Electronic Controls for Broiler Houses

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INTRODUCTION

This fact sheet discusses the use of electronic controllers to maintain the environment within broiler houses. There are some special considerations when installing controllers in broiler houses, primarily caused by the very large size of today's houses. Three main items are addressed in this fact sheet: 1) the selection of a controller, 2) installation considerations, and 3) protection against controller failure.

SELECTION OF A CONTROLLER

Selecting a controller requires some careful investigation. Initial cost is very important, but even more important is to determine what you will control, and how you want it controlled. Fans and heaters are the most likely candidates for the equipment to be controlled, since they are the heart of any environmental control system.

For broiler housing, the most common ventilation strategy is a negative pressure system, i.e. the fans all exhaust air from the building. Fresh air is drawn in through inlets by the exhaust fans. Air distribution within the building is mostly controlled by properly adjusting the air inlets as ventilation rate changes to maintain a constant pressure drop between inside and outside. The ventilation in a typical broiler house will be "staged", which means that as the inside temperature rises above the desired value, additional fans will be activated at predetermined temperature "set points".

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If the temperature falls below a desired value, heaters will be activated. "Staging" is a practical method to keep the inside temperature near the desired value.

Most broiler houses have multiple thermostats to activate heaters and fans. In principle, these thermostats can all be adjusted so that they come on in stages. But in reality, this doesn't happen because it is very difficult to keep all the thermostats in calibration; especially when the desired inside temperature is changed frequently such as during brooding. Few broiler houses actually operate with a truly staged ventilation system. Consequently, staged ventilation is a completely different way of maintaining the interior environment, and can lead to some confusion when trying to select a controller. Once the fundamental idea of staged ventilation is understood, deciding what equipment to put on each stage is fairly straightforward and may even be specified by the integrator in some locations.

For minimum ventilation, there are two basic approaches. Some controllers have built-in interval timers to run fans. Many, however, do not and so conventional mechanical timers must be used. The location of these timers should be close to the controller, for ease in making timely adjustments. Remember, most fuel is used during brooding, and the amount is directly related to the rate of minimum ventilation. So any steps that can be taken to ensure that minimum ventilation is correctly set can result in fuel savings.

Setting heat stages is generally straightforward. Some controllers have more than one stage for heat, so that if the inside temperature continues to drop after the first stage of heat is activated, another stage will be activated. Also, some controllers have multiple inside temperature sensors that can be used independently to activate heaters in the area that the sensor is located. This is typically called "zone heating". Controllers with this feature tend to be quite a bit more sophisticated, and more expensive.

**EXAMPLE BROILER INSTALLATION**

To illustrate an example of how to use an electronic controller, consider the broiler house in Figure 1.

As shown in Figure 1, the broiler house consists of four sidewall fans for minimum ventilation, eight large fans at one end for tunnel ventilation, and six LP gas heaters. Pairs of the large end fans share a common 240 VAC circuit, three pairs of heaters are placed on two 120 VAC circuits, and the timer actuated sidewall fans are placed on two 240 VAC circuits.

A possible staging schedule is as follows:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Equipment Operated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat</td>
<td>H1 through H6</td>
</tr>
<tr>
<td>1</td>
<td>S1 and S3</td>
</tr>
<tr>
<td>2</td>
<td>S2 and S4</td>
</tr>
<tr>
<td>3</td>
<td>T1 and T2</td>
</tr>
<tr>
<td>4</td>
<td>T3 and T4</td>
</tr>
<tr>
<td>5</td>
<td>T5 and T6</td>
</tr>
<tr>
<td>6</td>
<td>T7 and T8</td>
</tr>
</tbody>
</table>
This staging of the ventilation equipment provides for a gradual increase in the number of fans as the inside temperature rises. Another alternative is to approximately double the ventilation for each stage.

To visualize how the system will operate, it is helpful to consider what stage is activated as the inside temperature varies around the set point temperature. Figure 2 illustrates how the example building would operate. If the inside temperature is more than 3°F colder than desired, then the heat stage is activated. As the house temperature warms up, the heat stage shuts off and stage 1 is activated. For this example, stage 1 is connected to sidewall fans S1 and S3, which are operated by the controller’s interval timer.

As the interior temperature continues to rise, additional stages are activated. The temperature difference between stages is 3°F in this example. Once the inside temperature exceeds the set point by 18°F, all fans will be running.

INSTALLATION CONSIDERATIONS

Once a general strategy for the heating and ventilation system is decided upon, the task of selecting a controller can be done. There are some hidden costs in implementing controllers that are not readily apparent. First, most controllers are not built to directly switch large electrical loads such as fan motors. Instead, they have a “control relay” for each stage, which in turn activates the coil of a “power relay” that actually switches the equipment on or off (see Figure 3). These power relays typically cost from $25 to $75 each, and at least one per stage is required. More than one power relay per stage can be useful, for instance to control multiple heaters on one heat stage. Several companies manufacture relay boxes, which consist of several power relays pre-wired with ON/OFF/AUTO switches (Figure 4). The "ON" position provides a manual override of the controller, the "OFF" position typically is used as a disconnect, and the "AUTO" position is used under normal operation. These units typically cost about $50 per relay.

Another important consideration is how the controller interacts with air inlet control. In many older broiler houses, there is no air inlet control except for one or more hand cranks used to adjust the inlet width. Never operations typically use inlet controllers that attempt to maintain a constant static pressure difference between inside and outside. This type of system is very easy to utilize with virtually any environmental control system, because the inlet controller will automatically adjust inlets as the number of fans operating changes. Some new environmental controllers have a feature to adjust inlets (or curtains) based on temperature. This is very beneficial for buildings that utilize curtains as part of a ventilation strategy. Another method is to connect a curtain controller to one stage of the electronic controller. Equipment dealers that are familiar with a specific line of control equipment can be very helpful in putting together systems of this type.

Recently, "tunnel ventilation" has become very popular as a means to cool broilers in very hot weather. By placing all fans at one end of the building, and admitting fresh air at the other end, a "breeze" is created and this provides additional cooling for the birds. Equipment manufacturers are currently grappling with various strategies to automate the change-over from conventional to tunnel ventilation with varied degrees of success. Some of these strategies have been very well received, especially for use in buildings that utilize curtains for fresh air in moderate temperatures. For totally enclosed buildings with static pressure air inlet controllers, the main difficulty that tunnel ventilation presents is to determine when to shut the inlets and open the curtains at the end opposite the fans.
Installation is greatly enhanced if a central location is chosen for the controller and all auxiliary equipment. The most common choice for this location is near the electrical service panel, typically in the center of the building but in the brood portion. A very useful technique is to attach all the equipment to a board and pre-wire as much of it as possible before installation. A 4″ or 6″ deep raceway mounted at the bottom of the board is essential to a clean installation. Flexible conduit can be used to attach each piece of equipment to the raceway. Electrical circuits can be intercepted from the service panel and routed into the raceway. Then power relay lines can be run from the raceway back to the original lines feeding the equipment. On a new installation, the raceway and control board can be the first "stop" for power lines.

For existing buildings, another approach is to install the power relays near the fans to be activated. This can save on wiring costs, because low voltage coils (such as 24 V) can be used so that 20 or 22 AWG wire can be run from the control relays to the appropriate power relays. If a power relay is used remote from the controller, it is a good idea to select one with the on/off/auto switch configuration described above. This can be used to provide a safety disconnect near the equipment.

**PROTECTION AGAINST CONTROLLER FAILURE**

An independent and reliable alarm system is widely recognized as an essential piece of equipment in all broiler houses. The alarm system senses temperature extremes, and perhaps additional items such as power failure and low water pressure. The system activates one or more alarm-sounding devices, usually a loud audible alarm. Many newer installations are also activating an automatic telephone dialer that can repeatedly call several pre-programmed numbers with a warning message. Some operators also use a telephone pager in conjunction with these systems, so that they are immediately notified when the alarm is activated, even if they are far from the broiler house or their telephone. Another excellent feature for curtain-sided houses is an automatic curtain drop system that activates if inside temperature exceeds an upper limit.

As important as an alarm system is, it is very important to note that it should be the last line of defense against a controller failure. While a controller failure is fairly uncommon, it is a real possibility. Any electronic system that has life-support responsibilities should have mechanical backup thermostats and timers that can maintain a reasonable environment. The best way to provide these backup devices is by connecting them "in parallel" with the environmental controller. For broiler houses operated in tunnel ventilation mode, we have designed four distinct mechanical backup systems. Each mechanical backup system provides a separate function. These functions are: 1) low temperature safety, 2) high temperature safety, 3) brooding minimum ventilation, and 4) tunnel minimum ventilation. Each backup system is described in the following sections. To facilitate the illustration of these systems, the schematic of the broiler house in Figure 1 is used.

**Low Temperature Safety Override**

For low temperature protection in the event of a controller failure, one of the heater circuits is provided with a mechanical thermostat connected in parallel with the electronic controller (Figure 5). Regardless of the operation of the controller, if the mechanical thermostat senses a temperature that is lower than its setting, then it will close and provide power to the heaters. If more than one pair of heaters is desired, then two thermostats should be used. To wire this arrangement, the hot leg of the 120 VAC power circuit must be intercepted between the power relay and the service panel.
High Temperature Safety Override

For the possibility of controller failure during hot weather, it is essential to activate fans. In principal, this is identical to the low temperature safety override, except the mechanical thermostat is wired to activate "on rise" (Figure 6). For 25,000 birds two 48" fans provide 2.7 cfm/bird which should be adequate for survival, until an alarm is sounded due to high temperature. If additional ventilation backup is desired, another thermostat could be used. To wire this arrangement, either leg of the 240 VAC power circuit to the fans should be intercepted between the power relay and the service panel. Note that if an automatic curtain drop unit is installed in the building then this back-up is not necessary.

Brooding Minimum Ventilation Override

During brooding, if the controller fails there is a possibility that the lack of ventilation would be catastrophic. To cover this event, the schematic in Figure 7 illustrates one solution. Two sidewall fans (for instance, S1 and S3 in Figure 1) are the first stage of ventilation which is assumed to be controlled by a built-in interval timer. The minimum ventilation is adjusted by selecting the amount of "on-time" which the fans are desired to be run each interval. If the controller's timer were to fail so that the control relay CR2 never closed, then the power relay PR2 would never be actuated and the fans could not run.

To override a controller failure, the normally closed contacts of the power relay ("NC" of CR3) are connected to one leg of the power. The contacts of a time delay relay (TD) are next connected in series. Finally, a conventional mechanical timer is connected between the TD contacts and the fans.

The system works as follows. The time delay relay contacts are open when power is first applied to the TD coil. After a delay (which is set for slightly longer than the interval timer cycle, for example 12 minutes) if power has remained on the TD coil, then the TD contacts will close. If power to the TD coil is removed prior to the time delay, then the relay is reset and the TD contacts remain open. By placing the TD contacts between a mechanical timer and the NC contacts of PR2, the mechanical timer can control the fans if the NC contacts of PR2 are not opened within the delay time of the TD relay.

To use the system, the operator must adjust the mechanical timer MT, to a setting that is appropriate for the bird age, litter condition and outside temperature. Typically, MT, should be adjusted to the same value as the controller.

Tunnel Minimum Ventilation Override

In the event of controller failure during whole house brooding, the brooding minimum ventilation backup in Figure 7 may be insufficient, or as is often the case, the sidewall fans may be shut off. In either case a substantial temperature rise would have to occur before either the alarm system or the high temperature mechanical backup (Figure 6) were activated. Consequently, the mechanical backup for tunnel brooding depicted in Figure 8 is designed to account for this possibility. Its primary purpose is to provide a reasonable amount of ventilation at moderate or cold outside temperatures.

The backup system consists of a mechanical timer wired in parallel with the power relay that the controller activates, for example tunnel fans T1 and T2. The location of this timer should be near the electronic controller so that it is properly adjusted at all times. During brooding when the sidewall fans are activated, the mechanical timer can be turned off, or the power to the fans can
be removed.

TRANSIENT OVER-VOLTAGE PROTECTION

In addition to an independent alarm system and the mechanical backups discussed above, an often-overlooked item is transient over-voltage protection. This is sometimes referred to as "lightning protection", which is really not the same because transient over-voltages can come from a variety of sources. And while they may not have the full energy of a direct lightning strike, they can wreak many different kinds of havoc with electronic equipment. Most controller manufacturers are providing a reasonable level of protection built directly into the controller. However, no controller is fully protected. Reliability can be substantially improved by simply adding transient protection to the electrical system. The following additional levels of protection are recommended:

1. A lightning arrestor on the main service.
2. Properly grounded building service.
3. Transient arrestor for the building service.
4. Transient suppressor for the circuit with the controller.

The most common transient arrestor used is the Metal Oxide Varistor, referred to as an MOV, or sometimes just a varistor or lightning arrestor. It can sense an over-voltage on a line and very quickly shunt that over-voltage to ground. Each leg of the electrical service, including neutral, should be protected. Because the over-voltage is shunted to ground, it is very important that a proper ground is provided. If in doubt, the utility company can make a simple measurement to determine the adequacy of the service ground. Another prevalent surge arrestor is a gas discharge device. While not quite as fast acting as an MOV these can be adequate.

Transient arrestors are available in the price range of about $25 up to several hundred dollars. Beware of imitations, such as "silicon oxide arrestors", unless they are rated by an independent laboratory (such as Underwriter’s Labs) to survive the ANSI Standard C62.41-1980 transient over-voltage test waveform. Look for "Category A or B" level protection for circuit and electrical service protection, respectively. Some manufacturers are listed in the Reference Section.

Lightning protection is also very important. Most broiler houses do not have any lightning protection. As an absolute minimum the feed bins and any metal building exterior should be grounded. An excellent source of lightning protection information is the National Fire Protection Association (Batterymarch Park, Quincy MA).

The most commonly damaged equipment in broiler houses due to nearby lightning strikes is telephone equipment. Many of the more sophisticated environmental controllers can remotely dial a central computer to send information and receive changes to the building set points. And, as pointed out above, many new alarm systems utilize an automatic dialer for remote warning. These systems are very vulnerable to transient over-voltage, and should be protected by placing a surge suppressor on the telephone service, and on each piece of equipment that is connected to the telephone system. The telephone company can provide the service protection, and provide more information on surge suppressors for equipment connected to phone lines. Again, look for surge arresters that are independently tested to pass the ANSI Standard C62.41-1980.
REFERENCES

The following two references are available from the University of Kentucky Cooperative Extension Service for $5.00 each.


The following companies manufacture surge suppression devices, some of which are suitable for use in poultry facilities. (The University of Kentucky does not endorse any of these products; they are listed as a convenience only.)

1. Joslyn Electronic Systems Corporation, Santa Barbara Research Park, P. O. Box 817, Goleta, CA 93116. (805) 968-3551. Customer Service: (800) 752-8068. (Model 22-175)


FIGURE 1: An example of the electrical wiring for ventilation equipment in a broiler house. This system utilizes 4 pairs of 48 inch fans (circuits C, D, E, & F) at one end of the house to provide "tunnel ventilation". Four sidewall fans (circuits A & B) are used for minimum ventilation. Six LP gas heaters (circuits G, H, & I).

FIGURE 2: Staging diagram for the example broiler house. As inside temperature varies about the set point temperature, different equipment is activated according to what "stage" the system is in. For this example there is a constant 3°F between each ventilation stage. The temperature must drop 3°F below the set point before the heaters are activated. See Table 1 for the equipment that is assigned to each stage.
FIGURE 3: Example of the Use of A Controller to Actuate A Fan. When controller contact S1 closes, current flows through the power relay (PR1) coil. This closes the PR1 contacts and provides power to the fan motor. NOTE that in this schematic, only one leg of the power to the motor is shown switched by PR1; however, use of a double-pole relay would allow both legs to be switched. Note that failure of either the power relay, or the controller, would result in no ventilation in this simple example.

FIGURE 4: A "relay box" provides automatic control functions when the manual switch is placed in the auto position, and allows operation as described in Figure 3. When the manual switch is placed in the "OFF" position, both legs of the power circuit are broken; whereas in the "ON" position the automatic control is overridden and the fan runs continuously. These units can be purchased individually, or several per enclosure. Most also provide a lamp to indicate whether power is on the equipment side of the manual switch.
FIGURE 5: Low Temperature Safety Override. Two LPG heaters on a single 120 V circuit are turned ON by either the relay box, or the override thermostat. The thermostat is set to turn ON if the temperature drops below 60°F, even if the controller fails or if the relay box fails. During brooding a higher temperature should be selected, e.g. 70°F.

FIGURE 6: High Temperature Safety Override. Two 48" fans on a single 240 V circuit are turned ON by either the relay box contacts, or the override thermostat. The thermostat is set for a temperature at which the fans must always be ON. For this example using fans T3 and T4 which are stage 4, a setting of 80°F is recommended. If the controller fails, or if the power relay fails, these two fans will still run as long as the temperature exceeds 80°F.
FIGURE 7: Brooding Minimum Ventilation Override. During normal operation, the controller switch CR₂ acts like an interval timer and turns ON/OFF the power relay PR₂, which in turn provides power to the brooding fans. If CR₂ or PR₂ fails, then the time delay relay (TD) actuates after a pre-set period and provides power directly to a mechanical timer (MT₁) which overrides the failure. Note that a double pole power relay that disconnects both legs of the power circuit cannot be used for this to work properly.

FIGURE 8: Tunnel Minimum Temperature Override. This safety override provides minimum ventilation during whole house operation when the sidewall fans might be shut OFF. If the controller fails the mechanical timer, MT₂, continues to operate.