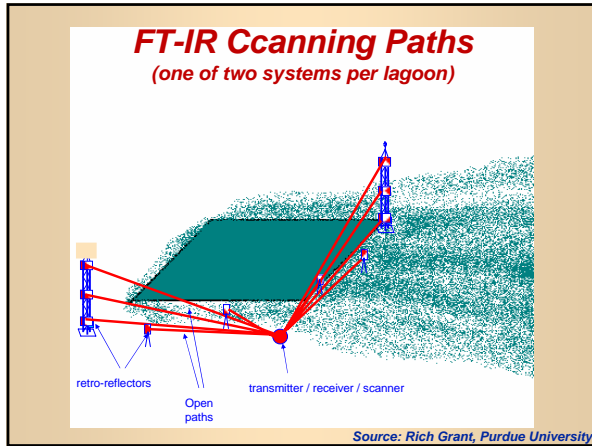
- ### National Livestock Compliance Agreement
- **What will livestock industry do?**
 - Pay for nationwide monitoring project
 - Comply with laws based on results
 - **What will U.S. EPA do?**
 - Grant temporary safe harbor
 - Forgive all past violations
 - Convert data into policy
 - Enforce rules following project
- Source: John Thorne: C&M Capitolink

- ### Description of Emissions Study
- Selected farms will represent pork, egg, broiler, turkey and dairy production
 - Two years of continuous barn emission data
 - Extractive sampling of gases
 - Real-time dust measurements
 - Effluent ponds monitored every season
 - Open path FTIR and UV sensors
 - Tomography
 - Backward Lagrangian stochastic modeling
 - Standardized design and operating procedures
- Source: John Thorne: C&M Capitolink

- ### Real-Time Emission Data to be Collected by NAEMS
- Ammonia – chemiluminescence, FTIR, UV
 - Hydrogen sulfide – Pulsed-fluorescence, UV
 - Carbon dioxide – Photoacoustic Infrared, FTIR
 - PM ($PM_{2.5}$, PM_{10}) – (TEOM)
 - VOC: GC-MS
 - TSP: integrated samples with Illinois method.
 - Building airflow (fan status~vibration, pressure, vane anemometer, FANS)
 - Include ambient measurements of PM, gases

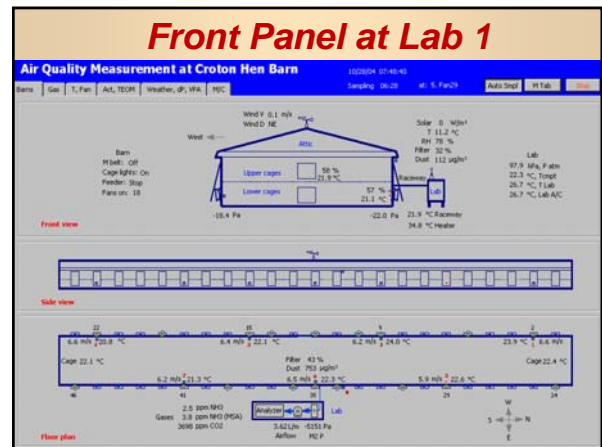
- ### Operational Data to be Collected
- Heating, flushing, feeder, and fan operation
 - Temperature and humidity
 - Building static pressure
 - Animal activity
 - Lighting
 - Wind speed and direction
 - Solar radiation
 - Animal inventory and mass
 - Manure production
 - Manure removals
 - Manure, feed and water analysis
 - Milk production
 - Egg production

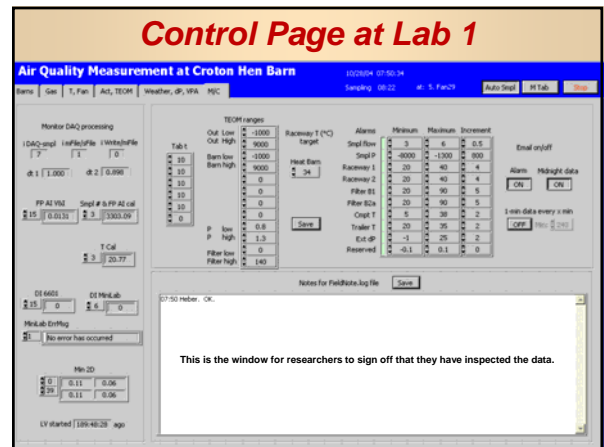
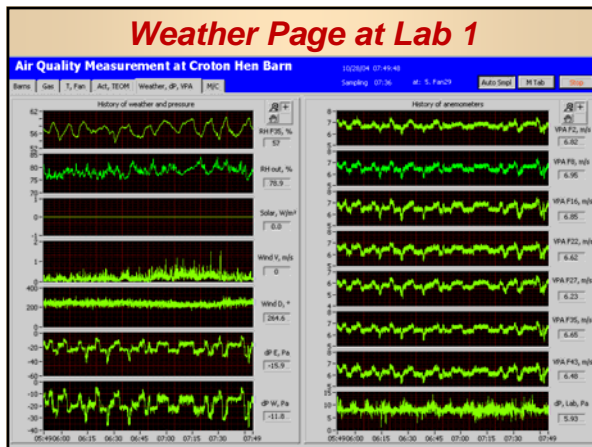
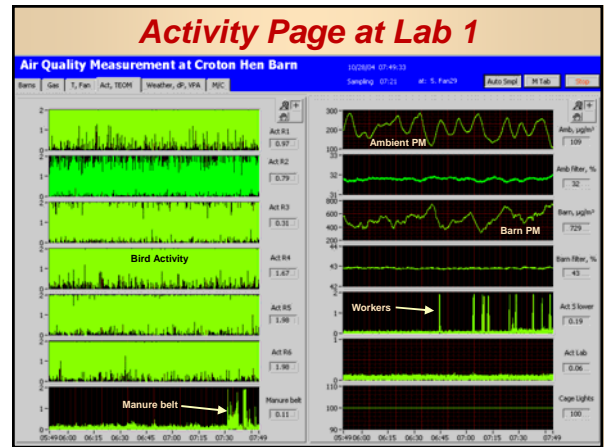
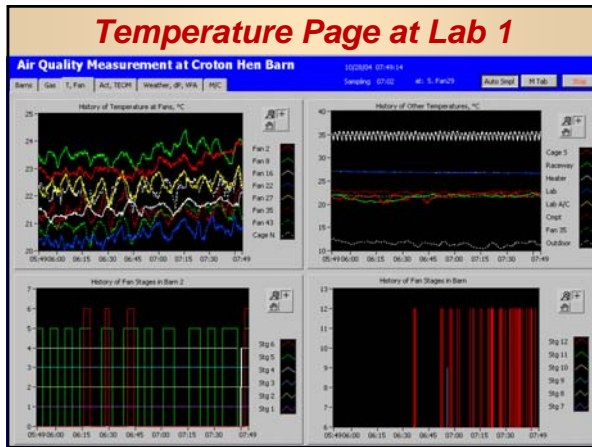
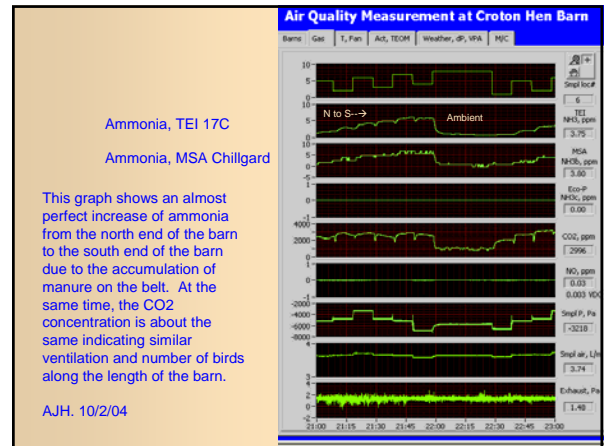
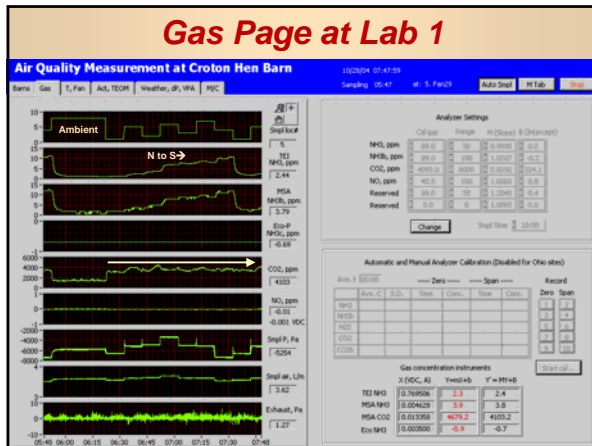




Appendix A: Real-Time Data

The next few pages show screen shots of the data acquisition system at Lab 1 in Ohio in case we do not get connected on-line in the seminar.





Summary

- *Stricter regulations*
- *Innovative compliance agreement*
- *Consensus test protocols*
- *Current efforts.*