Local Air Extraction System for Air Pollution Control in Poultry Houses

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Problem:

Concentrated Animal Feeding Operations (CAFO) are being questioned as major polluters. Tests have shown that broiler operations are capable of emitting 100 lbs. of ammonia per day.

The majority of these emissions come from the animal waste, which subsequently rests on the floor of the building. A solution is needed that can reduce the emissions of this waste, without interfering with the production of the birds.

Objective:

To design and test an air extraction system to allow the capture of air emissions from poultry houses at the source. All components of the system must be compatible with hydrogen sulfide (H_2S) and ammonia (NH_3), as well as be readily available commercially. The system should be able to lift, in order to alleviate problems to the producer during routine barn maintenance. The system will have a minimum life span of 10 years.

The system should be designed for minimum total CFM output in order to direct the ammonia emissions to a small reactor for absorption. This is while keeping a high enough CFM at the collection points to be effective.

Our Plan:

The method that we have created to solve the problem and accomplish our goal is to collect the air using inverted funnels. These funnels are located at high ammonia production areas, which are between the feeders and water line. A smaller collection system has been created to test how functional the cone collection system is and what modifications are necessary to become effective. A test design was created to display how the full scale system would work and to estimate costs of this system.

References http://www.mnbeef.org/MnFRAC/images/chicken1.jpg

Full Scale Design

Pressure Loss and Air Speeded Calculations

Calculation Constants	
Air Temperature, F	70
Air Temperature, R	530
Air Density, lb/ft3	0.075
Air Dynamic Viscosity, lb/ft-hr	0.04398
Air Kinematic Viscosity, ft2/hr	0.5865
Pipe Absolute Roughness, ft	0.000005

Head Loss Results

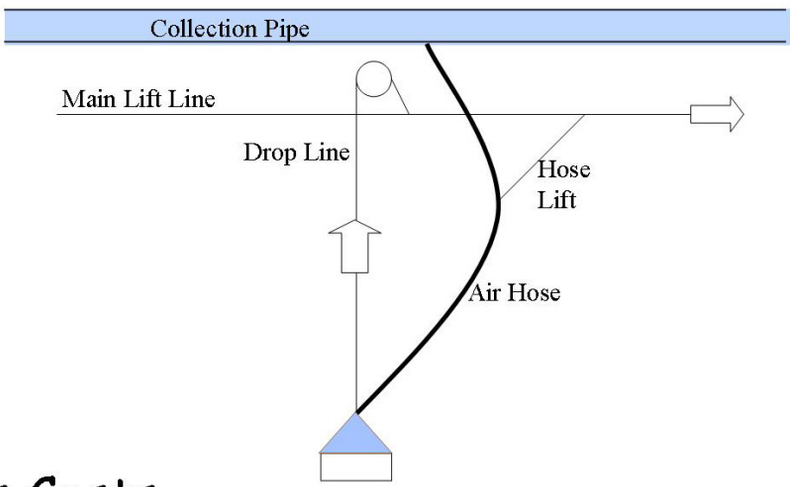
	Length (ft)	Inner Dia. (in)	Loss (in of H_2O)
Hose	14	0.75	0.484
Continuous Dia. Pipe	250	8	0.357
Varying Dia. Pipe	50/section	4 to 8	0.570

Analyses of the Collection Head

System Standards		
Exhaust	5000	CFM
Number of heads	200	
Exhaust per Head	25	CFM

Air Speed at Funnel Inlet		
Gap Height	0.75	in
Dia. Head	8.00	in
Open Area	18.85	in^2
Air Speed	95.49	ft/min

Lift System



Estimated Parts Costs

Drop Down Parts

	# of units on each drop	Price/unit	Price/drop	# of drops in building	Total
Carriage Bolt 1" (1/4")	4	$0.09	$0.36	200	$ 72.00
Nut (1/4")	4	$0.06	$0.24	200	$ 48.00
Rubber Hose (1/2")	14	$0.82	$11.48	200	$ 2,296.00
Pulley (20mm diameter)	1	$12.00	$12.00	200	$ 2,400.00
Nylon Rope (.05")	14	$0.12	$1.68	200	$ 336.00
Stainless cable clamps	1	$3.14	$3.14	200	$ 628.00
Coupling from hose to PVC	1	$0.49	$0.49	200	$ 98.00
PVC Spacers	4	$0.12	$0.48	200	$ 96.00
Eye bolt hooks for Pulley (2 7/8)	1	$0.88	$0.88	200	$ 176.00
Metal Hook	1	$0.71	$0.71	200	$ 142.00
Plastic molding	1	$1.26	$1.26	200	$ 252.00
Ball Shutoff Valve	1	$0.87	$.087	200	$ 174.00
Circular plastic bottom	1	$0.35	$0.35	200	$ 70.00
				Total	**$ 6,788.00**

Collection Line Parts

	# needed	Price/unit	Total
Cyclone Filter	2	$ 490.00	$ 980.00
8" PVC	1080	$ 3.43	$ 3,704.40
24" Fan	2	$ 449.00	$ 898.00
8" PVC 90 degree bend	4	$ 22.10	$ 88.40
Stainless Steel Cable (1/8")	1000	$ 0.33	$ 330.00
Stainless cable clamps	2	$ 3.14	$ 6.28
Cable Crank	2	$ 59.95	$ 119.90
Larger Pulley	2	$ 250.00	$ 500.00
Eyebolt (3 7/8)	4	$ 0.95	$ 3.80
PVC ceiling brace	200	$ 1.58	$ 316.00
Box of Screws (5 lb)	2	$ 19.97	$ 39.94
Enlarger for PVC to Fan	2	$ 54.00	$ 108.00
		Total	**$ 7,094.72**

Grand Total $13,882.72

Test Design

Location: Lilly's Animal Research Building

Sample Size: 100 Chickens

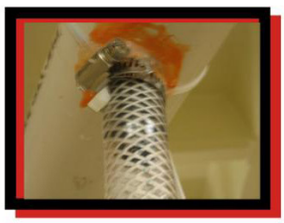
# of Collection Heads: 5

Test Design Collection Head

Ammonia (NH_3) Measurement Equipment

- Chillgard
  - Uses a vacuum pump to receive collection sample
    - Occurs at the exhaust of the system
- Teflon Tube
- Data Acquisition Board
  - Includes a thermocouple for temperature

Pipe Reducer (Manifold to Cyclone Filter)



3/4 " Adapter (Rubber Hose to Manifold)

Chillgard (ammonia measuring device)

Data Acquisition Board

Manifold Components

- Collection Head
- ¾" Braided Rubber Hose (Air Hose)
- ¾" Adapter
- 3" PVC
- 3" 90° PVC Bend
- Cyclone Filter
- Pipe Reducer 3" to 2"
- Shop Vacuum Rated at 130CFM

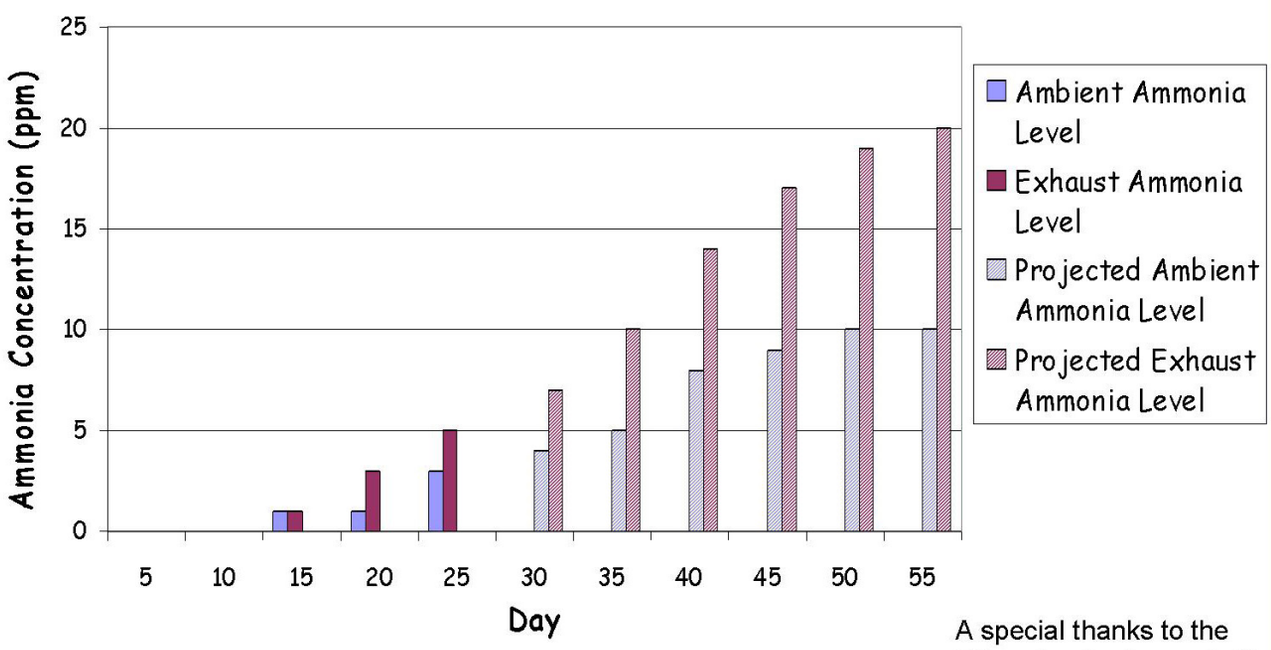
Sampling Location

The concentration of ammonia being sampled fluctuates based on the location of the collection heads within the pen. The most effective position was determined to be between the water line and the feeders. This is because the ammonia concentration is greatest around moisture and locations of high manure.

Cyclone Filter

3" 90° PVC Bend

Projected Ammonia (NH_3) Readings



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