Troubleshooting Livestock Environmental Control Systems

Don D. Jones
William H. Friday
Sherwood S. DeForest
TROUBLESHOOTING LIVESTOCK ENVIRONMENTAL CONTROL SYSTEMS

Don D. Jones and William H. Friday, Extension Agricultural Engineers, Purdue University, and Sherwood S. DeForest, P.E. Agricultural Engineer, Consultant
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Environmental control systems for confinement livestock include proper building insulation, exhaust fans, furnaces, fresh air intakes and electrical control units, all working together to maintain a desired environment for the animals. These systems make possible the labor-efficient buildings that have contributed significantly to livestock production profits. But at times, they have also been blamed for excessive heating costs, animal disease and various other management problems.

An environmental system properly designed and maintained should have relatively few problems. (See Purdue Extension Publication AE-96 on the management and operation of such a system.) On the other hand, incorrect selection and installation of equipment or improper operation can be costly in terms of both energy waste and reduced animal productivity. Even a successful system will 'go sour' if its electrical and mechanical components are not kept in good working order.

The purpose of this publication is to help producers quickly recognize environmental problems in confinement livestock buildings, determine (troubleshoot) their causes and know what must be done to correct them. First, we will look briefly at the two main contributors to good animal performance in closed confinement, the best clues as to how an environmental system is functioning, and some basic 'tools' used in troubleshooting.

Then we list ten symptoms that signal environmental problems, and discuss their possible causes and cures. Many of the solutions merely require adjustments in system operating procedures; others call for some structural or equipment changes. A few involve extensive—and expensive—alterations. That's why correct diagnosis is so important.

ASSURING ANIMAL COMFORT IN CONFINEMENT HOUSING

Two keys toward insuring the comfort, health and productivity of animals in confinement are: (1) maintaining an optimum surrounding temperature and (2) confining according to age and/or size.

Table 1 shows the recommended environmental temperatures for various types and sizes of livestock. Keeping the facility within the appropriate temperature range should help maximize animal performance. Also, because animals of similar size and age have similar environmental needs, grouping them this way in closed confinement most effectively utilizes a given set of environmental conditions.

| Table 1. Temperature Optimums and Ranges for Confinement Swine and Dairy Animals. |
|--------------------------------|----------------|
| Type of animal               | Temperature (°F) |
|                              | Optimum | Range |
|================================|---------|-------|
| **Swine**                    |          |       |
| Lactating sow                | 60      | 50-70 |
| Litter, newborn              | 95      | 90-100|
| Litter, 3 weeks              | 75      | 70-80 |
| Pre-nursery pigs, 12-30 lbs. | 80      | 75-85 |
| Nursery pigs, 30-75 lbs.     | 75      | 70-80 |
| Growing-finishing pigs       | 60      | 50-70 |
| Gestation sow and boar       | 60      | 50-70 |
| **Dairy**                    |          |       |
| Cows                         | 50      | 45-70 |
| Calves                       | 70      | 45-80 |
Remember that the environment in livestock buildings should be comfortable for the animals, not necessarily for the workers. The best clue to how the environmental system is functioning, therefore, is animal behavior. If animals are comfortable, they look and act comfortable.

For instance, when too cold, small pigs tend to curl up, huddle in groups, lie next to the sow or bristle their hair coats. When comfortable, they will stretch out and lie in the middle of the floor. When too hot, they not only stretch out but lie in moist floor areas, pant and drink large amounts of water.

‘TOOLS’ USED IN TROUBLESHOOTING

There are several readily available and relatively inexpensive ‘instruments’ that aid in monitoring the performance of a livestock building environmental control system and pinpointing problems should they arise. Following are the basic ones, and where and how they might be used.

Thermometer

Use a good quality thermometer to check all thermostatic controls for accuracy at least twice a year. Make sure that all fans and heaters start and stop at the correct temperature, and that the temperatures at thermostat locations represent the temperature in the animal area. (See AE-96 for recommended locations.)

Also consider using a Hi-Lo thermometer that records room maximums and minimums over a period of time. This would indicate how well environmental equipment controls are functioning. Temperature fluctuations in cold weather should coincide with the range of the furnace thermostat—usually about 5 degrees.

Smoke Generator

This ‘tool’ can be anything from a long-handled container with smoldering, oily rags to a commercial smoke bomb or smoke stick. It is used to visualize inside air movement. By holding the smoke source at the furnace exhaust, fresh air intake and various locations around the room, you can tell if ventilation air is being distributed uniformly or if there are drafts or dead spots in the animal area.

In winter, incoming cold air should be ‘thrown out’ from the intake in a distinct flume shape for a distance of 12-15 feet before it mixes with warm building air and settles down around the animals (Figure 1). In summer, the intake baffle should be adjusted to divert the incoming air down on the animals. The smoke will show you if the air is going where you want it to go.

Air Speed Meter

Pocket air velocity meters (velometers) are used to measure air speed near the air intake. They cost from $20 to $200 and may record velocities up to 2000 feet per minute (fpm).*

In an exhaust-fan-ventilated building, air entering through a slot intake should have a speed of 700-1000 fpm (8-11 miles per hour) at the point where it leaves the baffle (Figure 2). The baffle on the slot intake can be opened or closed to regulate the air speed if found not to be in this range.

Air speeds in the animal resting area are normally in the range of 30-50 fpm. However, in hot weather when cooling is needed, the speeds should be increased to 150 fpm or greater. Air in the slotted area of a partly-slotted floor pen should be 25-50 fpm higher than in the solid floor resting area, to encourage good dunging habits.

Negative-Pressure or Vacuum Gauge

This instrument (also called a manometer) measures the difference in static air pressure between inside and outside (Figure 3). Inside pressure should always be less than outside pressure in buildings ventilated by exhaust fans.

A manometer is simply a transparent U-shaped tube filled with colored liquid. One end of the tube is open to the building environment, the other to the outside atmosphere. The part running to the ‘outside’ is sometimes placed in the attic instead, to eliminate any vacuum effect caused by wind blowing across the open end of the tube. Of course, the attic must be properly vented to minimize differences between attic and outside air pressure. The instrument (costing around $30) is usually wall-mounted in an area of the room where it can be easily read.*

Pressure difference is expressed in inches of water. A reading of about 0.04 inch indicates that the slot air inlet is operating properly. This corresponds to a slot opening of about 1 square inch for each 4 cubic feet per minute (cfm) of fan capacity.

* In Indiana, both air speed meters and manometers are available from F. W. Dwyer, Inc., Michigan City, IN 46360.
TROUBLESHOOTING ENVIRONMENTAL SYSTEM PROBLEMS—SYMPTOMS, CAUSES, SOLUTIONS

Now let's troubleshoot ten common closed confinement environmental problems. Each numbered main heading identifies the symptom most indicative of a specific problem; the secondary headings list the probable causes; and the paragraphs that follow suggest the steps needed to correct them. Many environmental problems have more than one possible cause; this often means a persistent trial-and-error procedure to correct the trouble.

1. ANIMALS OBVIOUSLY COLD

Animals huddle in groups, shiver, lie in feeders, curl up or bristle their coats.

Cold Building
- If the temperature at animal level is below the value shown in Table 1, see 9. BUILDING TOO COLD.

Stray Air Currents (Drafts)
- Improper slot air intake velocity. Correct by adjusting the air intake baffle. Replace baffles if warped to the point where a uniform opening cannot be maintained.
- Drafts running lengthwise through the building. Break up the air flow by using partitions between pens. In a partly-slotted-floor building, all partitions should be solid along the solid floor resting areas.

In a total-slotted-floor building, make every other pen partition solid.
- Drafts in the animal resting area. Place a hover over about one-third of the pen area. For best results, locate hovers next to a solid wall or solid pen partition (Figure 4). Air velocities in the resting area should be 30-35 fpm for new-born and nursery pigs and 45-50 fpm for larger animals.
- Too much fan capacity in pit ventilation system. The pit ventilation fan should be sized to handle only cold weather ventilation rates (Table 2). Also, there should be at least 12 inches of space between the manure and the slat supports. (For more information, see Purdue Extension Publication AE-98.)

Cold Floor
- Foundation uninsulated. If the situation permits, consider insulating the outside foundation perimeter. (See Purdue Extension Publication AE-95 for information on perimeter insulation.) Another solution is to overlay the floor area adjacent to the outside wall with plywood. Or use bedding if it would not interfere with a liquid manure system; bedding has about the same effect as raising the floor temperature 10°F. Also remember that wood or plastic flooring loses less heat through an uninsulated foundation than concrete or metal flooring.
- Wet soil conditions around a solid floor or foundation. Since wet soil tends to conduct heat away from the building, regrade to divert surface water.
2. HIGH ODOR LEVEL

Pit Ventilation Not Working Properly
- Not enough free space above liquid manure. There should be at least 12 inches between slat supports and the liquid manure.
- Improperly sized or located pit fans, air ducts or duct inlet openings. With exhaust annex pit ventilation systems, no part of the slotted floor should be located more than 50 feet from a pit ventilation fan. With an exhaust duct system, no part of the slotted floor should be more than 15 feet from an inlet to the duct. (See publication AE-98 for recommended sizes and design.)

Poor Air Movement
- Improperly adjusted baffles at the slot air intakes. Poor air movement can be confirmed using smoke to track the air flow as it leaves the slot inlet. Air velocity at the inlet should be in the range of 700 to 1000 fpm. Since ventilation requirements change with the temperature of the incoming air, baffles need frequent adjustment (see publication AE-96).
- Insufficient fan capacity. Check rated fan capacity against the recommendations given in Table 2.
- Insufficient ventilation. An extended period of very cold outside temperatures can cause the ventilation system to operate at its minimum (moisture control) level for long periods of time. As long as the system controls moisture buildup, animals should not suffer from the higher odor level. However, you may want to increase the ventilation rate temporarily to remove odors at those times you plan to be in the building.

3. POOR DUNGING HABIT IN PARTLY-SLOTTED FLOOR BUILDINGS

Hot Animals
- If the temperature at animal level is above the value shown in Table 1, see 8. BUILDING TOO WARM.
- Insufficient insulation. The sun can warm walls and ceilings, turning them into sources of radiant heat and forcing animals away from the walls, where slats are often located. Insulate walls to a heat flow resistance value of at least R=13. (For more information, see publication AE-95.)
- Insufficient fan capacity causing too low a ventilation rate. Check your system against the recommendations in Table 2.

Table 2. Recommended Per-Head Ventilation System Rates for Confinement Swine and Dairy Animals.

<table>
<thead>
<tr>
<th>Type of animal or facility</th>
<th>Cold weather rates</th>
<th>Mild weather rates</th>
<th>Hot weather rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moisture control* on -</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fully slotted</td>
<td>Partly slotted</td>
<td>Solid floor</td>
</tr>
<tr>
<td>Swine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sow and litter</td>
<td>10</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Pre-nursery pig (12-30 lbs.)</td>
<td>1.0</td>
<td>1.6</td>
<td>2</td>
</tr>
<tr>
<td>Nursery pig (30-75 lbs.)</td>
<td>1.5</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Growing pig (75-150 lbs.)</td>
<td>3.5</td>
<td>5.5</td>
<td>7</td>
</tr>
<tr>
<td>Finishing hog (150-220 lbs.)</td>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Gestating sow (325 lbs.)</td>
<td>6</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Boar (400 lbs.)</td>
<td>7</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Dairy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>16.5</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>Calf</td>
<td>5</td>
<td>8.5</td>
<td>10</td>
</tr>
<tr>
<td>Milk room (total cfm)</td>
<td>-</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Parlor (total cfm)</td>
<td>-</td>
<td>-</td>
<td>8</td>
</tr>
</tbody>
</table>

*Increase moisture control ventilation rate by about 20 percent of the solid floor value if unvented furnaces used.
4. EXCESSIVE HEATING COSTS IN PROPERLY INSULATED BUILDINGS

Poorly-Designed Winter Ventilation System

- **Cold-weather ventilation rate too high.** When the furnace is operating, use only enough fan capacity to control moisture; this should result in about 2 or 3 air changes per hour. The ventilation system should be operated at a higher rate to control odor only when workers are in the building. (See Table 2 to check your winter ventilation capacity against recommended values.)
- **Thermostats controlling the mild-weather ventilation fans set too low.** The fans used to provide rates higher than needed for moisture removal (with the exception of a manually-controlled, odor-control fan) should not come on until room temperature is at least 3 degrees higher than the furnace shut-off temperature. Use an interlocking thermostat with a built-in temperature lag to keep the furnace and mild-weather fans from working against each other. (For more information, see publication AE-96.)
- **Inaccurate fan or furnace thermostats.** Use a good-quality thermometer to check the accuracy of the furnace and fan controls. Make sure the temperatures at the thermostats are representative of temperatures at animal level.

Low Animal Density

- **Facility overventilated for the number of animals present.** See Table 2 for recommendations. Ventilation and heating systems are designed for buildings operated at capacity. If not at capacity in cold weather, you must either add more heat or more animals to maintain the desired temperature. With some ventilation systems, fan capacity can be lowered, or as a last resort, a timer can be used. Avoid timers if possible, because they can result in high humidity levels and drafts, and can cause condensation in the attic. (See publication AE-96 for ways to reduce the ventilation rate of a single-speed fan.)

5. CONDENSATION ON INTERIOR SURFACES

Insulation Problems

- **Insufficient insulation.** Levels of at least R=13 in walls and R=20 in the ceiling are needed in heated buildings. (See publication AE-95 for specific recommendations.)
- **Wet insulation.** If there is no vapor barrier on the warm (animal) side of the insulation, it can become wet. And wet insulation may lose heat faster than a wall with no insulation at all. To correct, apply a vapor barrier—two coats of aluminum paint or spar varnish—on the interior walls and increase ventilation through the wall cavities and attic space.
- **Extremely cold outside temperatures.** This can cause cold inside wall surfaces which cool the air until it no longer holds its moisture (dew-point temperature), resulting in condensation or frost. The problem should go away when the weather warms up.

Improper Ventilation

- **Not enough ventilation.** Check fan capacity against the recommendations given in Table 2. The fan used to control moisture must be sized properly and operated 24 hours a day. It should not be operated with a timer.
- **Too much ventilation.** As cold incoming air is warmed, it evaporates moisture. Too high a ventilation rate can cause air to move through the building too fast to be warmed up enough for adequate moisture removal. Side effects will be drafts and difficulty in maintaining a high enough building temperature. Check the thermostat settings on furnace and fans; then check the capacity of the fans against the capacity recommended for cold weather (Table 2).
- **Non-uniform air distribution.** Poor air distribution can result in too much ventilation in one section of the building and not enough in another. Check slot air intake baffles for proper opening size and air deflection. Provide 1 square inch of intake for every 4 cfm of fan capacity. To determine the quality of air distribution, check air speed at the intake and the level of static air pressure in an exhaust-ventilated building.

High Humidity

- See next section.

6. HIGH BUILDING HUMIDITY IN WINTER

Humidity level is more than 80 percent, making the air feel muggy.

Excess Moisture

- **Added moisture from unvented gas heaters.** Unvented gas heaters can add, as a by-product of combus-
tion, over 1 pound of water per pound of propane burned. If such heaters are used, increase the cold weather ventilation rate an additional 20 percent of the solid floor rate shown in Table 2.

- Added moisture from sick animals with diarrhea, leaky waterers, high-pressure washers or flush-gutter waste systems. The problem can be alleviated by removing as much as possible the source of excess water, or by increasing the ventilation rate and adding more heat to the building.

**Improper Ventilation**
- See 5. CONDENSATION ON INTERIOR SURFACES.

### 7. DEAD AIR ZONES OR HOT SPOTS

**Non-Uniform Air Distribution**
- Improperly adjusted baffles at the slot air intakes. Check air distribution using smoke. Air speed at the inlet should be in the range of 700 to 1000 fpm. Since needed fan capacity changes with the temperature of the incoming air, the baffles need frequent adjustment. Consider using an automatic baffle control operated with a pressure-sensing unit.
- Short-circuited air distribution system. Check for open doors or windows, which decrease the pressure difference and cut the air flow coming through the slot inlet.

**Insufficient Fan Capacity**
- See next section.

### 8. BUILDING TOO WARM

**Insufficient Fan Capacity**
- Thermostats set too high. If this is the case, the fans do not come on soon enough.
- Incorrectly sized fans. Check your fan capacity against that recommended in Table 2 for your particular building. It is important to use fans that can deliver the recommended amount of air against a static pressure of 1/8 inch of water, which is the same as operating against a 15 mph wind. At this pressure, fans usually deliver only about 75 percent of their free-air capacity. For best results, purchase only fans stamped to show they have been tested by the Air Moving and Conditioning Association (AMCA).

Inadequate capacity is a common problem with variable-speed fans, since they have very little torque at low speed when operating against a wind. Unfortunately, low-speed operation is usually necessary to obtain the moisture control ventilation rate. A single-speed fan operates better against high static pressures and is preferred for cold weather use.

- Restrictions to air flow. At least every 4 months, remove dust from shutters, blades, shrouds and fan housings. Dirty fan shutters can easily cause a 20-25 percent reduction in fan capacity. Also, in very cold weather, shutters on intermittently-operated fans can freeze shut.

**Restricted Air Intakes**
- Air intake too small or clogged. Be sure the slot air intake is sized at 1 square inch per 4 cfm of fan capacity and that the louver and soffit air intakes into the attic provide 2 square inches per 4 cfm. If attic louvers were covered with furnace filters in winter to prevent snow blow-in, remove the filters when the weather warms up. Use 1/2-inch hardware cloth on attic intakes and soffit vents to keep birds out; a smaller mesh will plug up too easily. Measure static air pressure in the building to find out if air intakes are restricted; greater than 1/10-inch water pressure indicates they probably are.

**Unseasonably Hot Summer Weather**
- Not enough air movement in animal pens. Direct the air flow from baffled slot intakes down to the animals. In hot weather, air speed at animal level should be about 150 fpm.
- Need for additional cooling. Consider using mist sprinklers, set to operate 2 minutes each hour, or evaporative cooling to make animals more comfortable. (See publication AE-103 for information on cooling systems.)

**Insufficient Insulation Levels**
- Insulate heated buildings to at least R=13 in walls and R=20 in ceilings. (See publication AE-95 for information on selecting and installing insulation.)

### 9. BUILDING TOO COLD

**Excessive Ventilation Rate**
- Winter fans operating at too high a capacity for the building. Check against the cold and mild weather ventilation rates recommended in Table 2. Either use lower capacity fans or limit their air flow, as outlined in publication AE-96.
- Improper fan control settings. Check thermostatic controls for accuracy. Only the moisture-control fan should be running when the furnace is on. No mild weather fans should come on until the temperature is at least 3 degrees higher than the furnace shut-off temperature.

**Insulation Problems**
- Wet insulation or lack of adequate insulation levels. See 5. CONDENSATION ON INTERIOR SURFACES.

**Low Animal Density**
- Not enough animal body heat produced. This will occur if the building is not at designed capacity. See 4. EXCESSIVE HEATING COSTS IN PROPERLY INSULATED BUILDING.
Insufficient Heating System

- Furnace too small. See publication AE-96 for recommended furnace sizes.
- Furnace controls set too low. The furnace setting should be about 2 degrees lower than the desired room temperature. Check thermostatic controls for accuracy. (See publication AE-96 for more information.)

Unusually Cold Weather

- Need for additional heat or protection. Use supplemental space heating or creep heaters on a temporary basis. Also consider adding bedding if it will not interfere with the liquid manure system.
- Ventilation rate adjustment. As a last resort to maintain building temperature, lower the ventilation rate by using a timer. This is only a temporary solution, since timers tend to increase humidity and draft problems and can cause moisture in the attic.

10. FANS OR FURNACE NOT WORKING

Electrical Malfunction

- Tripped circuit breaker, blown fuse or tripped fan motor thermal overload switch. Find and fix the cause of failure before restarting the fans or furnace. Check for and remove dust from around the service entrance and fan motor housing on a regular basis.
- Defective thermostatic controls. Check for improper thermostat operation and replace as needed.
- Improperly located thermostat controls. Move sensing units to where they will accurately reflect temperatures at animal level.
- Improperly wired fans and controls. Recheck installation instructions.
- Controls improperly calibrated. See your fan or furnace owner’s manual for recalibration instructions.

Related Publications

Single copies of the following ‘Energy Management in Agriculture’ publications are available free to Indiana residents from their county Cooperative Extension Service office or by writing to the CES Mailing Room, AGAD Building, Purdue University, West Lafayette, IN 47907:

- “Cooling Systems for Livestock” (AE-103)
- “Energy Conservation for Livestock Housing” (AE-101)
- “Environmental Control for Livestock Housing” (AE-96)
- “Insulating Livestock and Other Farm Buildings” (AE-95)
- “Manure Pit Ventilation” (AE-98)
- “Natural Ventilation for Livestock Housing” (AE-97)
- “Solar Heat for Livestock Housing” (AE-99)
- “Wind and Snow Control for the Farmstead” (AE-102)
- “Worksheet for Sizing Livestock Housing Environment Control Systems” (AE-109)

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