A Quality Assurance Project Plan for Monitoring Gaseous and Particulate Matter Emissions from Broiler Housing (Appendices A–C)

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A Quality Assurance Project Plan for Monitoring Gaseous and Particulate Matter Emissions from Broiler Housing (Appendices A–C)

Abstract
Section Titles: Appendix A: SOP of Information Required from Tyson and Information for the Producer; Appendix B: SOP of Gas Sampling System; Appendix C: SOP of Field Estimation of Ventilation Capacity Using FANS--Field Estimation of Ventilation Capacity Using "UK Version 1" FANS Unit.

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Quality Assurance, Emission, Broiler Housing, Particulate Matter, PM2.5, PM10

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Appendix A: SOP of Information Required from Tyson and Information for the Producer

Measurements To Be Taken
1. Inside and outside temperature and relative humidity.
2. Fan status (on/off) and airflow rate.
3. Operation of lights, feeders.
4. Static pressure difference between inside and outside the barn.
5. Inside and outside ammonia and carbon dioxide concentrations.

Measurement Duration
Continuous monitoring of two barns for 12 months, beginning January 2006.

Measurement Logistics
Gas samples are collected using flexible FEP tubes, at three locations in each barn. All gas samples and instrumentation equipment are housed in an 8 ft × 14 ft MAEMU positioned adjacent to the barn. This MAEMU will serve as a shelter for measurement instrumentation.

Project staff visit the site once a week or more often as needed. This is required to check equipment status, calibrate sensors, and to make sure everything is working as planned. Most of this time is spent in the instrumentation trailer and not the barns, although some time needs to be spent in the barns to change sample line filters, TEOM filters, exchange TEOM inlet heads, and to check sensors. Strict adherence to biosecurity as per Section 10 will be followed.

Barn Modifications
In order to introduce the sensor wires and gas sampling lines into the barns, two 4-in PVC pipes connect the MAEMU to each barn. These pipes house data lines and air sample lines and are buried.

Requirements for Tyson and Collaborating Producer
Tyson is required to provide the university the following information about each barn:
1. Animal diet, feed consumption, inventory and body weight
2. Production outputs, marketed birds and birds mortality
3. Record of litter removals
4. Record of cleaning operations
5. Record of animal movements in and out of the barn
6. Record of water consumption
7. Advance notification of any alteration in production schedules and methods.
8. Record of equipment failures, (e.g., ventilation fans, inlet control)
9. Power failures
10. Temperature set points
11. Operation of lights
Appendix B: SOP of Gas Sampling System

Vacuum pumps (P1-P4) with Teflon wetted parts are used to deliver air from the sampling locations via solenoids and a manifold (M1) and transport the air stream to another manifold (M2) connected to the gas analyzer. Teflon or Teflon coating is used in all wetted parts of the sampling system (pump, solenoid valves, manifold, and tubing). Four pairs of 2-way solenoid valves (S1-S8) located in sampling lines are controlled by the DAQ system and control unit to allow measurements of gas concentrations by automatic gas sampling from four locations (Figure B.1). To avoid the malfunction of solenoid valves as a result of overheating, solenoid cool boards are used to drive the solenoid valves. When the control module sends the signal to the cool boards, the cool boards will provide full power (12 VDC) on the solenoids during the first 100 ms and then cut the power to approximately half (5 VDC) and hold it. The cool boards solve the overheating problem of the solenoid valves (Figure B.2). Individual supply pumps with 16 L/min delivering capacity are used to continuously draw air from each of the sampling locations. The sampling train is designed such that a sample will be drawn from all four sampling points continuously unless a sampling point is not being analyzed. When this occurs, the flow will be bypassed through the normally open solenoid valve (S5-S8). This arrangement is designed to minimize the residence time and thus greatly reduce sample-to-sample purging time. When a sampling stream is selected, the corresponding normal close valve will open and the normal open valve will close; and the selected gas stream will flow from the sample inlet via the tubing through the manifolds (M1 and M2). The internal pump of the gas analyzers draws air from manifold M2. The gas sampling system is designed such that all solenoid valves, manifolds, and associated connections are under positive pressure. Using this positive pressure approach, if a leak were to develop on the gas sampling control board at any of these components it would not impact the integrity of the gas sample.

![Diagram of gas sampling system](image-url)

Figure B.1. Schematic of sampling system configuration. (The analyzers have internal pumps.)
When needed, sampling lines are heated with heat trace or heat tape to prevent in-line condensation. Temperature of the sampling line, and thus power input of the heat trace or tape, is continuously monitored and regulated through the DAQ and control system.

Two pleated paper filters are used to exclude insects and other coarse particulates. Additionally, a 47-mm diameter, in-line Teflon PFA filter holder housing a Teflon PTFE-laminated polypropylene membrane filter with 20-μm pore size is installed at the sampling end of each gas sampling tube to remove airborne particulate from the sampled air. Another 5-μm pore size PTFE filter is installed right after the vacuum pump to provide double protection. Both in-house sample filters are changed weekly (Figure B.3).
Figure B.3. Photographs of the air sampling system.
Appendix C: SOP of Field Estimation of Ventilation Capacity Using FANS

Field Estimation of Ventilation Capacity Using “UK Version 1” FANS Unit

Introduction

A device for in-situ exhaust fan airflow capacity measurement, referred to as the Fan Assessment Numeration System (FANS) device, previously developed and constructed at the USDA-ARS Poultry Research Unit, was refined and constructed by University of Kentucky (Gates et al., 2004). FANS measures the total airflow rate of a ventilation fan by integrating the velocity field obtained from an array of five propeller anemometers used to perform a real-time traverse of the airflow entering ventilation fans of up to 122-cm (48-in) diameter. This SOP provides instructions on installation of the program and operation of the FANS analyzer, and helps in producing high quality measurements.

Data Acquisition Computer

Before using the FANS analyzer, it is necessary to prepare a computer with the required hardware and software to link with the FANS analyzer to control and record data. For this, a Keithley DriverLINX card, and the WildCat Anemometer Program (Anemometer2.exe) is needed. The installation procedures that follow were provided by Ken Casey of the University of Kentucky and distributed with each FANS unit manufactured.

Installing Keithley DriverLINX and Anemometer Program

1. Close down all background applications of the computer to be installed
2. Insert Keithley Card into PCMCIA
3. Insert the Keithley DriverLINX CD and run the autostart program with command “setup.exe”
4. After the installation window appears, click “Install DriverLINX”
5. Click “Install Drivers”—c:\Program Files\DrvLINX4
6. and follow directions for registration, use defaults
7. Click “Install Interfaces”—same procedures as step a
8. Be sure to select all options (three of them)
9. Use default folder
10. Click “Install Documentation”—use default folder
11. Click “Back”, “Exit”, and “Done”
12. Your computer will be restarted

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13. Once restarted, a screen should come up for hardware configuration
14. Follow step 2. Plug & Play should install drivers
15. Wait some time for response
16. Afterwards—click “continue”, follow directions
17. Probably, click “configure”
18. Under hardware configuration
19. Assign logical device number (the default—probably 0)
20. Leave all other values at default, click “OK”, and close window
21. Remove Keithley Card, wait about 10 seconds
22. Reinsert card, click “Start”, “Programs”, “DriverLINX”, “Test Panels”
23. Run the AIO Panel
24. If it says “No Driver loaded”—reboot, ignore the rest of installer and restart AIO Panel.
25. You should be ready to run
26. You may need to tweak in “DriverLINX Configuration Panel”
27. Copy Anememeter2.exe and Anememeter2.mdb from floppy disc supplied into your
   directory

FANS Analyzer Unit

In order to ensure the FANS analyzer is operating properly, test both manual and software
control as follows:
   1. Supply the FANS analyzer with power.
   2. The right-most toggle switch should be in up position.
   3. Toggle left-most switch up and down, holding for a few seconds at a time to ensure that
      the motor is moving the anemometers properly.
   4. After successful manual operation, test the “motor up” and “motor down” functions on
      the computer screen to determine if software has functional control.

If all is working properly, initiate a data collection traverse with no airflow and without
anemometer propellers installed to establish the zero offset airflow correction. Then place the
individual propellers onto the unit. The propellers cannot be installed at the traverse end
positions because of limited space; therefore the traverse bar must be moved at least six inches
from the top or bottom. Make sure that the number of the propeller and of the open-vane
anemometer match (there are five in all—numbers are marked on both).

Operation
The fan to be tested should be turned on and warmed up for at least 10 minutes. A fan is tested
over the normal operating range of building static pressure (SP) difference. At least four SPs are
tested covering a range from slightly below to slightly above the normal building operating
range. After the FANS is positioned at a chosen fan, a static pressure (SP) is set. Once SP has
stabilized, two FANS traverses are run in quick succession. If the two runs differ by more than
2%, another traverse is performed. For lower range airflows, a 3% difference between traverses
is acceptable. All tests are done when the house has no birds present so that any ventilation
condition could be evaluated without jeopardizing bird comfort and well-being.
Moving and Positioning
A cart is helpful to aid in moving the FANS unit down the length of a long poultry house and positioning it in front of a fan. A hydraulic lift can be added to provide easy height adjustment of the 80-pound FANS unit to match the test fan height. Moving and positioning is best done with two workers. Complications with FANS setup include the need to move knee braces, water lines and electrical outlets in certain facilities. Each of these situations and other anomalies require special attention and can add substantial time to each setup.

Sealing FANS to Fan Housing
Sealing the FANS to the wall and/or fan housing is critical to accurate measurement, and can take the bulk of the setup time in moving the FANS from one fan to the next. A special gasket created from open-cell pipe insulation placed over \( \frac{1}{2} \)-in PVC pipe and positioned between the FANS frame and the wall has been successfully used to provide a tight seal and reduce the need for extensive taping. The FANS is positioned against this gasket and two ratchet straps are used to draw the FANS unit tightly against the gasket and wall. Duct tape is used to seal any remaining gaps or cracks.

Fan housings that project through the wall into the interior space can prevent the FANS unit from being placed against the wall and thus present special challenges. For these situations, a 6-inch extension of the FANS frame, constructed of polystyrene and the same dimensions as the FANS frame, has been used to seal against the above mentioned pipe insulation gasket.

Duct Transition to Smaller Fan
Measurement accuracy is not affected by use of a transition to measure smaller diameter fans. A lightweight collapsible duct (blue polystyrene R-3) can be used to connect the FANS unit, with square opening of about 52 in, to 36 in or smaller fans. Gaps are sealed with duct tape. The duct is 48 inches long, which is about 1.3 fan diameters of the smaller fan, with one to two diameters length considered acceptable. Setup time for the duct is even longer than for the sealing method described in the previous section for testing larger fans. Wherever possible, the FANS unit should be used directly without a transition, simply to save time.

Measuring Larger Ventilation Fans
Measurement accuracy is affected by use of a transition to measure larger diameter fans. Available literature (Gates et al., 2004) suggests that there is a penalty associated with forcing airflow through the FANS unit and into a fan whose approach aperture exceeds that of the FANS. It is recommended that each model of fan be independently tested in a certified fan test facility, with and without the FANS unit, to assess the degree of penalty. Ventilation fans of 48 inches or smaller have not been shown to be affected by this issue.

Streamlining Data Collection
Once the crew is practiced at setting up and operating the FANS at different static pressures, a complete setup and test for 4 or 5 static pressures can be accomplished in 1 to 1 ½ hours per fan in a broiler barn. The approximate time required for each fan test is as follows. About 7 minutes is needed for two consecutive FANS traverses plus data notation time, although more than 2 traverses are sometimes required. Changing and stabilizing each static pressure setting requires
less than 5 minutes, but with even minor complications this can exceed ten minutes. For example, end doors and all inlets need to be opened to get a zero SP reading and then closed again to get the other SP settings. These FANS traverses are preceded by 10 to 20 minutes of FANS positioning and about 10 minutes of sealing the FANS to the fan housing. If a transition duct is used for a 36-inch fan, then 40 to 50 minutes is needed to assemble and seal a pre-cut duct between the FANS and the fan housing. More time is needed if the duct is fabricated from scratch.

Walkie-talkie radios are used so that the person adjusting static pressure in the control room can communicate with the person(s) running the FANS unit. Often these two people are out of sight of each other. The radios eliminate disruptive yelling and miscommunications. The FANS unit operator can tell the SP control person when tests are completed. Likewise, the SP control person can indicate when the test SP is adjusted and steady in order to start the test.