Factsheet 2

April 2007

Instruments for Measuring Indoor Air Quality

Agdex 720-2

EVALUATING LIVESTOCK HOUSING ENVIRONMENTS

The indoor environment of a barn has a tremendous effect on animal health, welfare and overall performance. Air quality characteristics are quantified with instruments that provide a comparison to the desired indoor air quality (IAQ) and potential adjustments to improve it. Environmental changes can also be evaluated over time. For example, a thermometer will show that air temperature in a dairy barn is 30°C, yet dairy cows are most comfortable at 10°C or cooler (assuming reasonable humidity level). The goal would be to lower the barn temperature or compensate for the heat stress in other ways.

This factsheet examines portable, hand-held, field-quality instruments commonly used to diagnose animal environments. Approximate instrument costs, as of January 2007, and information on suppliers are also provided.

Some of the equipment required to measure environmental features such as temperature, relative humidity and air pressure (static pressure) is very affordable. Pharmaceutical and feed companies frequently buy the equipment in bulk and provide it as a service to customers.

Other items are more costly and complex. For such expensive items, renting from a supplier should be considered, especially when the suggested frequency of use is occasional (e.g., annual) or only under special circumstances. Renting ensures that the equipment is maintained and, often, the rental company can provide interpretation of the results.

Table 1. Environmental features that can be reasonably measured

Common Environmental Features that Should be Measured Frequently	Special Circumstances
Air temperature Humidity Air pressure (ventilation vacuum) Air flow visualization	Surface temperature Gases Dust

Alberta

Table 2 answers the following questions:

1. What environmental feature do you want to measure?
2. Where should the measurement be taken from?
3. When should you measure this environmental feature?
4. What is the instrument you use to measure this environmental feature?
5. How does this instrument work?

Table 2. Measuring environmental features

What	Where	When	Why	How	Units
Air temperature	Near controller sensor	Each production cycle or two times yearly	Calibrate controller, verify max/min	Digital temperature devices with max/min recall	To match controller, in °F or °C
Surface temperature	Outside walls and ceilings, floors	Bi-annual, winter and summer	To verify insulation is sound	Digital infrared thermometer	To match controller, in °F or °C
Relative humidity	At controller sensor	Monthly	Calibrate	Digital device, checked yearly	Percent (%)
Ventilation vacuum pressure	From room to just opposite air inlet supply	Continuous	To verify inlet adjustment correct	Slant tube manometer	Inches or pascals of water column
Air flow visualization	In pens, at animal level	To calibrate/commission new barns (winter is best)	To verify air speeds acceptable	Digital hot wire anemometer, accurate to < 25 ft/min	Typically feet/minute or meters/second
Gases	At animal level	Fall and winter	To verify gases at or below acceptable levels	Dosimeter tubes	Typically parts per million (ppm) or mg/m^3
Dust	At controller sensor	To assess barn, usually only once in winter	To identify levels present	Digital recording logger	Milligrams dust/cubic meter of air (mg/m^3)

Measuring in Multiple Rooms

In many cases, especially in swine barns, there are multiple identical rooms. Each room must be individually measured and calibrated for temperature (space and surface), relative humidity, and static pressure. Gases and dust can be measured in one room and taken as representative of all rooms. Common sense would dictate that under special circumstances, more rooms should be checked. For example, if two or three rooms have high ammonia levels, then each room should be evaluated.

Digital Devices

In most cases, digital devices provide the best value considering the purchase price. They respond quickly to changes and possess other favorable features such as maximum and minimum memories. Many of them are capable of measuring more than one parameter. For example, a pen type "Temperature/Relative Humidity" device (**Figure 1**) measures both air temperature and relative humidity ($150). Although digital devices can display measurements to one decimal place, e.g., 15.7 °C, this does not necessarily mean that the device is very accurate. Discuss measurement accuracy concerns with your supplier or an engineer.

Figure 1. Digital temperature / relative humidity pen

Measuring Indoor Air Quality Characteristics

Space Temperature

Temperature is the most critical item for animal health comfort and performance. Young poultry and swine are particularly susceptible to cooler temperatures and can quickly become chilled and sick.

Air temperature is measured with a common ***thermometer***, either using a glass bulb fluid filled type (alcohol is a common fluid) or via a ***digital thermometer***. In most cases, the digital device should be chosen as it will respond more quickly to changes in the air temperature. Fluid thermometers can take 15 minutes or longer to show a 1°C change in temperature. The sensor tip must not be exposed to radiant energy such as direct sunlight or a heating system radiator as this exposure will increase the sensor tip temperature.

Be sure that your measured temperature is representative of air in the zone of importance, and the area where animals usually spend most of their time. For example, air temperature in a central aisle is not indicative of the air temperature close to the barn wall at the back of the animal pen.

A maximum/minimum digital thermometer that can be left in the barn is a low-cost tool that can help determine whether wide temperature swings occur in the building over a period of time. Note that many controllers have this feature as well. Be sure that the device records the lowest temperature and not an average low from multiple controller sensors.

Surface Temperature

Surface temperatures have a strong effect on animal comfort yet are often ignored in environmental analysis. A warm ceiling temperature from the summer sun can make it feel warmer for the animals than the space temperature thermometer would reveal. Similarly, very cold surrounding surfaces can make animals feel chilled even though the air temperature seems adequate. A regular thermometer would not measure this radiant heating or cooling effect.

Radiation is a very strong form of heat transfer, yet it is purely a surface phenomenon that can be characterized by an object's surface temperature. An object must "see" another surface to feel its radiant heat transfer effect. Animals in enclosures will feel the effects of hot or cold nearby surface temperatures even though they have no contact with them. Even a surface outside the barn can cause heat stress if the enclosed animals can "see" it.

For example, a black asphalt pavement may heat to 93°C on a sunny day. This surface adjacent to a curtained, naturally ventilated freestall dairy may affect cow comfort when the curtains are completely opened since there is a clear radiant heat transfer sight line between the cow and the hot surface.

Surface temperature measurements will indicate areas with poor insulation, leakage, or thermal bridging (structural components without any insulation).

An ***infrared thermometer*** measures surface temperature (**Figure 2**). The instrument's field of view widens with increasing distance between the object of interest and the instrument. Therefore, be sure that the thermometer is not also detecting adjacent surfaces.

Small objects will require having the instrument close. A large object, such as a ceiling, can be evaluated while standing several feet away at floor level. Be sure to evaluate surfaces that the animals "see" from their enclosure. An essential option is a built-in laser to indicate the centre of measured surface area.

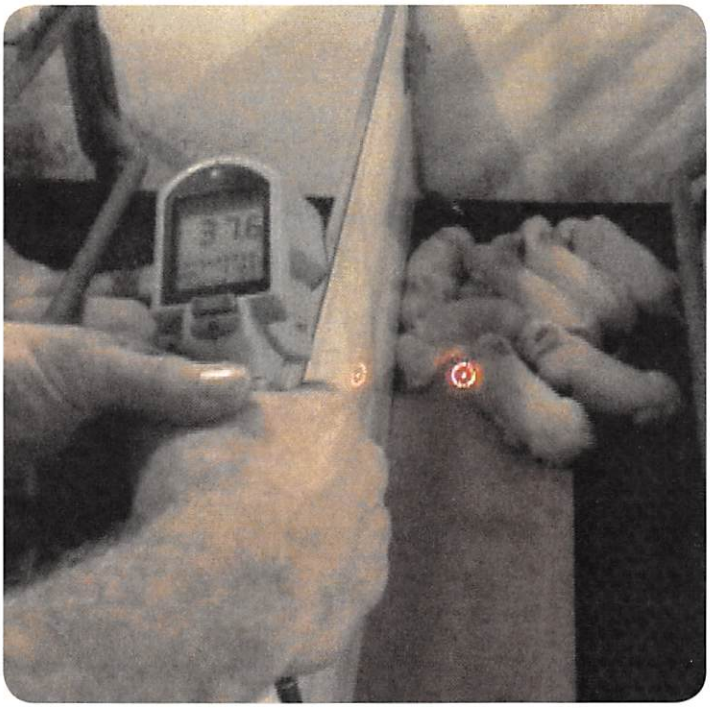
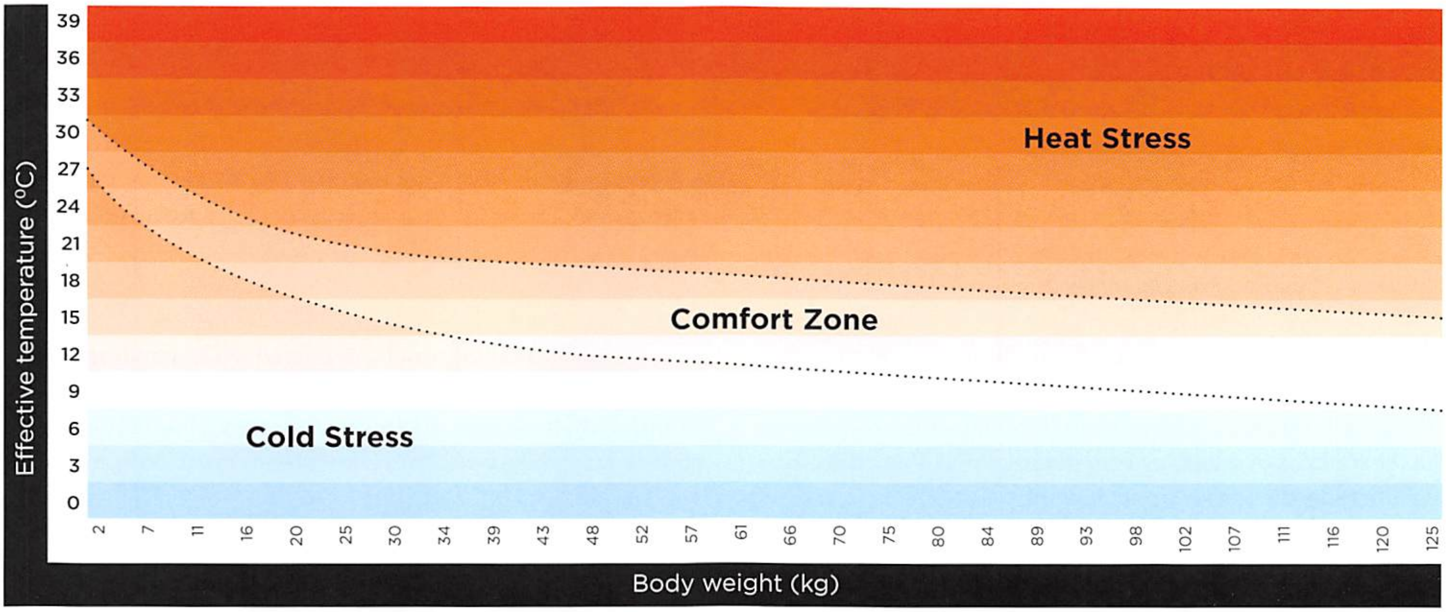


Figure 2. An infrared thermometer used to detect the surface temperature of a hot water pad (Note: the laser dot indicating the area being measured).

Be aware that a shiny surface will not show the correct temperature. If the surface being measured is not black or dark coloured or has a rough surface, you may have to paint a small area black to allow the unit to work properly. Some models allow you to adjust when measuring reflective surfaces (called emissivity adjustment).

How do your pigs really feel?

Effective Temperature for Pigs



How to Estimate Effective Temperature for Pigs

1. First measure the air temperature at pig level.

2. Then make appropriate additions or subtractions for the following environmental conditions:

Floor Type		Air Speed	
Straw or shavings	+4	0.15 m/s	-4
Lying mat	+2	0.45 m/s -	7
Uncoated wire	-5	1.50 m/s	-10
Plastic coated wire	-4		
Extruded plastics	-4		
Dry concrete	-5		
Wet concrete	-10		

Building Insulation*		Evaporative Cooling	
Good (RSI 3 wall / 5 ceiling) -0.5		Pad system	-3
		Fogger	-3
Fair (RSI 2 wall / 3 ceiling)	-2	Dripper	-6
Poor (RSI 1 wall / 2 ceiling)	-7	Sprinkler	-6

*cold-weather only

Radiant Heat Source* +7

*for pigs having direct access to the heated area

3. Now use the chart to find where the calculated effective temperature falls according to pig weight.

a) Below the thermal comfort zone, your pigs are cold stressed. The more severe the cold stress, the more feed they eat and the greater their susceptibility to disease.

b) Above the thermal comfort zone, your pigs are heat stressed. The more severe the heat stress, the less feed they eat and the slower their weight gain.

c) In the comfort zone, your pigs have optimal feed intake, feed conversion efficiency, and defenses against disease.

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Humidity

Relative humidity (RH) is critical during the heating season. High humidity (> 75%) and low humidity (< 50%) both affect air quality and health in negative ways. Humidity that is too low will cause irritation of the respiratory systems while humidity that is too high may promote the growth of fungus infections. In addition, too low an RH will cost a lot in wasted energy dollars.

Humidity is commonly measured as "relative humidity" which compares the "relative" percentage of moisture in the air to how much moisture the air could potentially hold at that same temperature. Air can hold more moisture as its temperature increases. RH can be measured using a wet bulb/dry bulb thermometer. This instrument is not recommended for use in barns although it is a preferred method for greenhouses.

Careful and regular calibration is essential. Note that when RH is very dry (< 10%) or moist (> 95%), the sensor may not work at all or may give a false reading.

Digital devices offer the advantage of direct humidity measurements and are available in several cost-accuracy categories. A relatively inexpensive pen-shaped instrument provides digital dry bulb temperature and RH readings (**Figure 1**). These pens can take several minutes to display a correct reading and provide humidity measurements with an unimpressive accuracy of ±5 percent. More accurate devices (accuracy ± 1 percent) are better but come at a high cost. Some models can record and store maximum and minimum temperature and humidity in the device memory, a very useful feature.

Air Speed

Excess air speeds create a "wind chill effect" and can cause animals to become cold and sick. Dairy calves, piglets and young poultry are the most susceptible to wind chill as they have limited fat and immunity.

Air speed is measured with an ***anemometer.*** In livestock building applications, two types of anemometers, vane anemometer and hotwire anemometer, are common. Either one is used depending on the type of airflow being measured. Both instruments are composed of two connected parts. One part is the sensing probe while the other part displays air speed.

A ***hot-wire anemometer*** is the instrument of choice for low air speed applications (**Figure 3**). Air moving less than 50 feet per minute (fpm or 0.25 meter per second) is considered still air. This condition exists in many animal pens, especially piglet crates, and in many draft evaluations. Due to their small size, hot wire anemometers can be used in small places such as an inlet jet of a ventilation system or in hard to reach spaces such as a duct.

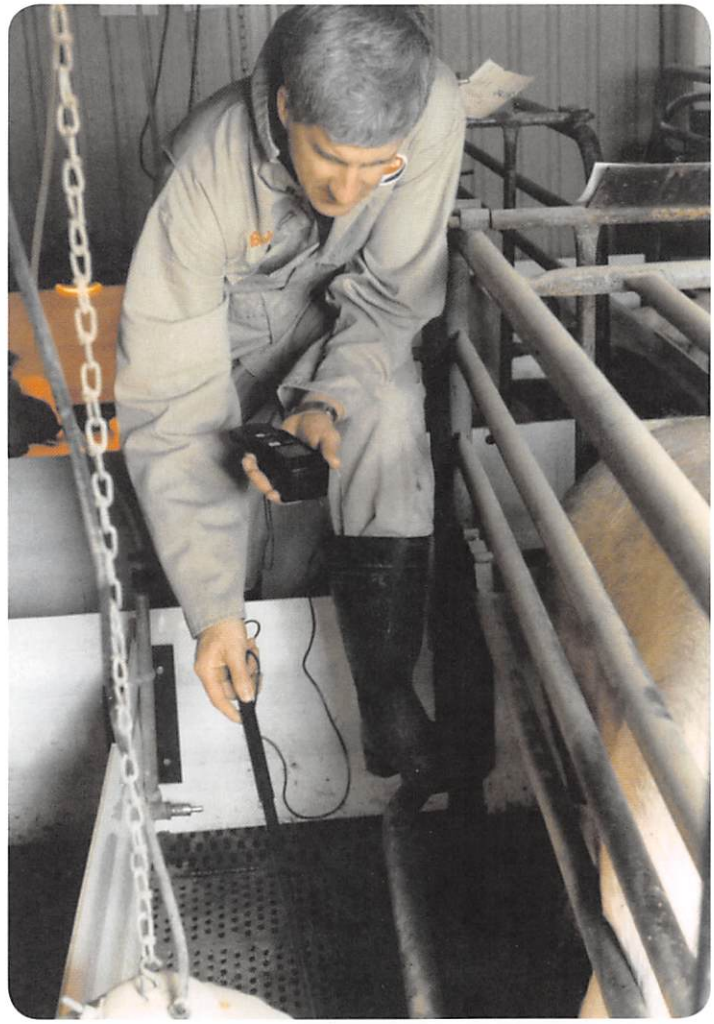

Figure 3. Hot wire anemometer

The ***vane anemometer*** uses a rotating impeller to sense air velocity (**Figure 4**). Vane anemometers are the best choice for measuring higher wind speeds. Many have user selectable units of measure, e.g., ft/min, m/s, MPH, km/h, knots, and Beaufort force (measure of wind intensity) to accommodate a wide variety of applications. It is a more rugged instrument than the hot wire device, but typically not accurate below 50 fpm (0.25 m/s) and is better for determining airflows of fans or velocity at an air inlet.

One key technique in using an anemometer is to take measurements while air speed and direction are minimally altered by the instrument's placement. Using a smoke pencil (the type that does not rise or sink in still air due to weight or heat problems) will clearly indicate the air flow direction, allowing proper placement of the air measuring probe. The operator should stand away from the airflow being measured.

When reading air speeds, the measured value will fluctuate wildly (for example, when measuring the output of an exhaust fan). In these cases, a qualified professional is recommended to ensure useful information is collected. A stable air speed should be plus or minus 10% of the value read. For example, a series of air speeds that fluctuate between 90 and 100 ft/min (0.46 and 0.51 m/s) is a good reading.

Figure 4. Vane anemometer

Static Pressure

An air inlet system is designed to provide uniform air throughout the barn. In the winter, it must also prevent cold drafty areas or warm stale humid areas from developing. A key to making sure the system is performing is the use of a static pressure manometer gauge (**Figure 5**). These gauges are low cost (< $75) and easily installed. The target operating static pressure (measured in inches of water column) of most barns is 0.04 inch in summer to 0.08 inch in winter. Smaller buildings may require lower pressure. By controlling the air pressure across the air inlet, fresh air will enter the barn at the correct speed, mix properly with warm inside air and distribute uniformly. It is impossible to measure the static pressure without a gauge.

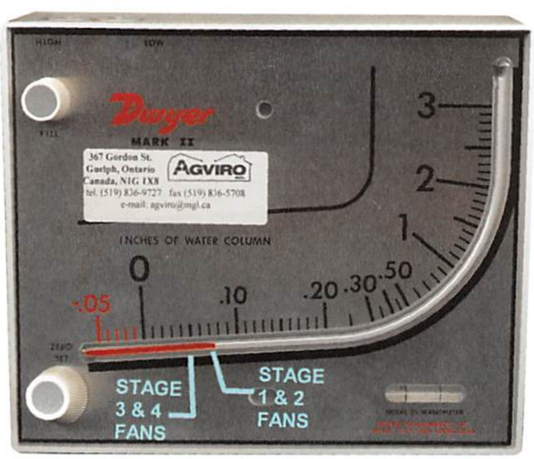

Figure 5. Static pressure manometer

Because air is invisible to the naked eye, people need assistance to see it in action. This visualization approach is helpful when:

- drafts are suspected
- air speed measurements are needed
- leaks need to be located
- airflow direction and stability is unknown

Smoke sticks are intended for use in air movement studies. Specific uses include estimating air speed through animal pens or crates and determining inlet airflow and general airflow patterns. The dense white smoke produced bysmoke sticks makes them ideal for this application.

There are two main types of smoke systems that can be used on farms. The first type uses a chemical reaction to create a dense cloud of smoke. This type comes in gun, stick, candle and bomb formats with an increasing amount of smoke, respectively (**Figure 6**). Smoke and stored sticks are irritating and corrosive. The benefit of this type of chemical reaction system is that it does not require other items to make it work, which is helpful in biosecure facilities. Most importantly, the smoke has the same characteristics of air. This means the smoke does not rise because of self-heating.

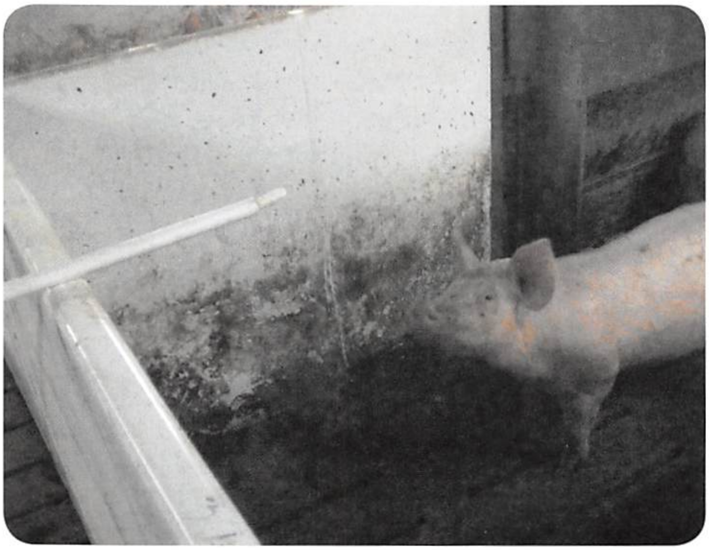

Figure 6. Chemical smoke sticks

Another system uses actual ignition (smoke candles) to create the smoke, and therefore, heat is generated by the smoke system. This heat is not an issue in a location of high air speed such as an air inlet or to detect leakage at a door seal, allowing you to see the air direction and relative volumes. However, at lower speeds, the heat generated will cause the smoke to rise and give a false indication of air speed and direction.

Some other methods can be used but each has disadvantages:

- Very small, neutrally buoyant ***soap bubbles*** constructed with helium and compressed air can last long enough to show airstreams within an enclosure. The apparatus used to generate bubbles is cumbersome and expensive compared to other airflow visualization devices.
- Children's ***soap bubble toys*** can be useful in faster flowing airstreams but are not neutrally buoyant. The bubbles naturally sink due to gravity and may not represent true airflow.
- A set of ***air speed streamers*** may be used to detect air speed at various locations in a building. Threads of material or ribbons, such as string or plastic tape, can be "calibrated" to a size that blows horizontally at a particular airflow of interest. These inexpensive tiny posts with attached free-to-spin streamers can be positioned in many locations as indicators of the "calibrated" desired airflow

and direction. As conditions change in a livestock building, a quick survey of the streamers will indicate which areas are receiving desirable airflow. For example, a mechanical ventilation system inlet air speed of 700 fpm or faster is desirable. Streamers that have been "calibrated" to blow horizontally at 700 fpm (3.6 m/s) are positioned at various inlet locations to observe whether inlet air speed is at least 700 fpm (3.6 m/s).

Table 3. Summary of air visualization methods

Name	How it Functions	Pros and Cons
Smoke sticks	Chemical reaction	- Smoke generated is the best, thermally neutral in air - Biosecure - Smoke is harmful to eyes and lungs
Smoke candles	Combustion	- Smoke is hot and wants to rise so works best in high air speed locations (> 700 ft/min (3.6 m/s)) - Fire hazard
Soap bubbles	Soap	- Bubbles want to fall so works best in high air speed locations (> 700 ft/min (3.6 m/s))
Streamers	Various material strips in air stream	- Can be left in place for on-going observation - Only in high air speeds (> 700 ft/min (3.6 m/s)

Light Meters

Light is an important component of the indoor environment. Correct levels of light and the length of time the light is on in a day (known as photoperiod) increase milk, egg and reproductive performance.

A light meter can be used to measure the light levels reaching the animals eyes. In this way, there is assurance that the minimum amount required is available. Light meters are readily available for as little as $100. Selection of the correct meter is important. For example, a poultry barn that operates at very low light levels (two or three lux or about 0.2 foot-candles) requires a more sensitive scale than a swine or dairy barn.

Using light meters is complex. A professional approach is recommended to ensure accurate measurements and the evaluation of problems such as design of the system, shadowing, dust and dirt on the light system, interference with the ventilation system, etc.

Gas Levels

Many gases are extremely harmful to animals and humans when concentrations are excessive. Gas concentrations are typically higher in the colder months when ventilation systems are operating at minimum levels to conserve heat. Therefore, winter is the most important time to keep an eye on gas levels.

Additional information on gases and other environmental levels are shown in **Table 4** (on the following page).

Colourimetric gas detection

The lowest cost method to measure harmful gases in the barn uses glass tubes (Colourimetric) that change colour in proportion to the gas concentration in the air. Dozens of gas and vapor-specific detector tubes are available including ones for ammonia, hydrogen sulfide, carbon dioxide and carbon monoxide. There are two types:

Active systems: Active colourimetric gas detection uses a special manual syringe-pump or battery-operated pump to draw a specific volume of air (for example, 100 ml) through a special indicator tube. The tube is made of clear glass and contains a crystalline reagent that reacts specifically with the gas of interest changing colour as the gas moves along the reaction column. The higher the gas concentration, the longer the length of the colour stain. The easy-to-read measuring scale printed on each tube lets you make convenient, accurate gas measurements in less than 60 seconds. Gas measurement requires a pump that can cost $500 and up. Tubes (used once per reading and discarded) cost about $7 each.

Passive systems: Dosimeter tubes or dositubes provide an inexpensive way to assess average gas concentrations over short periods of time (one to eight hours) **Figure 7.** Dosimeter tubes use an indicator column similar to that of the active systems, but no air pump is employed. Instead, air moves passively through the column over time. Readings taken from the scale on the side of the tube are time dependent. The longer the tube is exposed, the higher the reading. To correct for the time factor, readings are divided by the hours of exposure to yield a time-weighted average.

Figure 7. Passive dosimeter tubes

Table 4. Suggested gas and other environmental levels

Species	Room Ambient Temperature Winter[1] (° C)	Surface Temperature Winter Below Room[2] (° C)	Surface Temperature Summer Above Room (° C)	Relative Humidity Maximum[3] (%)	CO_2 Maximum[4] (ppm)	NH_3 Maximum[4] (ppm)	H2S Maximum[4] (ppm)	Light Level[5] (lux)	Static Pressure Summer (in. w.g)	Static Pressure Winter (in. w.g)	Winter Max Velocity in (ft/min)
Dairy Cattle	< 15	-10	+5	70	< 3,000	< 15	< 2	100 - 200	0.04 - 0.06	0.06 - 0.08	< 50
Dairy - Calves	< 20	-5	+5	70	< 3,000	< 5	< 2	100 - 200	0.04 - 0.06	0.06 - 0.08	< 25
Poultry < 1 wk	> 30	-5	+5	70	< 3,000	< 2	< 2	20 - 30	0.04 - 0.06	0.06 - 0.08	< 25
Poultry 1 - 3 wks	28 - 32	-5	+5	70	< 3,000	< 2	< 2	5 - 10	0.04 - 0.06	0.06 - 0.08	25 - 50
Poultry 3 - 6 wks	26 - 28	-5	+5	70	< 3,000	< 5	< 2	2 - 5	0.04 - 0.06	0.06 - 0.08	50 - 100
Poultry > 6 wks	15 - 26	-5	+5	70	< 3,000	< 5	< 2	2 - 10	0.04 - 0.06	0.06 - 0.08	50 - 100
Swine Breed Gestation	18	-5	+5	70	< 3,000	< 15	< 2	> 100	0.04 - 0.06	0.06 - 0.08	40 - 50
Swine Farrow	20	-3	+5	70	< 3,000	< 5	< 2	50 - 100	0.04 - 0.06	0.06 - 0.08	40 - 50
Swine Nursery	32 - 21	-3	+5	70	< 3,000	< 5	< 2	50	0.04 - 0.06	0.06 - 0.08	25 - 50
Swine Grow-Finish	21 - 15	-5	+5	70	< 3,000	< 10	< 2	50	0.04 - 0.06	0.06 - 0.08	40 - 100

[1] Actual temperatures can vary widely.
[2] Varies widely depending on type, such as breeding or meat production.
[3] Data from American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) E.EM Sterling, Criteria for Human Exposure to Relative Humidity, 1985.
[4] Various Sources, American Society of Agricultural and Biological Engineers (ASABE).
[5] Data from ASABE EP 344.

Dosimeter tubes can monitor gas concentration in a specific location, or they can be worn on lapel clips to monitor employee exposure to potentially harmful gases over the course the workday. Tubes (used once per reading and discarded) cost about $7 each.

Digital systems

Many other digital devices are available to measure gases, some with the ability to data log. They range in price from $700 for a carbon dioxide digital read-out to $3,500 for multilevel gas detectors with data logging. These devices also require frequent calibration, either on-farm (i.e., using gas cylinders and regulators- expensive) or by the supplier or manufacturer (i.e., device becomes unavailable for a period of time). With the notable exception of the hydrogen sulfide monitor, most farms would not benefit from owning these devices, but rentals can be arranged. See **Table 4** for recommended levels.

Hydrogen Sulfide

Hydrogen sulfide, sometimes called manure gas, is a potentially fatal by-product produced primarily from stored liquid manure. It can also be produced in solid storages. Any time stored manure is moved, a lethal concentration of the gas can escape and cause injury or death (see Alberta Agriculture and Food factsheet *Hydrogen Sulphide Emmisions and Safety*, Agdex 086-2). A low cost alarm device (< $250) is available and strongly recommended for any farm personnel moving or handling manure (**Figure 8**).

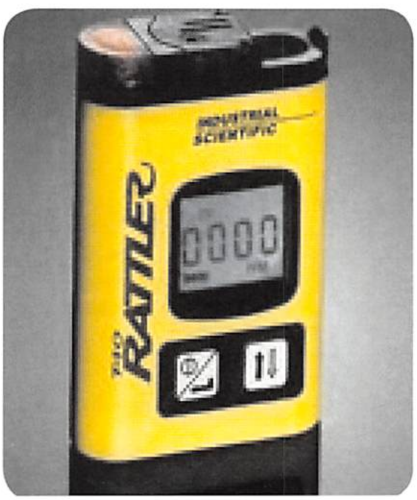

Figure 8. Hydrogen sulphide monitor

Dust

Dust is the most difficult environmental parameter to measure, and the appropriate measurement equipment is quite expensive. Dust particles need to be separated by size to determine the respirable portion. Respirable dust goes directly to the lungs and contributes to animal and human health problems. Dust, in general, is detrimental to animals, workers, and equipment with moving parts (see the factsheet *Dust Control for Livestock Buildings*, Agdex 086-5). There are two primary methods of determining dust concentrations (both expensive).

- Air samples may be taken and submitted to a lab where a cascade impactor or similar device is used to determine dust levels in a range of sizes. Collecting the air sample requires a specially designed vacuum pump and dust collection filter. This approach is more for a research environment than on a farm.
- A respirable dust data logger (**Figure 9**). These devices cost over $7,000 and are costly to maintain. An example of the data collected by a dust data logger is presented in **Figure 10.** Rental of this equipment will be of importance to farms where dust is suspected as being at excessive levels and management wishes to determine when high levels occur and to what extent.

Figure 9. Dust data logger

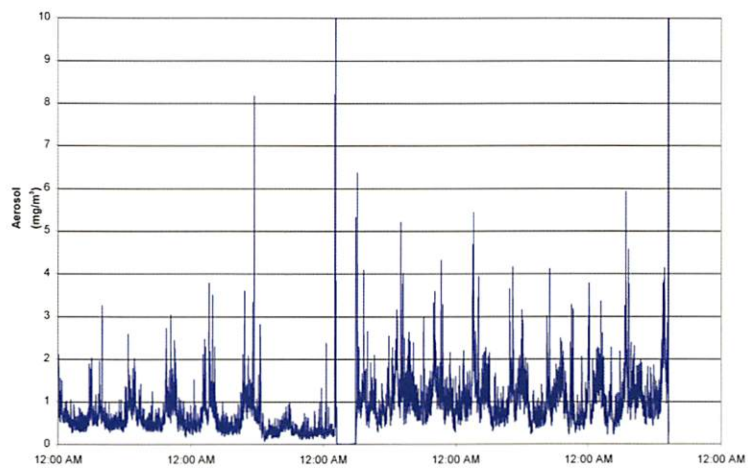

Figure 10. Sample graph from a swine finisher barn

Features to consider when you are purchasing an instrument:

- full size or pocket-sized, carrying case and straps
- measuring range, accuracy and resolution
- field-calibrated using reference standards
- RS-232 communication output and PC software for data acquisition
- on-board data logging to store readings for later analysis
- backlit digital display for easy reading in dark areas
- laser
- adjustable

Table 5. Approximate costs for monitoring equipment

Measurement	Device[1]	Notes	Cost[2, 3]	Comments
Temperature	Thermometer, with or without maximum and minimum	Dry bulb temperature: slow response to changes	$10 - 50	Not recommended except to calibrate digital device
Temperature	Digital max - min Thermometer	Dry bulb temperature: rapid response to temperature changes	$50	Recommended
Relative humidity	Digital hygrometer	Relative humidity: requires periodic calibration check	$75 - 400	Recommended
Air speed	Hot wire anemometer	Air speed: to as low as 10 ft/min	$700 - 1,000	Rental or professional
Air speed	Vane Anemometer	Air speed: for above 50 ft/min	$75 - 400	Recommended with training
Air speed	Velocity manometer – low or high	Air speed	$60	Not recommended, too inaccurate
Visualization	Smoke gun	Visualize air speed	$100 + refills	Recommended, great for leak detection as well
Visualization	Smoke sticks	Visualize air speed	$100/12 pack	Recommended, great for leak detection as well
Temperature of surfaces	Infrared thermometer	Radiant surface temperature	$150 - $2,600: note the $150 is suitable for most farm applications	Recommended
Gas levels	Gas sampler pump	Noxious gas level	$500 and up + $7/tube	Not recommended, too expensive
Gas levels	Dosimeter tubes	Noxious gas level	$7/tube	Recommended
Gas levels	Digital gas sampling	Noxious gas level	$200 and up	Rental or professional
Static pressure	Manometer	Static pressure	$40 - 100	Recommended
Fan rotational speed	Tachometer	Fan rotation	$200 - 300	Not recommended, complex
Light levels	Light meter	For agriculture need to go to as low as 1 lux	$100 and up	Rental or professional
Dust	Digital dust logger	Complex and expensive to purchase and maintain	$7,000	Rental or professional

[1] Almost all these devices can be rented or leased. Low cost items that are recommended should be purchased and kept on the farm.
[2] Price ranges reflect instruments suitable to agricultural applications. Higher priced instruments have improved accuracy and more features than lower priced models.
[3] Prices of the instruments as of January 2007.

Opportunities for Automation

Chart recorders and data loggers are available for periodic air temperature and humidity reading and recording. Thus, data may be collected over time and analyzed later for environmental comfort factors. Chart recorders are affordable but require manual data analysis. More sophisticated and convenient, computer-compatible data logging adds considerably to cost but is worthwhile for large data collection. Some ventilation system controllers can provide environmental data collection.

Canadian Suppliers

Agvrio
367 Gordon Street
Guelph, ON N1G 1X8
Phone: (519) 836-9727
Fax: (519) 836-5708
www.agviro.com

Grainger
www.acklandsgrainger.com
Phone: 1-800-668-8989

Levitt-Safety Limited
www.levitt-safety.com
Alberta locations:

Bay 4, 417- 53rd Ave. S.E.
Calgary, AB T2H 2E7
Phone: (403) 252-2703
Fax: (403) 252-2787

9241- 48 Street
Edmonton, AB T6B 2R9
Phone: (780) 461-8088
Fax: (780) 461-837

Unit # 21, 380 Mackenzie Blvd.
Fort McMurray, AB T9H 4C4
Phone: (780) 743-5032
Fax: (780) 743-5034

USA Suppliers

Animal Environment Specialists
119451 Rausch Road
Marysville, OH 43040
Tel/Fax: (937) 642-4691

Grainger
www.acklandsgrainger.com
Phone: 1-888-361-8649

Davis Instruments
4701 Mt. Hope Dr.
Baltimore, MD 21215
Phone: 1-800-368-2516

Cole-Parmer
7425 North Oak Park Ave.
Niles, IL 60714
Phone: 1-800-323-4340

Summary

Determining air characteristics in livestock housing environments allows producers to evaluate problems and their potential causes. This is the first step toward correcting any problems detrimental to production. A healthy and comfortable indoor environment will lead to productivity gains for livestock.

Quantifying air characteristics such as temperature, humidity, air speed and contaminant levels can show where livestock housing is falling short of optimal conditions. Changes in management and environmental conditions are the next step. Here again, air quality can be quantified for comparison. Progress in improving the environment can be determined, and animal health and comfort changes documented.

Each air quality characteristic, such as temperature, humidity, air speed and flow pattern, can be measured in more than one way. The cost of instruments often is weighed against the accuracy of readings.

Certain instruments are appropriate only for specific applications. Accurate readings are obtained when the basic principles of how the instrument detects an environmental characteristic are understood. Proper technique will minimize the human effect on the air being measured.

Periodic checks of environmental conditions with the appropriate instrument are a supplement to the everyday observation of building conditions, animal behaviour and production records.

Factsheets in this Series

Factsheet 1 Principles of Measuring Indoor Air Quality

Factsheet 2 Instruments for Measuring Indoor Air Quality

Factsheet 3 Optimizing Ventilation System Performance

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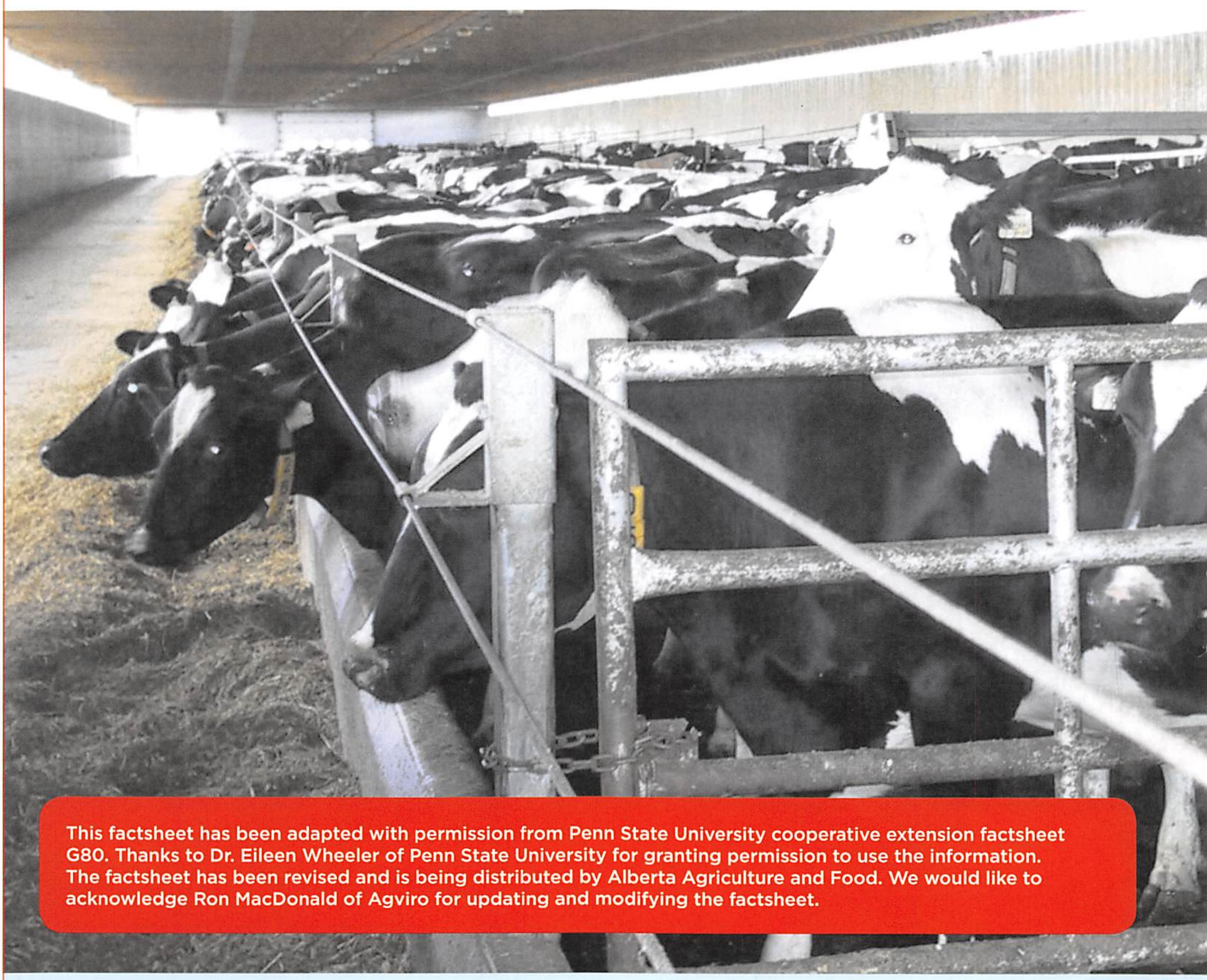

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