Arbor Acres

Broiler Management Guide

2009

Using This Manual

Finding a Topic

Red markers appear on the right-hand side of the manual. These allow readers immediate access to those sections and topics in which they are particularly interested.

The Contents List gives the title of each section and subsection.

An alphabetical Keyword Index is given at the end of the manual.

Key Points

Where appropriate, Key Points have been included to emphasize important aspects of husbandry and management. They are highlighted in red.

Performance Objectives

Supplements to this manual contain performance objectives that can be achieved with good management, environmental and health control.

Contents

Forward

The Manual

This manual is designed to help Aviagen's customers achieve optimum performance from their birds. While not intended to provide definitive information on every aspect of management, this manual does draw attention to important issues that if overlooked or inadequately addressed may depress flock performance. The objective of this manual is to provide management techniques that help growers achieve good overall bird performance from day one through to processing while promoting bird health and welfare.

Aviagen applies a balanced approach to genetic progress, concentrating on commercial traits such as growth rate, feed conversion ratio, livability and meat yield, while improving bird welfare in areas such as leg health, cardiovascular fitness and robustness. Achieving the genetic potential of the birds depends on three key factors:

- Management to provide birds with their required environment.
- A dietary regimen that offers nutrients in the appropriate profile.
- Effective biosecurity and disease control programs.

These three sectors, environment, nutrition and health, are interdependent. A shortfall in any one will bring negative consequences to the others and if any one of these elements is sub-optimal, broiler performance will suffer.

In reality, the guidance of a manual such as this cannot wholly protect against performance variations that may occur for a wide variety of reasons. While every attempt has been made to ensure the accuracy and relevance of the information presented, Aviagen accepts no liability for the consequences of using this information for the management of chickens.

Information presented in this manual combines data derived from internal research trials, published scientific knowledge and the expertise, practical skills and experience of the Aviagen Technical Transfer and Service teams.

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Introduction

Aviagen produces a range of genotypes suitable for different sectors of the broiler market. All Aviagen products are selected for a balanced range of characteristics in both parent stock and broiler birds. This approach ensures that the products are capable of performing to the highest standards in a wide variety of environments.

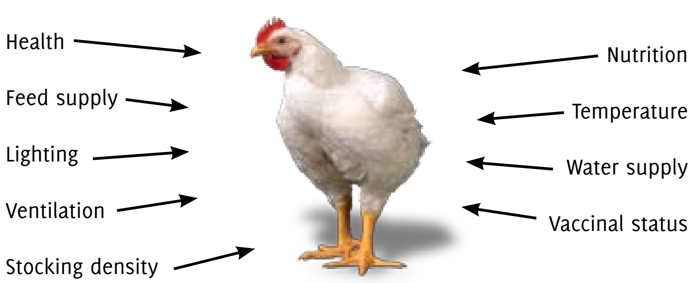
Aviagen applies a balanced approach to genetic progress. Characteristics of commercial importance such as growth rate, feed conversion ratio (FCR), livability and meat yield are consistently improved together with genetic advances made in bird welfare, leg health, cardiovascular fitness and robustness.

Achievement of the genetic potential inherent in the birds depends upon:

- An environment that is managed to provide birds with all their requirements for ventilation, air quality, temperature and space.
- The prevention, detection and treatment of ill health.
- The provision of nutrient requirements through the compounding of appropriate feed ingredients, and the proper management of the provision of feed and water.
- Attention to bird welfare throughout, especially prior to processing.

All of these are interdependent. If any one element is sub-optimal, then overall broiler performance will suffer.

Limits to Broiler Growth and Quality



Economic and commercial issues continue to influence the way broilers are managed:

- An increasing consumer demand for product quality and food safety.
- The need for flocks of broilers that can be grown to ever more predictable and pre-defined specifications.
- A requirement to minimize variability within flocks and hence variability of the final product.
- The demand for bird welfare enhancement.
- Full utilization of the genetic potential available in the bird for FCR, growth rate and meat yield.
- Minimization of avoidable diseases such as ascites and leg weaknesses.

As broiler production systems become more sophisticated, their management requires ever higher levels of responsiveness and the availability of ever better information.

The broiler growing phase is only one part of the integrated total meat production process. This includes parent stock farms, hatcheries, broiler growing units, processors, retailers and consumers.

Producing Quality Broiler Meat — The Total Process

LOCATION		OPERATION	OBJECTIVE
Parent Stock Farm		Parent Stock Management	
		Egg Collection	
		Egg Storage	
		Transport	
Hatchery		Egg Hatchery	
		Incubation	
	The Key Production Management Phases	Chick Processing and Handling	To produce high quality chicks To maintain chick quality
		Transport	
Broiler Farm		Brooding	To develop appetite To develop immune function
	Disinfection	Growth Management	To allow optimum development of skeleton, cardiovascular system
	Cleanout	Depletion	To optimize carcass quality
		Transport	
Processing Plant		Processing	
		Retail	

The broiler manager should strive to achieve the required flock performance in terms of live weight, feed conversion, uniformity and meat yield. The first two weeks of life in a broiler flock are critical and require particular attention. Chick handling, brooding and early growth management are all of great importance. Broiler production is a sequential process and ultimate performance is dependent on the successful completion of each step. Each stage must be assessed critically and improvements made wherever required for maximum performance.

The complexity of broiler production means that livestock managers should have a clear understanding of the factors affecting the whole production process as well as of those directly influencing bird management on the farm. Changes may be necessary in the hatchery, on the broiler farm, during transport or in the processing plant.

There are several stages of development throughout the broiler process. The hatchery deals with hatching eggs and chicks. The broiler farm deals with chicks and growing broilers. The processing plant deals with broilers and carcasses. Between each of these stages is a transition phase. Transitions must be managed with minimum bird stress. The key transitions for the broiler producer are:

- Chick emergence.
- Take off, storage and transportation of the chick.
- Development of good appetite in the young chick.
- Change over from supplementary feeding and drinking systems to the main system.
- Catching and transport of the broiler at depletion.

Aviagen's Technical Transfer Team has designed this manual with the following principles in mind:

- Bird welfare.
- The production chain and transition phases.
- Quality of the end product throughout the entire process.
- The need for observation of changes in the birds and their environment.
- Appropriate management in response to the constantly changing requirements of the bird.

No two broiler houses are the same and every flock of broilers will differ in its requirements. The broiler farm manager should understand the birds' requirements and, through application of responsive management as described in this manual, supply the individual requirements to ensure optimum performance in every flock.

Section 1

Chick Management

Objective

To promote early development of feeding and drinking behavior, allowing the target body-weight profile to be achieved with maximum uniformity and good welfare.

Contents

Principles

For best broiler performance, it is important to deliver the chicks to the broiler farm as quickly as possible and feed them immediately. Provide chicks with the proper environment and correctly manage them to meet all of their requirements.

During the first 10 days of life, the chicks' environment changes from the hatchery to the broiler house. Both current and final flock performance will suffer from deficiencies in the early environment. Chicks must establish healthy feeding and drinking behaviors if they are to achieve their genetic potential for growth.

A series of critical transitions in the first 7 to 10 days of the chick's life affect how and from where it receives its nutrients. This is why the management in this period is so essential for optimum flock performance.

In the final stages of incubation and as a very new hatchling, the chick receives all of its nutrients from the egg yolk. Once on the farm, the chick is offered a Starter feed in a sieved crumb or mini-pellet form in the automated feeding system and on the paper on the house floor. As soon as feed enters the gut, the residual yolk within the chick is mobilized. If the chick is fed promptly after hatch, it will receive a useful boost to growth from these nutrients.

For the first 3 days, residual egg yolk provides the chick with a protective store of antibodies and nutrients. Absorption of the yolk sac precedes the initiation of growth and therefore growth will be minimal until the chick starts to eat feed. Normally, residual yolk sac absorption is rapid during the first 48 hours but by 3 days of age it should be less than 1 gram (0.035 ounces). If some of the chicks have not started to eat for 1 or 2 or even 3 days, the growth will be uneven and the average flock weight at slaughter will be significantly reduced.

The chick, having found feed at floor level in the first days of its life, must find it again in the automated feeding system, whether pan or track, between 4 and 6 days of age. The chick must then cope with another change from a crumbled feed or mini-pellet to a pelleted feed at 10 days of age. It is important that both these transitions are made as easy as possible if performance is not to be adversely affected. Feed should be easily accessible from the automated feeding system. For example, flooding pan feeders will encourage feeding. At 10 days of age, the provision of a good quality pellet will limit the impact of the change in feed texture at this time.

The 7-day weight should be 4.5 to 5 times greater than that of the day-old chick provided the entire flock has coped well with all of these transitions and presuming that no environmental or nutritional factors are impeding growth.

Seven-day live weight should be routinely monitored. If the target is not achieved then action must be taken. Performance targets can be found in the **Arbor Acres Broiler Performance Objectives**.

Chick Quality and Broiler Performance

Attention to detail throughout the entire production process can determine final broiler performance and profitability. This involves good management of healthy parent stock, careful hatchery practice and efficient delivery of chicks that are of good quality and uniformity. Chick quality may be influenced at every stage of the process.

Planning

Chick quality results from the interaction between parent stock management, parental health and nutrition as well as incubation management. If a good quality chick is provided with proper brooding management and nutrition, it should have less than 0.7% mortality and be able to achieve target live weight uniformly over the course of the first 7 days.

- Plan placements of broiler flocks to ensure that differences in age and/or immune status of donor parent flocks are minimized. One donor flock per broiler flock is the ideal. If mixed flocks are unavoidable, keep similar parent flock ages together.
- Vaccination of donor parents maximizes maternal antibody protection in the offspring and is successful in protecting broilers against diseases which compromise performance (such as infectious bursal disease, chicken anemia virus and reovirus).
- A good quality chick should be clean after hatch. It should stand firmly and walk well, be alert and active, and vocalize contentedly. It should be free of deformities, with a fully retracted yolk sac and a healed navel.
- The grower can provide timely, accurate, detailed and measurable feedback to the hatchery if chick quality is lower than desired.
- Incorrect brooding management will make a chick quality problem worse.

The hatchery and transport system should ensure that:

- The correct vaccines are administered to all chicks at the correct dosage and in the correct form.
- After being sexed and vaccinated, the chicks are allowed to settle before transport. Hold chicks in a darkened area where the environment is controlled correctly.
- Chicks are loaded through controlled-environment loading bays into preconditioned lorries for transport to the broiler farm (see **Table 1.1**).
- The expected delivery time of the chicks is established beforehand so that they may be unloaded and correctly placed as quickly as possible.
- Chicks are fed and have access to water as soon as possible after hatch.

Table 1.1: *Summary of optimum conditions - chick holding and transport*

Chick holding conditions	22–24°C (72–75°F)* Ambient Temperature Minimum 50% Relative Humidity (RH) 0.71 m³/min (25 cfm**) per 1,000 chicks Air Exchange
Transport conditions	22–24°C (72–75°F)* Ambient Temperature Minimum 50% Relative Humidity (RH) for long haul*** 0.71 m³/min (25 cfm**) per 1,000 chicks Air Exchange

Note: The conditions in the holding area or transport vehicle should give temperatures of 30–35°C (86–95°F) and a RH of 70–80% among the chicks. It is more important to obtain these temperatures than to follow the advised temperature setting for the transport truck as settings may vary depending on the manufacturers recommendations.

* Temperatures should be adjusted according to actual chick temperature. Vent temperatures should be between 39–40°C (102–104°F).

** (cfm) cubic feet per minute.

*** Humidity should be provided during long haul transport in cold weather when the heaters are operational for long periods or where the air is dry.

Key Points

- Plan placements to minimize physiological and immune differences between chicks. Use single donor flocks if possible.
- Hold and transport chicks in conditions that prevent dehydration and other types of stress in chicks.
- Provide feed and water to the chicks as soon as possible after they leave the hatcher.
- Maintain high standards of hygiene and biosecurity in the hatchery and during transport.

Chick Arrival

Farm Preparation

Individual sites should be single-age (i.e. all-in/all-out). On multi-age sites, vaccination and cleaning programs are more difficult and less effective. It is also far more likely that health problems will occur and sub-optimal performance will be achieved on multi-age sites.

Houses, the surrounding areas, and all equipment must be thoroughly cleaned and disinfected before the arrival of the bedding material and chicks (see Section 3: Health and Biosecurity). Management systems should be in place to prevent pathogens entering the building. Vehicles, equipment and people should be disinfected before entry.

Spread litter material evenly to a depth of 8–10 cm (3–4 in). Uneven bedding material can restrict access to feed and water and may lead to a loss in flock uniformity. Where floor temperatures are adequate (28–30°C/82–86°F) the litter depth can be reduced where litter disposal costs are an issue.

Key Points

- Provide chicks with biosecure, clean housing.
- Control spread of disease by using single-age, (i.e. all-in/all-out) housing.
- Spread litter evenly.

Chick Placement

Chicks cannot regulate their own body temperature until they are around 12–14 days of age. Ideal body temperature must be attained by providing optimal environmental temperature. Preheating the house is vital as floor temperature at chick placement is as important as air temperature. Stabilize temperature and relative humidity for at least 24 hours prior to chick arrival.

Recommended values are:

- Air temperature of 30°C/86°F (measured at chick height in the area where feed and water are positioned).
- Litter temperature of 28–30°C/82–86°F.
- Relative humidity of 60-70%.

Monitor these values regularly to ensure a uniform environment throughout the whole brooding area, but by far the best indicator of temperature is chick behavior.

Make a final check of feed and water availability and distribution within the house prior to delivery of chicks. All chicks must be able to eat and drink immediately upon placement in the house.

The longer the chicks remain in the boxes, the greater the degree of potential dehydration. This may result in early mortality and reduced growth as indicated by 7-day and final live weight.

Place chicks quickly, gently and evenly onto paper within the brooding area. Feed and water should be freely and immediately available. The empty boxes should be removed from the house without delay.

Leave chicks to settle for 1 to 2 hours to become accustomed to their new environment. After this time, make a check to see that all chicks have easy access to feed and water. Make adjustments to equipment and temperatures where necessary.

For the first 7 days, provide 23 hours of light with 30-40 lux intensity (3-4 foot candles) to help the chick adapt to the new environment and encourage feed and water intake.

Adequate fresh, clean water must be available at all times to all birds with access points at an appropriate height (see Section 2: Provision of Feed and Water). Nipple lines should be installed at 12 birds per nipple and bell drinkers at a minimum of 6 drinkers per 1,000 chicks. In addition, 6 supplementary mini-drinkers or trays per 1,000 chicks should also be provided.

Initially, provide textured feed as a dust-free crumble or mini-pellet on feeder trays (1/100 chicks) and on paper to give a feeding area occupying at least 25% of the brooding area. Place chicks directly onto paper so that feed is immediately found. Automated feeding and drinking systems should be placed in the vicinity of the paper.

If the mixing of chicks from different parent flocks is unavoidable, chicks should be grouped by breeder age as much as possible. Chicks from a young donor flock of less than 30 weeks will require a warmer start temperature (+1°C or +2°F warmer than the given temperature profile) compared to an older flock of more than 50 weeks.

Key Points

- Pre-heat the house and stabilize temperature and humidity prior to chick arrival.
- Unload and place chicks quickly.
- Make feed and water available to the chicks immediately.
- Arrange equipment so that chicks can reach feed and water easily.
- Position supplementary feeders and drinkers near the main feeding and drinking systems.
- Leave chicks to settle for 1 to 2 hours with access to feed and water.
- Check feed, water, temperature and humidity after 1 to 2 hours and adjust where necessary.

Chick Start Assessment

Chicks are hungry in the period immediately after they are introduced to feed for the first time so they should eat well and fill their crops. Check a sample of birds at 8 and 24 hours after arrival on the farm to make sure that all the chicks have found feed and water. To do this, collect samples of 30–40 chicks at 3 or 4 different places in the house. Gently feel each chick's crop. In chicks that have found food and water, the crop will be full, soft and rounded (see **Figure 1.1**). If the crop is full but the original texture of the crumb is still apparent, the bird has not yet consumed enough water. Target crop fill at 8 hours after delivery is 80% and at 24 hours after delivery 95–100%.

Figure 1.1: *Crop fill after 24 hours.*

The chick on the left has a full, rounded crop, while the chick on the right has an empty crop.

Environmental Control

Introduction

Optimal temperature and humidity are essential for health and appetite development. Monitor temperature and relative humidity frequently and regularly; at least twice daily in the first 5 days and daily thereafter. Temperature and humidity measurements and sensors for automatic systems should be sited at chick level. Use conventional thermometers to cross-check the accuracy of electronic sensors controlling automatic systems.

Ventilation without drafts is required during the brooding period to:

- Maintain temperatures and relative humidity (RH) at the correct level.
- Allow sufficient air exchange to prevent the accumulation of harmful gases such as carbon monoxide (from oil/gas heaters placed inside the poultry house), carbon dioxide and ammonia.

It is good practice to establish a minimum ventilation rate from day one. This will ensure that fresh air is supplied to the chicks at frequent, regular intervals (see Section 4: Housing and Environment). Internal circulation fans can be used to maintain evenness of air quality and temperature at chick level.

If a choice has to be made, maintenance of brooding temperatures should take priority over ventilation and air exchange. Young chicks are prone to wind-chill effects, therefore actual floor/air speed should be less than 0.15 m/sec (30 ft/min) or as low as possible.

Key Points

- Monitor temperature and relative humidity regularly.
- Ventilate to provide fresh air and remove waste gases.
- Avoid drafts.

Humidity

Relative humidity (RH) in the hatcher at the end of the incubation process will be high (approx. 80%). Houses with whole-house heating, especially where nipple drinkers are used, can have RH levels lower than 25%. Houses with more conventional equipment (such as spot brooders that produce moisture as a by-product of combustion, and bell drinkers that have open water surfaces) have a much higher RH, usually over 50%. To limit the shock to the chicks when transferring from the incubator, RH levels in the first 3 days should be 60–70%.

Monitor RH within the broiler house daily. If it falls below 50% in the first week, the environment will be dry and dusty. The chicks will begin to dehydrate and be predisposed to respiratory problems and performance will be adversely affected. Take action to increase RH.

If the house is fitted with high-pressure spray nozzles (foggers or misters) for cooling in high temperatures, then these can be used to increase RH during brooding. Alternatively, RH can be increased by using a backpack portable sprayer to spray the walls with a fine mist.

As the chick grows, the ideal RH falls. High RH (above 70%) from 18 days onwards can cause wet litter and its associated problems. As the broilers increase in live weight, RH levels can be controlled using ventilation and heating systems.

Interaction Between Temperature and Humidity

All animals lose heat to the environment by evaporation of moisture from the respiratory tract and through the skin. At higher RH, less evaporative loss occurs, increasing the animals' apparent temperature. The temperature experienced by the animal is dependent on the dry bulb temperature and RH. High RH increases the apparent temperature at a particular dry bulb temperature, whereas low RH decreases apparent temperature. The target temperature profile in **Table 1.2** assumes RH in the range of 60–70%. The right hand side of **Table 1.2** shows the dry bulb temperature required to achieve the target temperature profile in situations where RH is not within the target range of 60–70%.

Table 1.2: *Dry bulb temperatures required to achieve target apparent equivalent temperatures at varying relative humidities*

			Dry Bulb Temperature at RH%				
	Target				Ideal		
Age (days)	Temp	RH% range	40	50	60	70	80
Day Old	30.0°C 86.0°F	60–70	36.0°C 96.8°F	33.2°C 91.8°F	30.8°C 87.4°F	29.2°C 84.6°F	27.0°C 80.6°F
3	28.0°C 82.4°F	60–70	33.7°C 92.7°F	31.2°C 88.2°F	28.9°C 84.0°F	27.3°C 81.1°F	26.0°C 78.8°F
6	27.0°C 80.6°F	60–70	32.5°C 90.5°F	29.9°C 85.8°F	27.7°C 81.9°F	26.0°C 78.8°F	24.0°C 75.2°F
9	26.0°C 78.8°F	60–70	31.3°C 88.3°F	28.6°C 83.5°F	26.7°C 80.1°F	25.0°C 77.0°F	23.0°C 73.4°F
12	25.0°C 77.0°F	60–70	30.2°C 86.4°F	27.8°C 82.0°F	25.7°C 78.3°F	24.0°C 75.2°F	23.0°C 73.4°F
15	24.0°C 75.2°F	60–70	29.0°C 84.2°F	26.8°C 80.2°F	24.8°C 76.6°F	23.0°C 73.4°F	22.0°C 71.6°F
18	23.0°C 73.4°F	60–70	27.7°C 81.9°F	25.5°C 77.9°F	23.6°C 74.5°F	21.9°C 71.4°F	21.0°C 69.8°F
21	22.0°C 71.6°F	60–70	26.9°C 80.4°F	24.7°C 76.5°F	22.7°C 72.9°F	21.3°C 70.3°F	20.0°C 68.0°F
24	21.0°C 69.8°F	60–70	25.7°C 78.3°F	23.5°C 74.3°F	21.7°C 71.1°F	20.2°C 68.4°F	19.0°C 66.2°F
27	20.0°C 68.0°F	60–70	24.8°C 76.6°F	22.7°C 72.9°F	20.7°C 69.3°F	19.3°C 66.7°F	18.0°C 64.4°F

Source: Dr. Malcolm Mitchell (Scottish Agricultural College)

Table 1.2 illustrates the relationship between RH and effective temperature. If RH is outside the target range, the temperature of the house at chick level should be adjusted to match that given in **Table 1.2**. For example, if RH is lower than 60% the dry bulb temperature may need to be increased. At all stages, monitor chick behavior to ensure that the chick is experiencing an adequate temperature (see Brooder Management below). If subsequent behavior indicates that the chicks are too cold or too hot, the temperature of the house should be adjusted accordingly.

Key Points

- Achieve target 7-day live weight by correctly managing the brooding environment.
- Use chick behavior to determine if temperature is correct.
- Use temperature to stimulate activity and appetite.
- Maintain RH between 60 - 70% for the first 3 days and above 50% for the remainder of the brooding period.
- Adjust temperature settings if RH increases above 70% or falls below 60%, while responding to changes in chick behavior.

Brooder Management

Two basic systems of temperature control are used for brooding broiler chicks:

- **Spot brooding** (canopy or radiant heaters). The heat source is local so chicks can move away to cooler areas and thus select for themselves a preferred temperature.
- **Whole-house brooding.** The heat source is larger and more widely spread so chicks are less able to move to select a preferred temperature. Whole-house brooding refers to situations where the whole house or a defined part of the house is heated by 'forced air heaters' only and the aim is to achieve one temperature in the house or air space.

In both spot and whole-house brooding systems, the objective is to stimulate both appetite and activity as early as possible. Achieving the optimum temperature is critical. Brooding temperatures for RH 60–70% are given in **Table 1.3**.

Table 1.3: *Brooding temperatures*

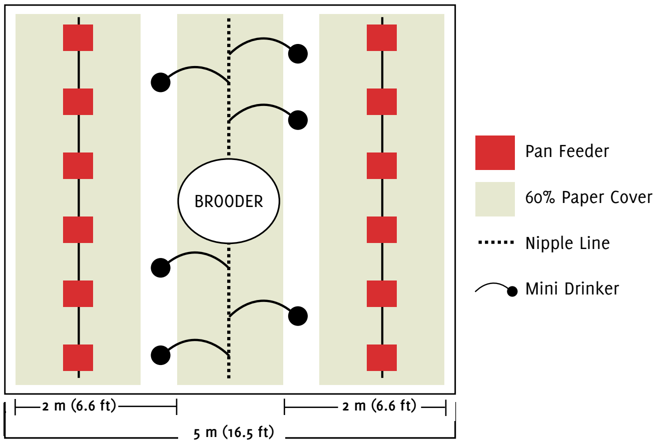
Age (days)	Whole-house Brooding	Spot Brooding	
		Temp	
	Temp	Brooder Edge (A*)	2 m (6.6 ft) From Brooder Edge (B*)
Day Old	30°C 86°F	32°C 90°F	29°C 84°F
3	28°C 82°F	30°C 86°F	27°C 81°F
6	27°C 81°F	28°C 82°F	25°C 77°F
9	26°C 79°F	27°C 81°F	25°C 77°F
12	25°C 77°F	26°C 79°F	25°C 77°F
15	24°C 75°F	25°C 77°F	24°C 75°F
18	23°C 73°F	24°C 75°F	24°C 75°F
21	22°C 72°F	23°C 73°F	23°C 73°F
24	21°C 70°F	22°C 72°F	22°C 72°F
27	20°C 68°F	20°C 68°F	20°C 68°F

*See Figure 1.3 for illustration showing areas A and B.

Spot Brooding

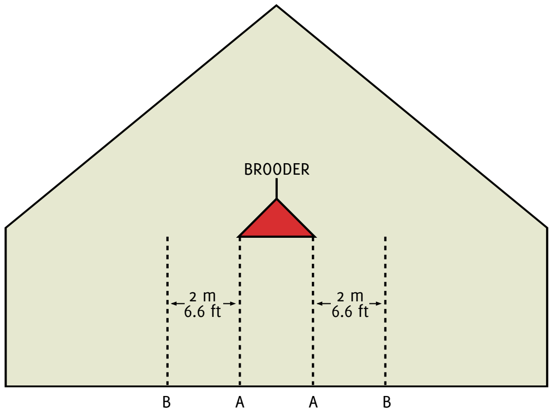
The layout for a spot brooding set up is shown in **Figure 1.2**, which would be typical for 1,000 chicks on day one. Chicks are placed in a 5×5 meter square (25 m²) or a 16.5×16.5 foot square (272 ft²), which gives an initial stocking density of 40 chicks/m² (4 chicks/ft²) If stocking density is increased, the number of feeders and drinkers, and the heating capacity of the brooder, should also be increased accordingly.

Figure 1.2: *Typical spot brooding layout (1,000 chicks)*



Within the context of the set up in **Figure 1.2, Figure 1.3** shows the areas of temperature gradients surrounding the spot brooder. These are marked A (brooder edge) and B (2 m (6.6 ft) from the brooder edge). Respective optimum temperatures are as shown in **Table 1.3**.

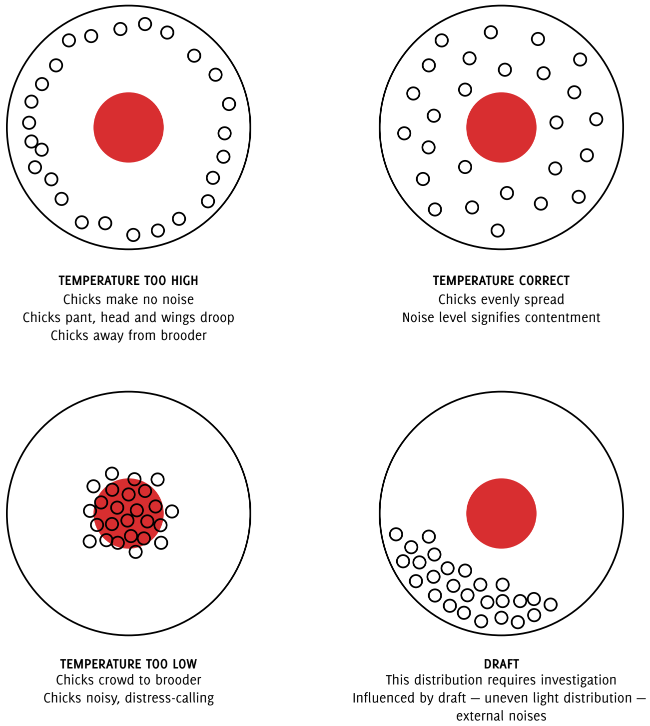
Figure 1.3: *Spot brooding – areas of temperature gradients*



Spot Brooding Behavior

Chick behavior is the best indicator of correct brooder temperature. With spot brooding, correct temperature is indicated by chicks being evenly spread throughout the brooding area as shown in **Figure 1.4**. In the diagram, the brooder area is shown as the red center circle.

Figure 1.4: *Bird distribution under brooders*



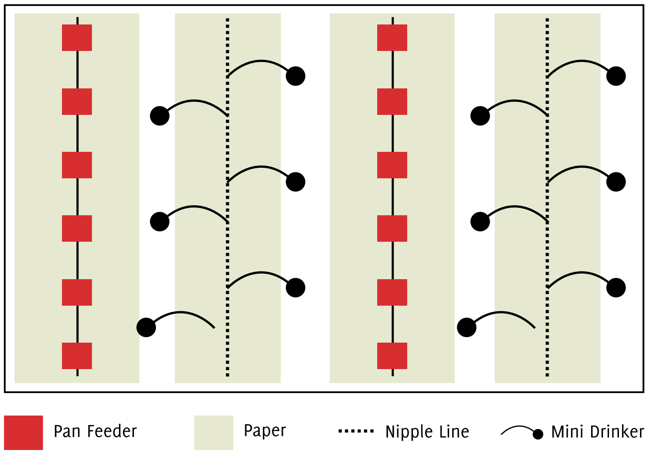
A picture of contented, spot-brooded birds at the right temperature is shown in **Figure 1.5**.

Figure 1.5: *Chicks in correct spot brooding conditions*

Whole-house Brooding

In whole-house brooding, there is no temperature gradient within the house, although supplementary brooders might also be provided. The main whole-house heat source can be direct or indirect (using hot air). A layout for whole-house brooding is shown in **Figure 1.6**.

Figure 1.6: *Typical layout of a whole-house brooding system*

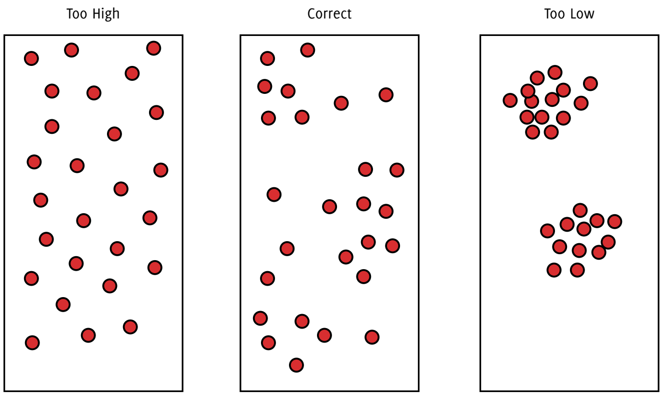


Within the context of the set up in **Figure 1.6**, optimum temperatures are as shown in the left-hand side of **Table 1.3**.

Whole-house Brooding Behavior

Chick behavior is the best indicator of correct temperature. **Figure 1.7** shows the different distribution of chicks in whole-house brooding at different temperatures. With whole-house brooding, correct temperature is indicated by chicks forming groups of 20–30, with movement occurring between groups. There should be continuous feeding and drinking within the flock.

Figure 1.7: *Typical behavior of chicks in whole-house brooding at different temperatures*



Carefully monitor and control house temperature and humidity when whole-house brooding is practiced (see 'Interaction Between Temperature and Humidity').

A picture of contented whole-house brooded birds is shown in **Figure 1.8**.

Figure 1.8: *Chicks in correct whole-house brooder conditions*

Key Points

- Temperature is critical and should be maintained as recommended.
- Temperatures should be checked manually at chick level.
- Chick behavior should be observed closely and frequently.

Section 2

Provision of Feed and Water

Objective

The objective of a defined feeding program is to supply a range of balanced diets that satisfy the nutrient requirements of broilers at all stages of their development and that optimize efficiency and profitability without compromising bird welfare or the environment.

The drinking and feeding systems employed, together with the management of those systems, will impact feed and water intake, thereby affecting bird performance and efficiency.

Contents

Principles

Feed is a major component of the total cost of broiler production. To support optimum performance, formulate broiler rations to give the correct balance of energy, protein and amino acids, minerals, vitamins and essential fatty acids. The choice of feeding program will depend on the target of the business; for instance whether the focus is on maximizing profitability of live birds or optimizing yield of carcass components.

Recommended nutrient levels and feed programs can be found in the current **Arbor Acres Broiler Nutrition Specifications,** which offers further information on:

- The choice of feeding program for a range of production and market situations.
- Optimum levels of dietary digestible amino acid levels for growth, efficiency, processing yield and profitability.

Supply of Nutrients

Energy

Broilers require energy for growth of tissue, maintenance and activity. Carbohydrate sources, such as corn and wheat, and various fats or oils are the major source of energy in poultry feeds. Energy levels in diets are expressed in Mega joules (MJ/kg) or kilocalories (kcal/kg or kcal/lb) of Metabolizable Energy (ME), as this represents the energy available to the broiler.

Protein

Feed proteins, such as those in cereals and soybean meal, are complex compounds that are broken down by digestion into amino acids. These amino acids are absorbed and assembled into body proteins that are used in the construction of body tissue, e.g. muscles, nerves, skin and feathers.

Dietary crude protein levels do not indicate the quality of the proteins in feed ingredients. Diet protein quality is based on the level, balance and digestibility of essential amino acids in the final mixed feed.

The Arbor Acres broiler is particularly responsive to dietary digestible amino acid levels and will respond well, in terms of growth, feed efficiency and profitability, to diets properly balanced as recommended. Higher levels of digestible amino acids have been shown to improve profitability by increasing broiler performance and processing yield. This becomes particularly important when broilers are grown for portioning or de-boning.

Macro Minerals

The provision of the correct levels of the major minerals in the appropriate balance is important for high-performing broilers. The macro minerals involved are calcium, phosphorus, sodium, potassium and chloride.

- **Calcium and phosphorus:** Calcium in the diet of broilers influences growth, feed efficiency, bone development, leg health, nerve function and the immune system. It is vital that calcium is supplied in adequate quantities and on a consistent basis. Phosphorus, like calcium, is required in the correct form and quantity to optimize skeletal structure and growth.
- **Sodium, potassium and chloride:** These minerals are needed for general metabolic functions. Shortages can affect feed intake, growth and blood pH. Excess levels of these minerals result in increased water intake and subsequent poor litter quality.

Trace Minerals and Vitamins

Trace minerals and vitamins are needed for all metabolic functions. Appropriate vitamin and trace mineral supplementation depends on the feed ingredients used, the feed manufacturer and local circumstances.

Due to differences in vitamin levels of various cereals, the level of supplementation of some vitamins must be modified. Accordingly, separate recommendations are usually proposed for some vitamins, depending on the cereals (e.g. wheat versus maize) upon which the diets are based.

Enzymes

Enzymes are now being routinely used in poultry feeds to improve digestibility of feed ingredients. In general, feed enzymes that act on carbohydrates, proteins and plant-bound minerals are available.

Key Points

- Use recommended digestible amino acid levels for optimum broiler performance.
- Ensure high-quality protein sources are used.
- Provide the correct levels of the major minerals in the appropriate balance.
- Vitamin and mineral supplementation depends on feed ingredients used, feed manufacturing practices and local circumstances.

Feeding Program

Starter Feeds

The objective of the brooding period (0–10 days of age) is to establish good appetite and maximum early growth in order to meet the Arbor Acres 7-day body-weight objective. It is recommended that a Broiler Starter feed be fed for 10 days. The Starter represents a small proportion of the total feed cost and decisions on Starter formulation should be based primarily on performance and profitability rather than purely on diet cost.

The benefit of maximizing nutrient intake on early broiler growth and subsequent performance is well established. Feeding broilers the recommended nutrient density will ensure optimal growth is established during this critical period of life.

Grower Feeds

Broiler Grower feed is generally fed for 14 to 16 days following the Starter. Starter to Grower transition will involve a change of texture from crumbs/mini-pellets to pellets. Depending on the pellet size produced, it may be necessary to feed the first delivery of Grower as crumbs or mini-pellets.

During this time broiler growth continues to be dynamic. It therefore needs to be supported by adequate nutrient intake. For optimum feed intake, growth and FCR, provision of the correct diet nutrient density (especially energy and amino acids) is critical.

Finisher Feeds

Broiler Finisher feeds account for the major volume and cost of feeding a broiler. It is therefore important that feeds are designed to maximize financial return for the type of products being produced.

Finisher feeds should be given from 25 days until processing. Birds slaughtered later than 42–43 days of age should be given a second Finisher feed specification from 42 days onward.

The use of either one or more broiler Finisher feeds will depend on:

- Desired slaughter weight.
- Length of the production period.
- Design of the feeding program.

Withdrawal periods for drugs will dictate the use of a special Withdrawal Finisher feed. A Withdrawal feed should be fed for sufficient time prior to slaughter to eliminate the risk of pharmaceutical product residues in the meat. Statutory withdrawal periods for prescribed medicines that are specified in product data sheets must be followed. It is not recommended that extreme dietary nutrient reductions be made during the withdrawal period.

Key Points

- It is recommended to feed the Starter diet for 10 days. Decisions on Starter feed formulation should be based on performance and profitability.
- The Grower feed must ensure that nutrient intake supports the dynamic growth during this period.
- Broiler Finisher feeds should be formulated to maximize financial return and be adjusted for bird age, but extreme nutrient withdrawal is not recommended.

Feed Form and Physical Feed Quality

Broiler growth and efficiency of feed use will generally be better if the Starter feed is crumbs or mini-pellets and the Grower and Finisher feeds are pelleted **(Table 2.1)**. Depending on pellet size fed, it may be necessary to deliver the first delivery of Grower feed as crumbs or mini-pellets.

Poor quality crumbs and pellets will reduce feed intake and performance. On the farm, pay attention during handling to reduce breakage of crumbs and pellets.

Table 2.1: *Form of feed by age in broilers*

Age	Feed Form and Size
0–10 days	sieved crumbs or mini-pellets
11–24 days	2–3.5 mm (0.08–0.125 in) diameter pellets or coarse grinded mash
25 days to processing	3.5 mm (0.125 in) diameter pellets or coarse grinded mash

Good quality crumbled and pelleted feeds are preferred to mash feed, however if feeding a mash feed, feed particles should be sufficiently coarse and uniform in size. Mash feeds may benefit from the inclusion of some fat in the formulation to reduce dustiness and improve homogenicity of feed components.

Key Points

- Poor physical feed quality will have a negative impact on broiler performance.
- Use good quality crumbled and pelleted feed for optimum performance.
- When feeding mash, ensure a coarse uniform particle size is achieved. Minimize fine particle (<1 mm/<0.04 in) levels to less than 10%.

Whole-wheat Feeding

The feeding of compound feed with whole wheat may reduce feed costs per ton. However, this must be offset against loss of eviscerated and breast meat yield.

In formulating the compound or balancer feed, precisely account for the level of inclusion of whole wheat. If an appropriate adjustment is not made, live bird performance will be compromised, as the diet will now have an inappropriate nutrient balance. Safe inclusion guides are given in **Table 2.2**.

Table 2.2: *Safe inclusion rates of whole wheat in broiler rations*

Ration	Inclusion rate of wheat
Starter	0%
Grower	gradual increase to 10%*
Finisher	gradual increase to 15%*

* Higher inclusions of wheat are possible if fed in combination with higher concentration compound or balancer feeds.

Remove whole wheat from the feed 2 days before catching to avoid problems of contamination during evisceration at the processing plant.

Key Point

- Dilution of diets with whole wheat may reduce performance if the compound feed is not properly adjusted.

Feed and Heat Stress

Correct nutrient levels and balance, together with the use of feed ingredients with higher levels of digestibility, will help to minimize the effect of heat stress.

Providing optimum crumb and pellet textures will minimize the energy expended to eat the feed and thereby reduce the heat generated during feeding. Optimum feed form will also improve feed acceptability and help compensatory feed intake to occur during cooler periods.

Providing an increase in feed energy from feed fats (rather than carbohydrates) during hot weather has been shown to be beneficial in some situations due to reducing the heat increment of the diet.

Readily available cool, low-salt water is the most critical nutrient during heat stress.

Strategic use of vitamins and electrolytes, either through the feed or water, will help the bird deal with environmental stresses.

Key Points

- Providing the correct nutrient levels and using more digestible ingredients will help to minimize the effects of heat stress.
- Optimal feed form will minimize heat stress and allow compensatory feed intake to occur.
- Provide cool, low-salt water.
- Ensure feed is available to the birds during the coolest part of the day.

Environment

Nitrogen and ammonia emissions can be reduced by minimizing excess crude protein levels in the feed. This is achieved by formulating diets to balanced recommended levels of digestible essential amino acids, rather than to minimum crude protein levels.

Phosphorus excretion rates can be reduced by feeding closely to the bird's requirement and utilizing phytase enzymes.

Key Points

- Formulating feeds to balanced levels of digestible essential amino acids will minimize nitrogen excretion.
- Phosphorus excretion can be minimized by feeding closely to the bird's requirements.

Litter Quality

Litter quality directly affects the health of the bird. Lower moisture levels in the litter help to reduce respiratory stress by reducing the amount of ammonia in the atmosphere. Good quality litter will also reduce the incidence of foot pad dermatitis.

With suitable management, health and environmental practices, the following nutritional strategies will help to maintain good litter quality:

- Avoid excessive levels of crude protein in diets.
- Avoid high salt/sodium levels, as this will increase bird water intake and cause wet litter.
- Avoid using poorly digestible or high fiber feed ingredients in the diets.
- Provide good-quality feed fats/oils in the diet, as this helps avoid enteric disorders which produce wet litter.

Water Quality

Water is an essential ingredient for life. Any increases in water loss or reductions in water intake can have a significant effect on the lifetime performance of the chick. (More detailed information can be found in the **Arbor Acres Update—Water Quality**).

Water supplied to broilers should not contain excessive amounts of minerals. Water should not be contaminated with bacteria. Although water supplied as fit for human consumption will also be suitable for broilers, water from bore holes, open water reservoirs or poor quality public supplies can cause problems.

Test the water supply to check the level of calcium salts (water hardness), salinity and nitrates.

After the house has been cleaned and before the chicks have arrived, sample water for bacterial contamination at the source, at the storage tanks and at the points for drinkers.

Table 2.3 shows the maximum acceptable concentration of minerals and organic matter in the water supply.

Table 2.3: *Maximum acceptable concentrations of minerals and organic matter in the water supply*

Material	Acceptable Concentration (ppm or mg per liter)	Comment
Total dissolved solids (TDS)	0–1,000	Higher levels will cause wet droppings and reduce performance
Fecal coliforms	0	Higher levels indicate contaminated water
Chloride	250	If sodium is higher than 50, acceptable chloride concentrations are much lower (less than 20)
Sodium	50	
Calcium salts (hardness)	70	
pH	6.5–8.5	Acid water will corrode equipment and disrupt health interventions
Nitrates	trace	
Sulphates	200–250	Maximum desirable level. Higher levels will increase wetness of droppings
Potassium	300	
Magnesium	50–125	Higher levels will exacerbate influence of sulphates
Iron	0.3	
Lead	0.05	
Zinc	5	
Manganese	0.05	
Copper	0.05	

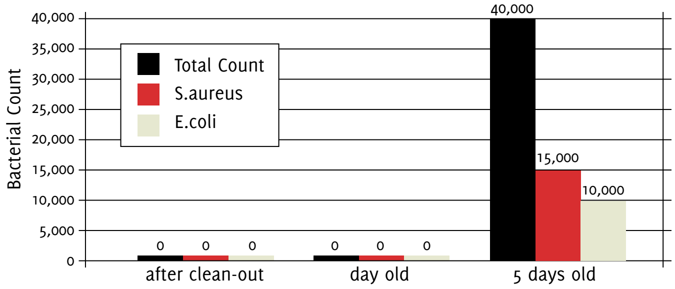
The levels presented in **Table 2.3** are unlikely to be exceeded if water is taken from a main supply.

If water is taken from wells or bore holes it may have excessive nitrate levels and high bacterial counts. Where bacterial counts are high, determine the cause and correct the problem. Bacterial contamination can often reduce biological production performances both on the farm and at the processing plant.

Water that is clean at the point of entry to the broiler house can become contaminated by exposure to bacteria within the house environment **(Figure 2.1)**. Chlorination between 3 and 5 ppm at drinker level will reduce the bacterial count, especially where drinker systems with open water surfaces are in use. Ultra Violet (UV) irradiation is also effective in controlling bacterial contamination.

Drinker valves and pipes may become blocked if the water is hard and contains high levels of calcium salts or a high level of iron. If sediment blocks the pipes, filter the supply with a mesh of 40–50 microns.

Figure 2.1: *Increase in bacterial count in drinkers where water is exposed to the broiler house atmosphere*



Key Points

- Provide unrestricted access to fresh, clean water.
- Test the water supply regularly for bacteriological and mineral contaminants and take any necessary corrective action.

Drinking Systems

Water must be available to broilers at all times. Inadequate water supply, either in volume or available drinker space, will reduce growth rate. Monitor the ratio of water to feed consumption to ensure that the flock is receiving sufficient water.

Measure water consumption to monitor:

- Feed and water system failures.
- Health.
- Performance.

At 21°C (70°F), the ratio of water to feed should be close to:

- 1.8:1 for bell drinkers.
- 1.6:1 for nipple drinkers without cups.
- 1.7:1 for nipple drinkers with cups.

Water requirement will vary with feed consumption.

Birds will drink more water at higher ambient temperatures. Water requirement increases by approximately 6.5% per degree Celsius (2 degrees Fahrenheit) over 21°C (70°F). In tropical areas prolonged high temperatures will double daily water consumption.

Very cold or very warm water will reduce water intake. In hot weather, it is good practice to flush the drinker lines at regular intervals to ensure that the water is as cool as possible.

There should be adequate water storage on the farm, in case the main supply fails. Ideally, there should be sufficient storage to provide 24 hours of water at maximum consumption.

It is vital to measure water consumption daily by metering. See **Table 2.4** for typical water consumption at 21°C (70°F). A reduction of water consumption gives an advanced warning of possible health and production issues.

Water meters must match flow rates with pressure. At least 1 meter is required per house, but preferably there should be more than one to allow within-house zoning.

Table 2.4: *Typical water consumption by broilers at 21°C (70°F) in liters and imperial gallons per 1,000 birds per day. M = males, F = females, AH = as hatched (mixed males and females).*

Age of birds (days)	**Nipple drinkers without cups** Liters (Imperial Gallons)			**Nipple drinkers with cups** Liters (Imperial Gallons)			**Bell drinkers** Liters (Imperial Gallons)		
	M	**F**	**AH**	**M**	**F**	**AH**	**M**	**F**	**AH**
7	54 (12)	54 (12)	54 (12)	58 (13)	58 (13)	58 (13)	61 (13)	61 (13)	61 (13)
14	112 (25)	102 (23)	107 (24)	119 (26)	109 (24)	114 (25)	126 (28)	115 (25)	121 (27)
21	182 (40)	163 (36)	173 (38)	194 (43)	173 (38)	184 (40)	205 (45)	184 (40)	194 (43)
28	254 (56)	222 (49)	237 (52)	270 (59)	236 (52)	252 (55)	286 (63)	250 (55)	266 (59)
35	312 (69)	277 (61)	293 (64)	332 (73)	294 (65)	311 (68)	351 (77)	311 (68)	329 (72)
42	349 (77)	318 (70)	333 (73)	371 (82)	338 (74)	354 (78)	392 (86)	358 (79)	374 (82)
49	366 (81)	347 (76)	357 (78)	389 (86)	369 (81)	379 (83)	412 (91)	391 (86)	401 (88)
56	370 (81)	365 (80)	368 (81)	393 (86)	388 (85)	391 (86)	416 (91)	410 (90)	414 (91)

Nipple Drinkers

Install nipple drinkers at 12 birds per nipple; supply additional supplementary drinkers (6 per 1,000 chicks) for the first 3-4 days.

The actual number of birds per nipple will depend on flow rates, depletion age, climate and design. Manage water lines daily for optimum performance.

High water pressure in the drinker line can result in water waste and wet litter. A low drinker line water pressure can result in a reduced water intake and a subsequent reduction in feed intake.

Drinker line height should be started low at the beginning of the flock and increased as the birds get older. Drinker lines that are too high can restrict bird water consumption while water lines that are too low can result in wet litter.

During the initial stages of brooding, place nipple lines at a height where birds are most able to drink. The back of the chick should form a 35-45° angle with the floor while drinking is in progress. As the bird grows, the nipples should be raised so that the back of the bird forms an angle of approximately 75-85° with the floor so that the birds are stretching slightly for the water **(Figure 2.2)**.

Figure 2.2: *Nipple drinker height adjustment*

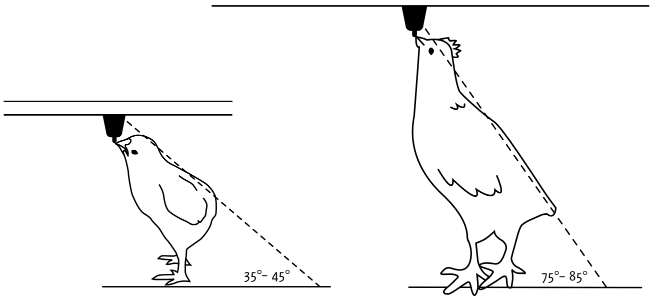


Figure 2.3: *Example of a nipple drinker*

Bell Drinkers

At day-old, provide a minimum of 6 bell drinkers of 40 cm (16 in) diameter per 1,000 chicks; 6 mini-drinkers or plastic trays per 1,000 chicks should also be available as an additional source of water.

As the broilers become older and the area of the house in use is expanded, provide a minimum of 8 bell drinkers of 40 cm (16 in) in diameter per 1,000 chicks. Place these evenly throughout the house so that no broiler is more than 2 m (6.6 ft) from water. As a guide, the water level should be 0.6 cm (0.25 in) below the top of the drinker until approximately 7-10 days. After 10 days there should be 0.6 cm (0.25 in) of water in the base of the drinker.

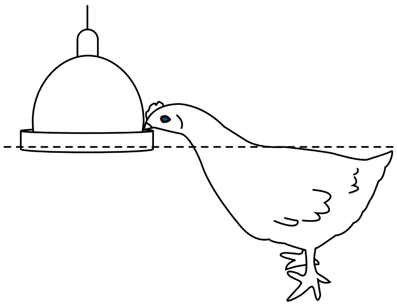
Within 3-4 days, gradually remove any additional mini-drinkers and trays that were used at day-old so that all chicks are drinking from the automatic drinkers. Minimum drinker requirements per 1000 birds post brooding are given in the table below.

Table 2.5: *Minimum drinker requirements per 1,000 birds post-brooding*

Drinker Type	**Drinker Requirements**
Bell drinkers	8 drinkers of 40 cm (16 in) diameter per 1,000 birds
Nipples	83 nipples per 1,000 birds (12 birds per nipple, or for broilers >3 kg (6.6 lb) 9-10 birds per nipple)

Drinkers should be checked for height daily and adjusted so that the base of each drinker is level with the base of the broilers back from day 18 onwards (**Figure 2.4**).

Figure 2.4: *Bell drinker height adjustment*



Key Points

- Drinking water should be available to the birds 24 hours a day.
- Provide supplementary drinkers for the first 4 days of a flocks life.
- Monitor the feed to water ratio daily to check that water intake is sufficient.
- Make allowances for increased water consumption at high temperatures.
- Flush drinker lines in hot weather to ensure that the water is as cool as possible.
- Adjust drinker heights daily.
- Provide adequate drinker space and ensure that drinkers are easily accessible to all birds.

Feeding Systems

Provide sieved crumbs or mini-pellets for the first 10 days of the chicks' life. Place feed in flat trays or on paper sheeting so that it is readily accessible to the chicks. Cover at least 25% of the floor with paper.

Gradually make the change to the main feeding system over the first 2–3 days as chicks begin to show interest in the main system. If photoperiod duration and pattern are used to modify growth, pay particular attention to feeding space to allow for the extra competition created.

The birds' actual diet will depend on live weight, depletion age, climate and type of house and equipment construction.

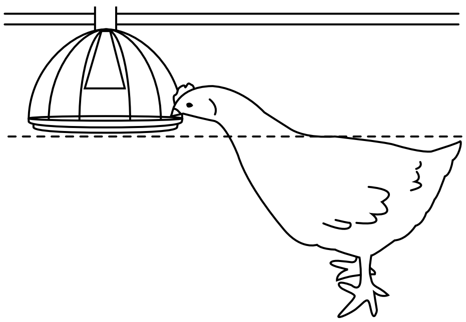
Insufficient feeding space will reduce growth rates and cause poor uniformity. The number of birds per feeding system will ultimately depend on the desired live weight at slaughter and design of system.

The main automated feeding systems available for broilers are:

- Pan feeders: 45–80 birds per pan (the lower ratio for bigger birds).
- Flat chain/auger: 2.5 cm per bird (40 birds per meter of track), 1 inch per bird (12 birds per feet of track).
- Tube feeders: 38 cm (15 in) diameter (70 birds per tube).

Adjust all types of feeders to ensure minimum spillage and optimum access for the birds. The base of the trough or pans should be level with the birds' backs **(Figure 2.5)**. The height of pan and tube feeders may have to be adjusted individually. The height of chain feeders is adjustable by winch.

Figure 2.5: *Height of feeders*



Incorrect feeder adjustment can increase feed spillage. When this happens, feed conversion estimates will become inaccurate and the spilled feed is likely to carry a higher risk of bacterial contamination.

With all feeding systems it is good practice to allow the birds to clear the feeders by consuming all the feed available in the tracks or pans once daily. This will reduce feed wastage and improve efficiency of feed use.

Adjustment of feed depth is easier with chain feeder systems because only a single adjustment to the hopper is required. Careful maintenance of chain feeders will minimize incidence of leg damage.

Make adjustments to each individual feeder when using pan and tube feeder systems.

The advantage of pan and tube feeders is that, if filled automatically, feed will be immediately available to the birds. Feed distribution takes longer to accomplish and feed is not immediately available when chain feeders are used.

Uneven distribution of feed can result in lowered performance and increased scratching damage associated with competition at feeders.

Key Points

- Supplement the main feeding system using paper and/or trays over the first 3 days.
- Supply sufficient feeders for the number of birds in the house.
- Increase feeder space per bird if photoperiod duration and pattern are modified to allow for increased competition at the feeder.
- Adjust feeder height daily so that the birds' backs are level with the base of the feeder.

Section 3

Health and Biosecurity

Objective

To maximize flock performance by minimizing or preventing poultry diseases and infections of public health concern through good husbandry, biosecurity and welfare practices.

Contents

Principles

Bird health is of extreme importance in broiler production. Poor chick health will have a negative impact on all aspects of production and flock management including growth rate, feed conversion efficiency, condemnations, livability, and processing traits.

The flock should start with day-old chicks of good quality and health. Source the chicks from a minimal number of breeder flocks with similar health status; ideally, 1 source flock per house.

On-farm disease control programs involve:

- Disease prevention.
- Early detection of ill health.
- Treatment of identified disease conditions.

Regularly monitor production parameters for early detection and targeted intervention. Early intervention in 1 flock will help prevent disease in surrounding and successive flocks.

Review the production parameters closely and compare them with company targets. Production parameters include birds dead on arrival (D.O.A.), 7-day body weight, daily and weekly mortality, water consumption, average daily gain, feed conversion efficiency and processing condemnations. When monitored production parameters fail to meet their established goals, a proper investigation should be conducted by trained veterinary personnel.

Biosecurity and vaccination are fundamental to successful health management. Biosecurity to prevent the introduction of disease in the first place and appropriate vaccination programs to address endemic disease.

Biosecurity

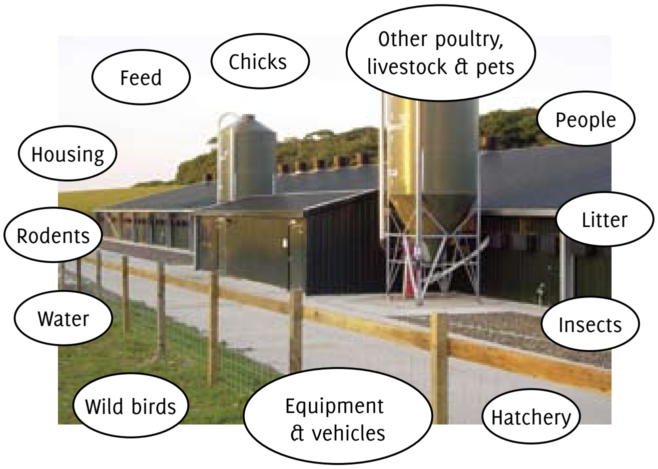
A strong biosecurity program is critical to maintain flock health. Understanding and following agreed biosecurity practices must be part of everyone's job. Regular education and staff training is essential.

Biosecurity will prevent flock exposure to disease-causing organisms. When developing a biosecurity program, 3 components should be considered:

- **Location:** Isolate farms from other poultry and livestock. Single-age sites are preferable to limit recycling of pathogens and live vaccine strains.
- **Farm design:** A barrier (fence) is necessary to prevent unauthorized access. Design housing to minimize traffic flow and to facilitate cleaning and disinfection. Construct housing to be bird and rodent proof.
- **Operational procedures:** Prevent the introduction and spread of disease with procedures that control the movement of people, feed, equipment and animals on the farm. Routine procedures may have to be modified in the event of a change in disease status.

Many of the potential routes of disease exposure are presented in **Figure 3.1**.

Figure 3.1: *Elements of disease exposure*



Key Points

- Restrict visitors.
- Establish visitation requirements for any visitor, including a risk assessment protocol for that individual which must be completed prior to entry.
- Stipulate farm entry protocols, including a change of clothing and footwear for staff and visitors.
- Provide a change of footwear or disposable boots at the entrance to every house.
- Clean and disinfect all equipment before it is brought onto the farm.
- Clean all vehicles prior to farm entry.
- Establish clear and implemented procedures for house cleaning and disinfection.
- Establish clear and implemented procedures for litter management and disposal.
- Reduce pathogen carryover by allowing adequate down-time for farm cleaning.
- Establish clear and implemented procedures for feed hygiene, transport and delivery.
- Establish clear and implemented procedures for water management and sanitation.
- Establish an integrated pest control program.
- Establish procedures for dead bird disposal.

Vaccination

Table 3.1 lays out some essential factors for successful vaccination of broilers.

Table 3.1: *Factors for a successful vaccination program*

Vaccination Program(s) Design	Vaccine Administration	Vaccine Effectiveness
Programs must be based on veterinary advice tailored to specific local and regional challenges established by health surveys and laboratory analysis.	Follow manufacturer recommendations for product handling and method of administration.	Seek veterinary advice prior to vaccinating sick or stressed birds.
Carefully select single or combined vaccines according to age and health status of flocks.	Properly train vaccine administrators to handle and administer vaccines.	Periodic and efficient house cleaning followed by placement of new litter material reduces the concentration of pathogens in the environment.
Vaccination must result in the development of consistent levels of immunity while minimizing potential adverse effects.	Maintain vaccination records.	Adequate down-time between flocks helps to reduce the build-up of normal house pathogens that can affect flock performance when re-using litter.
Breeder programs should provide adequate and uniform levels of maternal antibodies to protect chicks against several viral diseases during the first weeks of life.	When live vaccines are given in chlorinated water, use a vaccine stabilizer (such as non-fat powdered or liquid milk) added to the water prior to the vaccine to neutralize the chlorine. Chlorine can reduce vaccine titer or cause inactivation.	Regular audits of vaccine handling, administration techniques and post-vaccinal responses are critical to control challenges and improve performance.
Maternal antibodies may interfere with the chick's response to some vaccine strains. Levels of maternal antibodies in broilers will decline as the breeder source flock ages.		Ventilation and management should be optimized post-vaccination, especially during times of vaccine-induced reaction.

Key Points

- Vaccination alone cannot protect flocks against overwhelming disease challenges and poor management practices.
- Develop vaccination programs for broilers in consultation with trained poultry veterinarians.
- Vaccination is more effective when disease challenges are minimized through well-designed and implemented biosecurity and management programs.
- Base vaccination programs on local disease challenges and vaccine availability.
- Every bird must receive the intended dose of vaccine.
- Breeder flock vaccination programs must be factored into the design of an appropriate vaccination program for broiler progeny.

Disease Investigation

Disease investigation requires knowledge of what to expect at what age and how to detect what is abnormal for the flock.

When health problems are seen or suspected in broiler flocks, seek veterinary advice at the earliest possible opportunity.

When investigating the cause of disease, take care in associating a bacterium or virus isolated from the infected flock as the cause of the disease. Ill health arises from a wide variety of causes and interactions.

Many non-pathogenic bacteria or viruses may also be isolated from healthy broilers.

Continuous improvement of broiler health within a broiler operation requires good record keeping and sample collection throughout the lives of the flocks and across the whole production process.

It is helpful to keep up-to-date with local and regional health concerns in order to prepare for the unexpected.

A systematic approach is helpful when troubleshooting health issues on the farm.

These are the things to look at:

- Feed: availability, consumption, distribution, palatability, nutritional content, contaminants and toxins, and withdrawal.
- Light: adequate for efficient growth and development, uniform exposure and intensity.
- Litter: moisture level, ammonia level, pathogen load, toxins and contaminants, depth, material used, distribution.
- Air: speed, contaminants and toxins, humidity, temperature, availability, barriers.
- Water: source, contaminants and toxins, additives, availability, pathogen load, consumption.
- Space: bird density, feed availability, water availability, limiting obstacles, limiting equipment.
- Sanitation: hygiene of premises (inside and outside of house), pest control, maintenance, cleaning and disinfection practices.
- Security: biosecurity risks.

Tables 3.2 and **3.3** highlight examples of mortality parameters possibly related to bird quality and bird health. The Tables also suggest potential investigative actions using the systematic approach previously outlined.

Table 3.2: *Troubleshooting common issues in the 0–7 day brooding phase*

Observe	Investigate	Likely Causes
Poor chick quality - Increased dead on arrivals (D.O.A.'s) - Sluggish chick behavior - General chick appearance: unhealed navels, red hocks/ beaks, dark wrinkled legs, discolored or malodorous yolks or navels	Feed, Sanitation, Air and Water - Source flock health and hygiene status - Egg handling, storage and transport - Hatchery sanitation, incubation, and management - Chick processing, handling and transport	- Inadequate diet of source flock - Health and hygiene status of source flock, hatchery and equipment - Incorrect parameters for egg storage, relative humidity, temperatures and equipment management - Inadequate moisture loss during incubation - Dehydration caused by excessive spread of hatch time or late removal of chicks from the hatchers
Small chicks days 1–4	Feed, Light, Air, Water and Space - Crop fill at 24 hours post chick placement - Availability and accessibility to feed and water - Bird comfort and welfare	- Less than 95% of chicks with adequate crop fill by 24 hours post placement - Weak chicks - Inadequate feeders and drinkers - Inadequate feed and water levels - Equipment location and maintenance issues - Inappropriate brooding temperature and environment
Runted and Stunted Chicks - Small birds, as early as 4-7 days	Feed, Light, Litter, Air, Water, Space, Sanitation and Security - Flock source - Hydration status of chicks - Brooding conditions - Feed quality and accessibility - Down-time between flocks - Disease challenge	- Flock source variation - Dehydration of the chicks - Poor quality feed - Poor quality brooding conditions - Short down-times between flocks - Inadequate cleaning and disinfection - Disease - Poor biosecurity and hygiene practices

Table 3.3: *Troubleshooting common issues subsequent to 7 days of age*

Observe	Investigate	Likely Causes
Disease - metabolic - bacterial - viral - fungal - protozoal - parasitic - toxins **Stress**	Feed, Light, Litter, Air, Water, Space, Sanitation and Security - Broiler farm hygiene - Local disease challenge - Vaccination and disease prevention strategies - Feed quality and supply - Lighting and ventilation **Potential stressors** - Temperature - Management - Immunosuppressive disorders	- Poor environmental conditions - Poor biosecurity - High disease challenge - Low disease protection - Inadequate or improper implementation of disease prevention - Poor feed quality - Inadequate feed supply - Excessive or insufficient ventilation - Inadequate farm management - Inadequate equipment - Inadequate bird comfort and welfare
High number of birds D.O.A. to the processing plant High plant condemnation rate	Feed, Light, Litter, Air, Water, Space, Sanitation and Security - Flock records and data - Health status of flock - History of flock during the grow-out period (such as feed, water or power outages) - Potential equipment hazards on the farm - Bird handling by the catchers, handlers and haulers - Experience and training level of individuals handling and hauling birds - Conditions during catching and hauling (such as weather and equipment)	- Health issues during grow-out - Management of relevant historical events affecting bird health and welfare - Improper bird handling and hauling by crews - Harsh conditions (weather or equipment related) during handling, catching or transport to the processing plant

Key Points

- Know what to expect and be alert to deviations from the expected.
- Observe; Investigate; Identify; Act.
- Use a systematic approach.

Disease Recognition

The recognition of health problems involves several steps.

In diagnosing a disease problem, and planning and implementing a control strategy, it is important to remember that the more thorough the investigation, the more thorough the diagnosis and the more effective the controlling actions.

Early disease recognition is critical.

Table 3.4 highlights some of the ways in which signs of disease can be recognized.

Table 3.4: *Recognizing signs of disease*

Observations by Farm Personnel	Farm and Laboratory Monitoring	Data and Trend Analysis
Daily assessment of bird behavior	Regular farm visitation	Daily and weekly mortality
Bird appearance (such as feathering, size, uniformity, coloring)	Routine post-mortem examinations of normal, as well as diseased birds	Water and Feed Consumption
Environmental changes (such as litter quality, heat or cold stress, ventilation issues)	Proper sample collection size and type Proper choice of subsequent analysis and actions following post-mortem examination	Temperature trends
Clinical signs of illness (such as respiratory noise or distress, depression, fecal droppings, vocalization)	Routine microbiological testing of farms, feed, litter, birds and other appropriate material	D.O.A.'s after placement on the farm, or after arrival at the processing plant
Flock uniformity	Appropriate diagnostic testing Appropriate serology	Condemnation at slaughter

Key Points

- Daily observation.
- Accurate recording.
- Systematic disease monitoring.

Section 4

Housing and Environment

Objective

To provide an environment that permits the bird to achieve optimum performance in growth rate, uniformity, feed efficiency and yield without compromising the health and welfare of the bird.

Contents

For more detailed environmental control information, please see the document ***Environmental Management in the Broiler House***, 2009.

Principles

Ventilation control is the principle means of controlling bird environment. It is essential to deliver a constant and uniform supply of good quality air at bird level. Fresh air is required at all stages of growth to allow the bird to remain in good health and achieve full potential.

Ventilation helps to maintain in-house temperatures within the birds' comfort zone. During the early part of the production period keeping birds warm enough is the primary concern, but as they grow keeping them cool enough becomes the main objective.

The housing and ventilation systems used will depend upon climate, but in all cases effective ventilation should remove excess heat and moisture, provide oxygen and improve air quality by removing harmful gases.

Sensors that monitor ammonia, carbon dioxide, relative humidity and temperature are available commercially and can be used in conjunction with automated ventilation systems.

As broilers grow they consume oxygen and produce waste gases and water vapor. Combustion by brooders contributes further waste gases in the broiler house. The ventilation system must remove these waste gases from the house and deliver good air quality.

Air

The main contaminants of air within the house environment are dust, ammonia, carbon dioxide, carbon monoxide and excess water vapor. When in excess, they damage the respiratory tract, decreasing the efficiency of respiration and reducing bird performance.

Continued exposure to contaminated and moist air may trigger disease (e.g. ascites or chronic respiratory disease), affect temperature regulation, and contribute to poor litter quality, as shown in **Table 4.1**.

Table 4.1: *Effects of common broiler house air contaminants*

Ammonia	Can be detected by smell at 20 ppm or above ›10 ppm will damage lung surface ›20 ppm will increase susceptibility to respiratory diseases ›50 ppm will reduce growth rate
Carbon Dioxide	›3500 ppm causes ascites and is fatal at high levels
Carbon Monoxide	100 ppm reduces oxygen binding and is fatal at high levels
Dust	Damage to respiratory tract lining and increased susceptibility to disease
Humidity	Effects vary with temperature. At ›29°C (84°F) and ›70% relative humidity, growth will be affected

Water

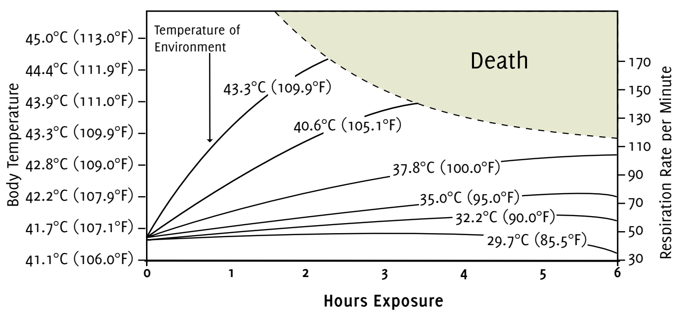
Birds produce a substantial volume of water, which passes into the environment and must be removed by ventilation (while maintaining required air temperatures). A 2.5 kg (5.5 lb) bird will consume some 7.5 kg (16.5 lb) of water in its lifetime and emit into the house atmosphere some 5.7 kg (12 lb) of water. This indicates that for 10,000 birds some 57 metric tonnes (62 tons) of water is lost into the environment as expired moisture into the air or excreted in droppings. This water load must be removed by the house ventilation system during the life of the flock. If water consumption is elevated for any reason, the requirement for moisture removal will be even greater than this.

Heat Stress

The normal body temperature of a broiler chicken is approximately 41°C (106°F). When the environmental temperature exceeds 35°C (95°F), the broiler is likely to experience heat stress.

The longer the broiler is exposed to high temperatures, the greater the stress and its effects. **Figure 4.1** refers to the relationship between environmental temperature and exposure.

Figure 4.1: *Relationship between environmental temperature, exposure time and body temperature*



Broilers regulate their body temperature by two methods; sensible and insensible heat loss. Between 13–25°C (55–77°F), sensible heat loss occurs as physical radiation and convection to the cooler environment. When the temperature rises above 30°C (86°F) insensible heat loss occurs through evaporative cooling and panting and increased respiration rate. The relationship between the two types of heat loss and environmental temperature is illustrated in **Table 4.2.**

Table 4.2: *Heat loss in broilers*

	Heat Loss %	
Environmental Temperature	Sensible (Radiation & Convection)	Insensible (Evaporation)
25°C (77°F)	77	23
30°C (86°F)	74	26
35°C (95°F)	10	90

Panting allows the bird to control its body temperature by evaporation of water from the respiratory surfaces and air sacs. This process uses energy. In conditions of high humidity panting is less effective. Where high temperatures are maintained for long periods or humidity is high, panting may be insufficient to control body temperature and the bird may then experience heat stress. As the bird passes into a condition of heat stress, vent temperature increases, heart rate and metabolic rate increases and oxygenation of the blood decreases. The physiological stress induced by these reactions can be fatal.

If the birds appear to be panting then general house temperature may be too high, or local house temperature may be elevated due to a problem with uniformity of the air distribution.

To reduce heat stress:

- Reduce stocking density.
- Ensure cool, fresh, low-salt drinking water is available at all times.
- Feed during the coolest part of the day.
- Increase airflow over the bird to 2–3 m/sec (400–600 ft/min).
- Minimize the effects of radiant heat from the sun.
- Reduce effects of excessive temperatures by placing sexes separately at lower stocking densities.

Housing and Ventilation Systems

There are 2 basic types of ventilation system; natural and power:

Natural (Open-sided Housing), which can be:

Non-mechanically assisted

Mechanically assisted

Power (Controlled Environment Housing), which can be:

Minimum

Transitional & Tunnel

Evaporative pad

Fogging/misting

Natural Ventilation: Open-sided Housing

Natural ventilation refers to an open-sided house with curtains, flaps or doors (**Figure 4.2**). Natural ventilation involves opening up the side of the house to allow convection currents to flow air into and through the house. Sidewall curtains are the most common and therefore natural ventilation is often referred to as curtain ventilation. When it gets warm, the curtains are opened to let in outside air. When it gets cold, the curtains are closed to restrict the flow of air.

Figure 4.2: *Example of natural ventilation*

Curtain ventilation requires continuous, 24-hour management if house environment is to be satisfactorily controlled. The constant monitoring of conditions and adjustment of curtains is required to compensate for changes in temperature, humidity, wind velocity and wind direction. Open-sided, naturally-ventilated housing is now less popular because of its high management demand and controlled environment housing is seen as delivering better livability, growth rate, feed conversion efficiency and bird comfort.

When open, house curtains allow a large volume of outside air through the house, equalizing inside and outside conditions. Curtain ventilation is ideal only when outside temperature is close to the target house temperature.

The air exchange rate depends on outside winds, and fan assistance improves the efficacy of air circulation. On warm to hot days with little wind, fans provide a wind chill cooling effect. Foggers or misters should be used with circulation fans to add a second level of cooling.

In cold weather, when curtain openings are small, heavy outside air enters at low speed and drops immediately to the floor which can chill the birds and create wet litter. At the same time, warmer air escapes from the house which results in large temperature swings. In cold weather, circulation fans help to mix incoming cold air with in-house warm air. In cool climates, automatic curtain operation is recommended with sidewall fans also operated by timers with thermostat overrides.

Power Ventilation Systems: Controlled Environment Housing

Power or negative pressure ventilation is the most popular ventilation method used to control house environment. Better control over air exchange rates and airflow patterns provide more uniform conditions throughout the house.

Power ventilated systems use electric exhaust fans to draw air out of the house and so create a lower pressure within the house than that outside the house (**Figure 4.3**). This creates a partial vacuum (negative or static pressure) inside the house so that outside air can pass in through controlled openings in the sidewalls. The speed at which air enters a house is determined by the amount of vacuum within the house. This, in turn, is a function of fan capacity and air inlet area.

Figure 4.3: *Example of power ventilation*

Matching the amount of sidewall openings to the number of exhaust fans in operation is the key to achieving correct negative (or static) pressure. Mechanical controls will automatically adjust inlet openings to the number of fans running. The amount of negative pressure generated can be monitored by a hand-held or wall-mounted static pressure gauge.

As broilers grow, ventilation rates must be increased. Set additional automatically-controlled fans to begin operating as needed. This is achieved by equipping the house with temperature sensors or thermostats placed in the center of the house or (preferably) at multiple points at bird level.

Negative pressure ventilation can be operated in 3 different modes according to the ventilation needs of the birds:

- Minimum ventilation.
- Transitional ventilation.
- Tunnel ventilation.

With any powered system, a standby emergency generator is required.

Minimum Ventilation Systems

Minimum ventilation is used for cooler weather and for small birds such as chicks. The aim of minimum ventilation is to maintain required air temperature while bringing in fresh air and exhausting in-house stale air so that there is a sufficient removal of excess moisture and harmful gases.

Temperature

Temperature requirements for chicks up to 21 days are given in Section 1 of this manual (Chick Management). Guideline temperatures at chick level fall from a recommendation of around 30°C (86°F) at day-old, to 20°C (68°F) at 27 days. Subsequently, the recommendation is for 20°C (68°F) through to slaughter. Actual and effective temperatures will, of course, vary from these guidelines according to circumstance and chick behavior as detailed here and in Section 1.

Ventilation

It is essential to ventilate the house for at least some minimum amount of time no matter what the outside temperature. **Table 4.3** gives typical minimum ventilation rates for a 20,000 bird house.

Table 4.3: *Minimum ventilation rates (20,000 bird house)*

Bird age (days)	Cubic meters/hour/bird (Cubic feet/minute/bird)	Total cubic meters/hour (Total cubic feet/minute)
1–7	0.16 (0.10)	3,200 (2,000)
8–14	0.42 (0.25)	8,400 (5,000)
15–21	0.59 (0.35)	11,800 (7,000)
22–28	0.84 (0.50)	16,800 (10,000)
29–35	0.93 (0.55)	18,600 (13,000)
36–42	1.18 (0.70)	23,600 (14,000)
43–49	1.35 (0.80)	27,000 (16,000)
50–56	1.52 (0.90)	30,400 (18,000)

The key to successful minimum ventilation is creating a partial vacuum (negative pressure) so air comes through all inlets at sufficient speed. This will ensure that incoming air is mixed with warm in-house air above the birds rather than dropping directly onto the birds and chilling them. The speed of incoming air should be the same through all inlets to ensure uniform airflow.

This type of ventilation is preferably timer-driven, calculated as shown below. As birds grow or as outside air temperatures increase, the timer should be overridden to provide adequate ventilation according to bird needs. The override should be activated by thermostats set to operate for each 1°C (2°F) rise in temperature.

Calculation for Minimum Ventilation Fan Timer Settings

To determine the interval fan timer settings for achieving minimum ventilation the following steps are employed. All these steps are laid out with example calculations in Appendix 7:

- Obtain the appropriate minimum ventilation rate as recommended in Appendix 7. The exact rates will vary with breed, sex and for each individual poultry house. Check with the company of manufacture and a local Aviagen Technical Services Representative for more specific information. The rates given in Appendix 7 are for temperatures between -1 and 16°C (30–61°F); for lower temperatures a slightly lower rate may be required and for higher temperatures a slightly higher rate.

- Calculate the total ventilation rate required for the house (total cubic meters per hour (cmh), or total cubic feet per minute (cfm)) as:

  Total minimum ventilation** = **Minimum ventilation rate per bird** x **Number of birds in the house

- Calculate the percentage time for running the fans as:

  $$\textit{Percentage of time} = \frac{\textit{Total ventilation needed}}{\textit{Total capacity of the fans used}}$$

- Multiply the percentage of time needed by the total fan timer cycle to give the time that the fans require to be on in each cycle (for example, 105 seconds in every 5 minutes).

Key Points

- Minimum ventilation is used for young chicks, night time or winter ventilation.
- It is essential to provide some ventilation to the house no matter what the outside temperature is, to provide fresh air and remove waste gases and excess moisture.
- Minimum ventilation should be timer-driven.

Transitional Ventilation Systems

Transitional ventilation operates using 2 ventilation principles based on the outside temperature and the age of the birds. It is used where both hot and cold periods are experienced.

Whereas minimum ventilation is timer-driven, transitional ventilation is temperature-driven.

Transitional ventilation begins when a higher than minimum air exchange rate is required. That is, whenever temperature sensors or thermostats override the minimum ventilation timer to keep fans running.

Transitional ventilation works in the same way as minimum ventilation, but a larger fan capacity gives a larger volume of air exchange. Successful transitional ventilation requires sidewall inlets linked to a static pressure controller so heat can be removed without switching to tunnel ventilation. Usually, transitional ventilation may be used when outside temperature is not greater than 6°C (10°F) above the target house temperature, or if the outside temperature is not greater than 6°C (10°F) below the target house temperature. If outside temperature is more than 6°C (10°F) above the target house temperature, then the fans used for transitional ventilation will not provide adequate cooling and tunnel ventilation will need to be employed. If outside temperature is more than 6°C (10°F) below the target house temperature, then the fans used for transitional ventilation will risk chilling the birds.

Key Points

- Transitional ventilation is temperature-driven based on the outside temperature and the age of the birds.
- Transitional ventilation is used when a higher than minimum air exchange is required.
- In general, transitional ventilation may be used when outside temperature is not greater than +/- 6°C (10°F) of target house temperature.

Tunnel Ventilation Systems

Tunnel ventilation keeps birds comfortable in warm to hot weather and where large birds are being grown by using the cooling effect of high-velocity airflow.

Tunnel ventilation provides maximum air exchange and creates a wind chill cooling effect. Each 122 cm (48 in) fan for birds under 4 weeks of age will generate a wind chill of 1.4°C (2.5°F). For birds over 4 weeks, this figure drops to 0.7°C (1.3°F).

The effective temperature felt by the birds falls as air velocity increases. The rate of fall is twice as great for younger birds as compared to older birds. Thus, with outside air at 32°C (90°F), an air velocity of 1 m/sec (200 ft/min) will cause a younger (4 week old) bird to feel an effective temperature of about 29°C (84°F). If air velocity increases to 2.5 m/sec (500 ft/min), the same bird will feel an effective temperature of about 22°C (72°F), a fall of 7°C (12°F). In the case of an older bird (7 weeks), the fall is about half of that (around 4°C or 7°F).

Bird behavior is the best way to assess bird comfort. If the house design only permits tunnel ventilation, then considerable caution should be practiced with young chicks which are prone to wind chill effects. For young chicks, actual floor air speed should be less than 0.15 m/sec (30 ft/min), or as low as possible.

In tunnel houses, birds will tend to migrate toward the air inlet end in hot conditions. Where airflow is correct, temperature differences between inlets and exits should not be large. Installing migration fences at 30 m (100 ft) intervals prior to 21 days of age will prevent bird migration problems. Avoid solid migration fences as they will restrict airflow.

Key Points

- Tunnel ventilation is used in warm to hot weather or where large birds are grown.
- Cooling is achieved through high-velocity airflow.
- Use bird behavior to assess if environmental conditions are correct.
- Care should be taken with young chicks which are prone to wind chill.
- Consider installation of migration fences.

Evaporative Cooling Systems

Tunnel ventilation is well-suited to the addition of an evaporative cooling system because of the high-velocity airflow of tunnel ventilation. Evaporative cooling is used to improve environmental conditions in hot weather and enhances the efficiency of tunnel ventilation. Evaporative cooling systems use the principle of water evaporation to reduce the temperature in the house.

Evaporative cooling is best implemented to maintain a required temperature in the house, rather than to reduce temperatures that have already become stressfully high.

The 3 factors which directly affect evaporative cooling are:

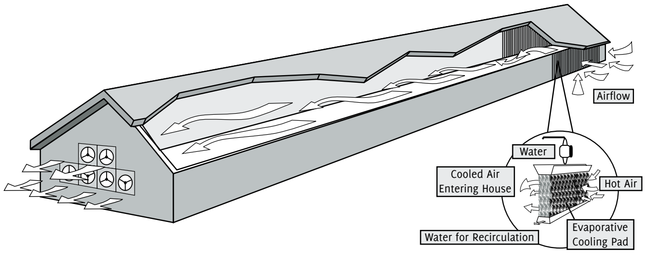
- Outside air temperature.
- Relative humidity (RH) of outside air.
- Evaporation efficiency.

There are 2 primary types of evaporative cooling systems; pad cooling with tunnel ventilation and Fogging or Misting.

Pad Cooling with Tunnel Ventilation

Pad cooling systems cool air by drawing it through wetted cellulose pads (see **Figure 4.4**). The dual effect of pad cooling and air speed allows control of environment when house temperatures are above 29°C (84°F). Excessively high house humidity can be minimized by making sure that evaporative cooling pads/fogging systems do not operate at temperatures below 27°C (81°F) in areas where the ambient humidity is high (greater than 80%).

Figure 4.4: *Pad cooling with tunnel ventilation*



Fogging/Misting

Fogging systems cool incoming air by evaporation of water created by pumping water through fogger nozzles. Place fogging lines near the air inlets to maximize the speed of evaporation and add additional lines throughout the house.

There are 3 types of fogging systems:

- Low pressure; 100–200 psi (7–14 bar); droplet size up to 30 microns.
- High pressure; 400–600 psi (28–41 bar); droplet size 10–15 microns.
- Ultra high pressure (misting); 700–1,000 psi (48-69 bar); droplet size 5 microns.

With low pressure systems, larger particle sizes can cause wet litter if house humidity is high. High pressure systems minimize residual moisture giving an extended humidity range. Fine droplet size will help avoid wet litter which is especially important during the brooding period.

Key Points

- Keep fans, foggers, evaporators and inlets clean.
- Evaporative cooling is used to enhance tunnel ventilation in hot weather.
- There are 2 types of systems: pad cooling and fogging/misting.
- Pad cooling draws air through wetted cellulose pads and allows control of the environment when house temperatures are above 29°C (84°F).
- Fogging systems cool incoming air by evaporation of water pumped through foggers. High pressure systems minimize residual moisture.

Lighting for Broilers

A lighting program should be simple in design. Complicated lighting programs can be difficult to implement successfully. Lighting recommendations are subject to local legislation and these should be taken into account before starting a program.

Light is an important management technique in broiler production. There are at least 4 important aspects:

- Wavelength (color).
- Intensity.
- Photoperiod length.
- Photoperiod distribution (intermittent programs).

Photoperiod length and distribution have interactive effects.

Many broiler growers use a lighting program that provides what is essentially continuous lighting. This system consists of a long continuous light period followed by a short dark period of 30–60 minutes. This short period of dark is to allow birds to become accustomed to darkness should a power failure occur.

Continuous lighting has, in the past, been assumed to help maximize daily live-weight gain; but this assumption is not correct.

Exposure to darkness influences bird productivity, health, hormonal profiles, metabolic rate, heat production, metabolism, physiology and behavior.

Recent information indicates that darkness exposure:

- Reduces early growth (but there may be later compensatory growth that can enable birds to catch up to equal target market weights; but only if the duration of darkness is not excessive. **For broilers processed at low body weights [e.g. <1.6 kg/3.5 lb] compensatory growth may not be achieved due to insufficient grow-out time**).

- Improves feed efficiency due to reduced metabolism during darkness and/or a change in the growth curve (i.e. a more concave growth curve).
- Improves bird health by reducing sudden death syndrome (SDS), ascites and skeletal disorders.
- Affects carcass yield with
  - A decrease in the proportion of breast meat.
  - An increase in the proportion of leg portions.
  - An unpredictable change (more, or less, or none) in abdominal fat.

All lighting programs should provide for a long day length such as 23 hours light and 1 hour dark in the early stages of growth to 7 days of age. This ensures chicks have good feed intake. Reducing day length too soon will reduce feeding activity and depress 7-day body weight.

When comparing various wavelengths of monochromatic light at the same light intensity, broiler growth rate appears to be better when exposed to wavelengths of 415-560 nm (violet to green) than in those exposed to ›635 nm (red) or broad spectrum (white) light.

A light intensity of 30–40 lux (3–4 foot candles) from 0–7 days of life and 5–10 lux (0.5–1.0 foot candles) thereafter will improve feeding activity and growth. The intensity of light should be uniformly distributed throughout the house (reflectors placed on top of lights can improve the distribution of light).

The European Union lighting requirements are based on Council Directive 2007/43/EC. These stipulate that a light intensity of at least 20 lux (2 foot candles) during the light period must be provided at all ages.

To attain a state of darkness, a light intensity of less than 0.4 lux (0.04 foot candles) should be achieved during the dark period. During darkness exposure, take care to avoid light seepage through air inlets, fan housings and door frames. Conduct regular tests to check the effectiveness of light proofing.

All birds should have equal, free and ad libitum access to nutritionally adequate feed and water as soon as the lights are switched on (see Section 2: Provision of Feed and Water).

Broilers will adapt their feeding behavior in response to reduced day length. For example, a change in day length from 24 to 12 hours of light will initially cause chicks to reduce feed intake by 30–40% during the first 3 days. However, as soon as 8 days later, the reduction in feed intake can be less than 10%. Broilers change their pattern of feeding in the light period by filling their crops in anticipation of the dark period. When the lights come back on they will do the same again. Birds sent for slaughter at younger ages have less time to adapt their eating and drinking behaviors in response to darkness exposure than do those slaughtered at correspondingly older ages. Thus the effects of darkness exposure on live performance are more pronounced in broilers slaughtered at younger ages.

Lighting program guidance based on slaughter weight target is provided in **Table 4.4**.

Table 4.4: *Basic light intensity and photoperiod recommendations to optimize live performance*

Live weight at slaughter	Age (days)	Intensity (lux) (foot candles)	Day length (hours)
Less than 2.5 kg (5.5 lb)	0–7 8–3 days before slaughter*	30–40 (3–4) 5–10 (0.5–1.0)	23 light/1 dark 20 light/4 dark**
More than 2.5 kg (5.5 lb)	0-7 8-3 days before slaughter*	30–40 (3–4) 5–10 (0.5–1.0)	23 light/1 dark 18 light/6 dark

* For at least the last 3 days before slaughter, 23 hours light and 1 hour dark should be provided.

** EU Broiler Welfare Directive requires a total of 6 hours darkness, with at least 1 uninterrupted period of darkness of at least 4 hours.

Aviagen does not recommend continuous lighting for the life of the broiler flock. Provide a minimum 4 hours of darkness after 7 days of age. Failure to provide at least 4 hour of darkness will result in:

- Abnormal feeding and drinking behaviors due to sleep deprivation.
- Sub-optimal biological performance.
- Reduced bird welfare.

In hot weather conditions, and where environmental control capability is not available, time the period without artificial light to maximize bird comfort. For example, when birds are reared in open-sided housing with no environmental control capability, feed is often removed for a time period during the heat of the day and continuous lighting is provided at night to allow birds to feed during this cooler period.

Broilers benefit from a defined pattern of light and dark (day and night) by having distinct time periods for rest and for activity. A number of important physiological processes, such as bone mineralization and digestion, normally exhibit diurnal rhythms. Therefore, defined cycles of light and dark allow broilers to experience natural patterns of growth and development.

Subsequent to feeding, normal gut passage time in the broiler is approximately 4 hours. Thus, exposure to darkness for more than 6 consecutive hours may encourage overly-aggressive feeding behavior when the lights come back on. This may result in an increase in skin scratches, an increase in condemnations and a reduction in carcass grade at the meat processing plant.

Additionally, darkness exposure beyond 4 hours will:

- Reduce breast meat yield.
- Increase leg meat yield.

This phenomenon is important to farmers who produce broilers for deboning.

Photoperiod distribution can also be modified and this is referred to as an intermittent program. An intermittent program consists of blocks of time containing both light and dark periods, which are repeated throughout the 24 hours. The benefit of such a program is that in giving broilers discrete meals (i.e. short feeding periods) followed by periods for digestion (i.e. dark periods), the efficiency of feed utilization (i.e. FCR) is improved. The extra activity caused by the regular pattern of light and dark is thought to be beneficial in improving leg health and carcass quality (e.g. lower incidence of hockburn and breast blisters). If intermittent lighting programs are used, the protocol should be designed as simply as possible to allow for practical implementation.

The extent of the effect of the lighting program upon broiler production is influenced by:

- The time of program application (early application being most effective in benefiting bird health).
- Age at marketing (older birds being likely to benefit more from darkness exposure).
- Environment (the effects of increased stocking density will be exacerbated by longer darkness exposure).
- Nutrition (the effects of limited feeder space will be made worse by longer darkness exposure).
- Rate of bird growth (the impact of lighting on health will be greater in rapidly growing birds than in birds fed nutritionally limiting diets).

Several types of light sources can be used for broilers and the most common types are:

- **Incandescent lights:** these provide a good spectral range, but are not energy efficient. However, incandescent lights with higher lumen output per watt will help reduce operating costs.
- **Fluorescent lights:** these produce 3 to 5 times the amount of light per watt compared to incandescent lights, but fluorescent lights lose intensity over time and must be replaced before actually failing. Fluorescent lighting provides significant savings in electricity costs after the additional installation costs have been recovered.

There are no differences between these light sources as far as broiler performance is concerned. Bulbs and reflectors must be cleaned regularly for maximum effectiveness.

Key Points

- Keep it simple.
- Continuous, or near continuous, lighting is not optimal.
- Chicks up to 7 days of age should have 23 hours light (30-40 lux, 3-4 foot candles) and 1 hour dark.
- After 7 days of age a period of darkness of 4 hours or more (but never more than 6 hours) is likely to be beneficial.
- The hours of darkness chosen will depend upon circumstances and market requirement.
- Many aspects of production management interact with the lighting program and modify the effects of lighting pattern on bird performance.

Litter Management

Local economics and raw material availability will dictate the choice of litter material used. Litter should provide:

- Good moisture absorption.
- Biodegradability.
- Bird comfort.
- Low dust level.
- Freedom from contaminants.
- Consistent availability from a biosecure source.

Evenly distribute soft wood shaving material to a depth of 8-10 cm (3-4 in). Where floor temperatures are adequate (28-30°C/82-86°F) the litter depth can be reduced where litter disposal is an issue. Concrete floors are preferable to earth floors since they are washable and allow more effective litter management. The characteristics of some common litter materials are given in **Table 4.5**.

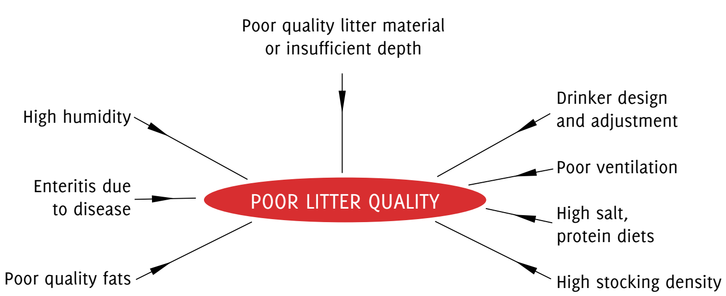
Table 4.5: *Characteristics of common litter materials*

Material	Characteristics
New white wood shavings	Good absorption and breakdown Possible contamination by toxic insecticides and other chemical compounds (giving a musty taint)
Chopped straw	Wheat straw is preferred Possible contamination by agrochemicals, fungi and mycotoxins Slow to break down Best used 50/50 with white wood shavings
Shredded paper	Can be difficult to manage in humid conditions Glossy paper is not suitable
Chaff and hulls	Not very absorbent Best mixed with other materials May be ingested
Sawdust	Not suitable Dusty, and may be ingested
Chemically treated straw pellets	Use as recommended by supplier
Sand	Can be used in arid areas on concrete floors If too deep bird movement may be impeded Needs good management
Peat moss	Can be successfully used

It is important that the litter is kept loose and dry throughout the life of the flock. If the litter becomes caked or too wet, the incidence of carcass downgrades can increase substantially.

The main causes of poor litter quality are given below.

Figure 4.5: *Reasons for poor quality litter*



Key Points

- Protect broilers from damage and provide a dry warm covering to the floor by using adequate quantities of a good quality litter material.
- Avoid nutritional causes of wet litter.
- Ensure adequate ventilation and avoid excess moisture.
- Choose a litter material that is absorbent, non-dusty and clean.
- Litter should be readily available at a low cost from a reliable source.
- Use fresh litter for each crop to prevent re-infection by pathogens.
- Protect litter storage facilities from the weather and secure from access by vermin and wild birds.

Stocking Density

Stocking density is ultimately a decision based on economics and local welfare legislation.

Stocking density influences bird welfare, broiler performance, uniformity and product quality.

Overstocking increases the environmental pressures on the broiler, compromises bird welfare and will ultimately reduce profitability.

Quality of housing and the environmental control system determine the best stocking density. If stocking density is increased, ventilation, feeding space and drinker availability must be adjusted.

The floor area needed for each broiler will depend on:

- Target live weight and age at slaughter.
- Climate and season.
- Type and system of housing and equipment; particularly ventilation.
- Local legislation.
- Quality assurance certification requirements.

In certain regions of the world the legislation of stocking density is based simply on kg/m (lb/ft). An example of this would be based on EU recommendations.

Within the European Union, stocking densities are based on the EU Broiler Welfare Directive:

- 33 kg/m^2 (6.7 lb/ft^2) or
- 39 kg/m^2 (8 lb/ft^2) if stricter welfare standards are met or
- 42 kg/m^2 (8.6 lb/ft^2) if exceptionally high welfare standards are met over a prolonged period.

Welfare standards refer to adequate provision of feed and water, sustainable good indoor climatic conditions and minimal incidence of foot pad dermatitis.

An alternative best practice recommendation, based on bird husbandry, takes into account bird number and bird mass in the floor area. An example of this would be based on USA recommendations. This recommendation is shown in **Table 4.6**.

Table 4.6: *Guide to stocking densities according to bird numbers and live weight (USA recommendations)*

Bird live weight kg (lb)	Square feet per bird	Birds/m² (Birds/ft²)	Bird weight kg/m² (lb/ft²)
1.36 (3.0)	0.50	21.5 (2.0)	29.2 (5.99)
1.82 (4.0)	0.70	15.4 (1.4)	28.0 (5.73)
2.27 (5.0)	0.85	12.7 (1.2)	28.8 (5.91)
2.73 (6.0)	0.90	12.0 (1.1)	32.7 (6.70)
3.18 (7.0)	1.00	10.8 (1.0)	34.3 (7.04)
3.63 (8.0)	1.15	9.4 (0.9)	34.1 (6.99)

Stocking Density in Hot Climates

In hot conditions, the stocking density used will depend on ambient temperature and humidity. Make appropriate changes in accordance with house type and equipment capabilities.

Example stocking densities used in hot conditions are as follows:

- In houses with controlled environment:
  - A maximum of 30 kg/m² (6 lb/ft²) at slaughter.
- In open-sided houses, with poor environmental control:
  - A maximum of 20–25 kg/m² (4–5 lb/ft²) at slaughter.
  - At the hottest times of the year a maximum of 16–18 kg/m² (3.2–3.7 lb/ft²).
- In open-sided houses, with no environmental control:
  - It is not recommended to grow birds to live weights above 3 kg (6.6 lb).

Key Points

- Adjust stocking density to allow for age and weight at which the flock is to be slaughtered.
- Match stocking density to climate and housing system.
- Reduce stocking density if target house temperatures cannot be achieved due to hot climate or season.
- Adjust ventilation and feeder and drinker space if stocking density is increased.
- Follow local legislation and requirements of quality assurance standards set by product purchasers.

Section 5

Monitoring Live Weight and Uniformity of Performance

Objective

To assess live flock performance against targets and to ensure that defined end product specifications are met as closely as possible.

Contents

Principles

Profitability depends upon maximizing the proportion of birds that closely meet target specifications. This requires predictable and uniform growth.

Growth management depends upon the knowledge of past, present and likely future growth performance. This knowledge, and safe subsequent actions, can only be achieved if the measurement of the growth is accurate.

Predictability of Live Weight

Accurate information on live weight and coefficient of variation (CV%) for each flock is essential in planning the appropriate age for slaughter and to ensure that the maximum number of birds fall into the desired weight bands at slaughter.

As growth rate increases and as slaughter age becomes earlier, prediction of live-weight gain over more than 2–3 days is less accurate. Accurate estimation and prediction of flock live weight at slaughter requires large numbers of birds (greater than 100) to be repeatedly sampled close to slaughter age (within 2–3 days).

Table 5.1 shows the number of sample birds required to give a live weight estimate of defined reliability and accuracy within flocks of differing variability.

Table 5.1: *Number of birds in a sample to give accurate estimates of live weight according to flock uniformity*

Uniformity of flock*	Number of birds to be weighed**
Uniform (CV% = 8)	61
Moderately uniform (CV% = 10)	96
Poorly uniform (CV% = 12)	138

* As measured by coefficient of variation (CV%; i.e. standard deviation/average body weight x 100); the higher the number the more variable the flock body weight is.
** Estimate of live weight will be within ±2% of the actual live weight and will be correct 95% of the time.

Birds can be weighed using manual or automatic weighing scales. Unexpected changes in live weight may be indicative of scale error or malfunction. Scales should be regularly checked for accuracy and repeatability.

When using manual scales the birds should be weighed at least 3 times per week. On each occasion, equal sized samples of birds should be taken from at least 2 locations in each house.

Place automatic weighing systems where large numbers of birds congregate and where individual birds will remain long enough for weights to be recorded.

Older, heavier males tend to use auto-weighers less frequently, which biases the flock mean downwards. Regularly check readings from any auto-weigher for usage rate (number of completed weights per day). At least once per week, cross-check the mean live weights achieved by manual weighing. Inaccurate live weight estimation will result from small sample sizes.

Key Points

- Weigh a sufficiently large number of birds.
- Weigh birds that are representative of the whole flock.
- Use accurate scales.
- Weigh birds frequently and accurately to ensure effective prediction of live weight at slaughter.

Flock Uniformity (CV%)

Broiler live weight will follow a normal distribution. The variability of a population (the flock) is described by the coefficient of variation (CV%) which is the standard deviation of the population expressed as a percentage of the mean.

Variable flocks will have a high CV%, uniform flocks a lower one.

Each sex will have a normal distribution of live weight. The As-Hatched (mixed sex) flock will have a wider CV% than single-sex flocks. (See **Figure 5.1** which refers to a flock at the end of grow-out).

Figure 5.1: *Distribution of live weights in a flock of as-hatched broilers*

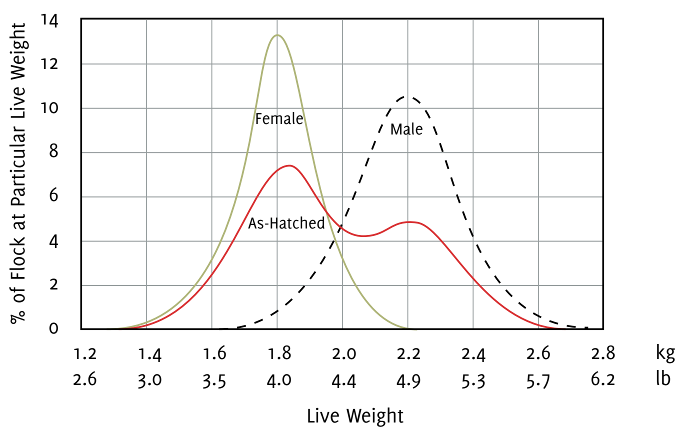
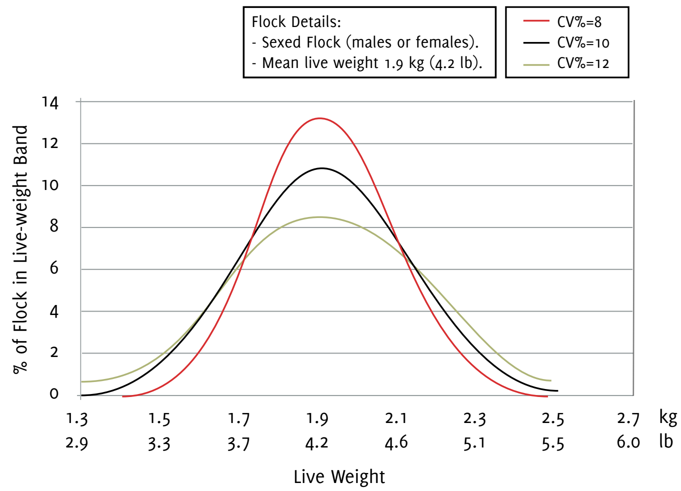


Figure 5.2 shows weight distributions at different levels of uniformity (CV%) for 3 single-sexed flocks, all achieving target live weight of 1.9 kg (4.2 lb). It can be seen that the weight distributions within each flock are quite different.

The lower the CV%, and therefore the less variable the flock, the more birds achieve the target.

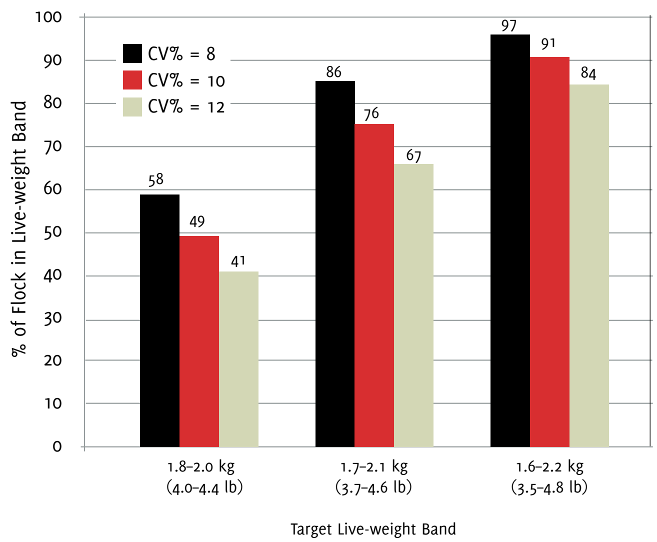
Figure 5.2: *Effect of CV% on live-weight bands in a flock of sexed broilers*



The proportion of birds achieving the target relates to the width of the band allowed for the target and the variability of the flock. Thus, if a live weight band of 1.8–2.0 kg (4.0–4.4 lb) is required, even at a CV% of 8, only 58% of the birds achieve required live weight (see **Figure 5.3**).

An understanding of these principles of biological variability forms the basis of effective planning in processing plants.

Figure 5.3: *Effect of CV% on proportion of birds in target live-weight band*



Key Points

- Birds in more uniform flocks will be more likely to meet the required target live weight.
- Variability in performance increases the flock CV%, which influences both flock profitability and processing plant efficiency.
- Minimize flock variability by monitoring and managing flock uniformity.
- Uniform flocks (low CV%) are more predictable in performance than uneven flocks.

Separate-Sex Growing

The number of birds which achieve live weight at, or close to, the flock mean can be predicted from the CV% of that flock. It follows that improvements in uniformity can be attained by growing flocks in single-sex populations from placement. Flocks can be sexed by feather sexing, which is described in Appendix 4.

The advantages of separate-sex growing can be best exploited when males and females are housed separately. Both sexes can be managed more efficiently with regard to feeding, lighting and stocking density.

Males grow faster, are more feed efficient and have less carcass fat than females. A different feeding program can be employed for the different sexes. The most practical method is to use the same feeds for both sexes but to introduce the Finisher earlier for females (i.e. before 25 days of age). It is recommended that the amount or duration of Starter feed be kept the same to ensure proper early development. For more information on separate-sex feeding please consult your local Aviagen Nutrition Services Representative.

Males may benefit from a modified lighting program if being killed at heavier weights compared to females. So where sexed flocks are placed in a divided single house, with a common environment and feed supply, careful thought will be needed to optimize the growth management for each sex without limiting the other.

Key Points

- Monitor and manage flock uniformity to minimize flock variability.
- Grow sexes separately to reduce variability.

Section 6

Pre-processing Management

Objective

To manage the final phase of the production process so that broilers are transferred to the processor in optimum condition, ensuring that the processing requirements are met and high standards of welfare are maintained.

Contents

Principles

The quality of the bird at the point of sale can be substantially influenced by management procedures at the end of the growth period, at catching and through handling and transportation.

Attention to aspects of bird welfare at this time will deliver benefits not only to the birds themselves, but also to their subsequent eating quality.

Growing conditions influence carcass yield and the incidence of downgrading, while inadequately managed feed removal will affect fecal and microbial contamination of the carcasses at the processing plant. Improperly supervised harvesting can inflict damage by bruising, wing breakage and internal bleeding of the thighs.

There are benefits in maintaining the high quality of broiler achieved thus far through detailed attention to management of the environment. There are also advantages in maintaining the welfare of the birds during catching, handling between the broiler house and the transport system, during transportation and at the processing plant.

It is inevitable that some weight loss will occur during the time the bird is without feed prior to processing due to loss of gut contents. The effect of these losses on carcass weight can be minimized by ensuring that the period without feed does not become excessive.

Birds without feed for more than 10 hours will dehydrate, have compromised welfare and reduced carcass yield. Birds will usually lose up to 0.5% of their body weight per hour when off feed for up to 12 hours (with water removed only when absolutely necessary). If they are allowed to go over 12 hours without feed, weight loss increases to 0.75–1.0% of body weight per hour. This weight loss cannot be recovered.

Preparation for Catching

Light

When growth has been modified through the application of restricted lighting programs, it is essential to return to 23 hours of light (5–10 lux or 0.5-1.0 foot candles). This will ensure that the birds are calm during collection. The EU Broiler Directive requires 20 lux (2 foot candles) at least 3 days prior to depletion.

Feed

A Withdrawal feed should be fed for sufficient time prior to slaughter to eliminate the risk of pharmaceutical product residues in the meat. Statutory withdrawal periods for coccidiostats and other prescribed medicines that are specified in product data sheets must be followed. Where thinning (i.e. partial depletion) programs are used, it may be necessary to keep the birds on the Withdrawal feed for longer than the mandatory period prior to slaughter.

Remove feed from the birds 8–10 hours before the expected slaughter time to reduce fecal contamination at the processing plant. This period should include catching, transport and holding time. If the time that the birds are without feed is prolonged, water absorbed from body tissue accumulates in the digestive tract resulting in reduced yield. Fecal contamination may also be increased.

The presence of watery droppings from broilers waiting to be processed is an indication that the birds have been without feed for too long. Other indicators include watery yellow fluid in the small intestine and litter in the crop and gizzard.

Remove whole wheat (if included in the diet) 2 days before slaughter to avoid the presence of whole grain in the gut.

Water

Provide unlimited access to water for as long as possible and remove water only when absolutely necessary.

Access to water will be prolonged by:

- Use of multiple drinker lines.
- Separation of birds into pens.
- Progressive removal of individual drinkers.

Key Points

- Use a Withdrawal feed (i.e. without coccidiostat) to avoid residues in meat.
- Allow 3 days on full light (23 hours light and 1 hour dark) to avoid problems during catching.
- Appropriate feed removal from the birds will ensure that the digestive systems are empty before processing commences, limiting fecal contamination during transport.
- Remove whole wheat from the ration 2 days before slaughter.
- Delay the removal of drinkers for as long as possible.

Catching

Catching and handling will cause stress to broilers. Most causes of downgrading observed at slaughter will have occurred during the period when the birds were being caught and handled. Carefully plan catching in advance and closely supervise all stages. The handling of birds and operation of machinery, such as harvesters and forklifts, must be carried out by appropriately trained, competent personnel. Minimize bird activity to avoid bruising, scratching and other injuries.

Mortality during the catching and transport process should not be more than 0.1%.

Pre-catch

Calculate the time it will take to catch and to transport. Start the catch according to when the birds are scheduled to be slaughtered.

Calculate the number of crates and trailers needed to transport the birds before the process commences.

Ensure all equipment used (including vehicles, crates, fencing and nets), are clean, disinfected and in good condition. Broken or damaged crates may injure birds.

Repair, compact and level the ground at the entrance to the poultry house (and any secondary roads leading to the house) to ensure a smooth exit for the loaded trucks. This will prevent bruising and wing damage.

Remove any wet litter from the broiler house that may hinder the efforts of the catching crew and replace with dry litter.

Raise all feeding equipment above head height of 2 m (6.6 ft), remove it from the house or re-position it to avoid obstruction to the birds or personnel.

Separate birds into pens within larger houses to avoid unnecessary crowding and allow access to water for birds not immediately due for catching.

Whenever possible, decrease the light intensity during catching to reduce stress. For night-time catching, which is preferred, reduce light intensity within the house to a minimum. For day-time catching, reduce light intensity as much as possible. In all cases light intensity must be sufficient to allow safe and careful catching. Blue light has been found to be satisfactory for this purpose. The best results are achieved when birds are allowed to settle after lights have been dimmed and when there is minimum disturbance.

The use of curtains over the main doors of the house is helpful when catching during daylight hours.

The opening of doors and removal of birds will affect the ventilation of thermostatically controlled environments. Carefully monitor and adjust the ventilation system throughout the catching procedure to reduce stress on the broilers and to prevent heat build-up within the house.

Catch

Broilers should be caught and held by both shanks (never the thighs) to minimize the distress, damage and injury that might otherwise result if they were able to struggle and flap.

Carefully place the birds into the crates or modules, loading from the top down. Modules have been shown to result in less distress and damage than conventional crates.

Crates or modules should never be overfilled as this can result in overheating, stress and increased mortality. Reduce the number of broilers per crate or module in high temperatures.

Improperly operated catching equipment can cause stress and damage to the broiler. Operate mechanical equipment used to catch birds (see **Figure 6.1**) at moderate speeds to prevent damage and stress to broilers. Never crowd or force the birds into the catching equipment. Properly align the opening chute of the catching equipment with the opening of the crate or module to prevent damage to the broiler.

Figure 6.1: *Example of a mechanical harvester*

Transport

Transport time should be within the local current guidelines or legislation.

At all times up to the arrival at the slaughter house, adequate protection from the elements is essential. Use ventilation, extra heating and/or cooling when necessary. Design vehicles to protect the bird from the elements. Stress on the birds will be minimized in trailers designed to provide adequate ventilation.

In hot weather, consider using fans while loading the birds to keep the air circulating through the crates or modules on the truck. Allow at least 10 cm (4 in) between every 2 tiers of crates. While waiting to be processed, use fans and foggers to help keep birds cool.

Heat stress will develop rapidly when the transport vehicle is stationary, particularly in hot weather or if on-board ventilation is not available. Vehicles should leave the farm as soon as loading is completed and driver breaks should be short.

Unloading at the holding area of the slaughter house must be completed without delay. Supplementary ventilation will be required if delay is unavoidable.

In cold weather, cover the load to minimize wind chill during transport. Check bird comfort frequently.

Delivery

At the slaughter house, park the trucks under a cover and remove any canvas that may restrict ventilation.

Good holding facilities at the slaughter house that provide the required ventilation and temperature control are essential for good bird welfare.

Equip holding areas with lights, fans and foggers. Use foggers during periods of high temperatures if relative humidity is below 70%. In very hot weather, water can be sprayed into the fans to assist evaporation. In summer conditions make sure all fans and foggers are functional in the holding areas.

Key Points

- Operate harvesting equipment properly.
- Maintain adequate ventilation during mechanical catching to reduce stress.
- Supervise catching and handling methods carefully to minimize trauma injuries to the birds.
- Remove or raise obstructions such as feeders or drinkers before beginning the catching operation and use partitions in large houses to avoid injuries caused by crowding.
- Reduce light intensity prior to catching to keep the birds calm and minimize damage and subsequent stress.
- Adjust bird numbers in crates and modules to allow for bird weight and ambient temperature.
- Plan journey and bird reception.
- Monitor welfare continuously.

Processing

Successful production of the maximum number of high quality carcasses with good yield depends on effective integration of the growing, catching and processing operations.

Careful planning and communication between the farm and processing plant will allow processing to proceed effectively. Management on the farm can influence the efficient operation of the killing, plucking and evisceration processes.

To minimize fecal contamination, carcass damage and downgrading, close attention should be given to:

- Litter quality.
- Stocking density.
- Feed removal times.
- Catching methods.
- Transport time.
- Holding time.

Key Points

- Present clean birds to the processor.
- Maintain good litter quality, depth and condition to minimize hockburn and other carcass quality problems.
- Scratching damage may be increased under high stocking densities, or when feeder or drinker spaces are inadequate, especially when lighting or feed control is used.
- Process under conditions that maintain best welfare of the birds.
- Minimize transport and holding times to reduce stress and dehydration.

Notes

Notes

Appendices

Contents

Appendix 1. Production Records

Record keeping and analysis are essential to determine the effects of changes to nutrition, management, environment and health status. Accurate production records are essential for the effective management, assessment of risk, control of the system and active response to developing problems.

Analysis and interpretation of production data (e.g. live weight, feed conversion efficiency and mortality) are essential to the upgrading and improvement of performance.

Hygiene and disease status should be monitored.

It is good practice for all processes in a broiler operation to have standard operating protocols (SOP). These should include documentation of established procedures, records, record analysis and monitoring systems.

Records Required in Broiler Production

Event	Records	Comment
Chick placement	Number of day-olds Flock of origin and flock age Date and time of arrival Chick quality	Live weight, uniformity, number of dead on arrival
Mortality	Daily Weekly Cumulative	Record by sex if possible Record culls and reason for culling separately Post mortem records of excessive mortality Scoring of coccidial lesions will indicate level of coccidial challenge
Medication	Date Amount Batch number	As per veterinary instruction
Vaccination	Date of vaccination Vaccine type Batch number Expiry date	Any unexpected vaccine reaction should be recorded
Live weight	Weekly average live weight Weekly uniformity (CV%)	More frequent measurement is required when predicting slaughter weight or where growth is modified through lighting
Feed	Date of delivery Quantity Date of starting feed withdrawal Feed type	Accurate measurement of feed consumed is essential to measure FCR and to determine cost effectiveness of broiler operation
Water	Daily consumption Water to feed ratio Water quality Level of chlorination	Plot daily consumption in graph form, preferably per house Sudden fluctuation in water consumption is an early indicator of problems Mineral and/or bacteriological – especially where bore holes or open water reservoirs are used
Environment	Temperature: daily minimum daily maximum during brooding, 4 to 5 times per day litter during brooding external temperature — daily Relative humidity — daily Air quality Litter quality	Multiple locations should be monitored especially in chick litter area Automatic systems should be cross-checked manually each day Ideally record dust, CO_2 , NH_3 or as a minimum observe levels of dust and NH_3
Depletion	Number of birds removed Time and date of removal	
Information from slaughter house	Carcass quality Health inspection Carcass composition Type and % condemnations	
Cleaning out	Total bacterial counts	After disinfection, salmonella, staphylococcus or E. coli may be monitored if required
House inspection	Record time of daily checks	

Appendix 2. Conversion Tables

Length	
1 meter (m)	3.281 feet (ft)
1 foot (ft)	0.305 meter (m)
1 centimeter (cm)	0.394 inch (in)
1 inch (in)	2.54 centimeters (cm)

Area	
1 square meter (m^2)	10.76 square feet (ft^2)
1 square foot (ft^2)	0.093 square meters (m^2)

Volume	
1 liter (l)	0.22 imperial gallons (gal) or 0.264 US gallons (gal US)
1 imperial gallon (gal)	4.54 liters (l)
1 US gallon (gal US)	3.79 liters (l)
1 imperial gallon (gal)	1.2 US gallons (gal US)
1 cubic meter (m^3)	35.31 cubic feet (ft^3)
1 cubic foot (ft^3)	0.028 cubic meters (m^3)

Weight	
1 kilogram (kg)	2.205 pounds (lb)
1 pound (lb)	0.454 kilograms (kg)
1 gram (g)	0.035 ounces (oz)
1 ounce (oz)	28.35 grams (g)

Energy	
1 calorie (cal)	4.184 Joules (J)
1 Joule (J)	0.239 calories (cal)
1 kilocalorie per kilogram (kcal/kg)	4.184 Megajoules per kilogram (MJ/kg)
1 Megajoule per kilogram (MJ/kg)	108 calories per pound (cal/lb)
1 Joule (J)	0.735 foot pound (ft lb)
1 foot pound (ft lb)	1.36 Joules (J)
1 Joule (J)	0.00095 British Thermal Unit (BTU)
1 British Thermal Unit (BTU)	1055 Joules (J)
1 kilowatt hour (kW-h)	3412.1 British Thermal Units (BTU)
1 British Thermal Unit (BTU)	0.00029 kilowatt hour (kW-h)

Pressure	
1 pound per square inch (psi)	6895 Newtons per square meter (N/m^2) or Pascals (Pa)
1 pound per square inch (psi)	0.06895 bar
1 bar	14.504 pounds per square inch (psi)
1 bar	10^5 Newtons per square meter (N/m^2) or Pascals (Pa)
	100 kilopascals (kPa)
1 Newton per square meter (N/m^2) or Pascals (Pa)	0.000145 pound per square inch (lb/in^2)

Stocking Density	
1 square foot per bird (ft^2/bird)	10.76 birds per square meter (bird/m^2)
10 birds per square meter (bird/m^2)	1.08 square feet per bird (ft^2/bird)
15 birds per square meter (bird/m^2)	0.72 square feet per bird (ft^2/bird)
20 birds per square meter (bird/m^2)	0.54 square feet per bird (ft^2/bird)
1 kilogram per square meter (kg/m^2)	0.205 pound per square foot (lb/ft^2)
15 kilograms per square meter (kg/m^2)	3.08 pounds per square foot (lb/ft^2)
34.2 kilograms per square meter (kg/m^2)	7.01 pounds per square foot (lb/ft^2)
40 kilograms per square meter (kg/m^2)	8.20 pounds per square foot (lb/ft^2)

Temperature	
Temperature (°C)	5/9 (Temperature °F – 32)
Temperature (°F)	32 + 9/5 (Temperature °C)

Operating Temperature

Operating temperature is defined as the minimum house temperature plus $^2/_3$ of the difference between minimum and maximum house temperatures. It is important where there are significant diurnal temperature fluctuations. For example:

- Minimum house temperature 16°C (61°F).
- Maximum house temperature 28°C (82°F).
- Operating Temperature = [(28 - 16) × $^2/_3$] + 16 = 24°C (Celsius).
- Operating Temperature = [(82 - 61) × $^2/_3$] + 61 = 75°F (Fahrenheit).

Ventilation	
1 cubic foot per minute (ft^3/min)	1.699 cubic meters per hour (m^3/hour)
1 cubic meter per hour (m^3/hour)	0.589 cubic foot per minute (ft^3/min)

Insulation

U value describes how well a building material conducts heat and is measured in Watts per square kilometer per degree Celsius ($W/km^2/°C$).

R value rates the isolative properties of building materials, the higher the R value the better the insulation. It is measured in km^2/W (or $ft^2/°F/BTU$).

Insulation	
1 $ft^2/°F/BTU$	0.1761 square kilometer per Watt (km^2/W)
1 km^2/W	5.67446 square feet per degree Fahrenheit per British Thermal Unit ($ft^2/°F/BTU$)

Light	
1 foot candle	10.76 lux
1 lux	0.093 foot candles

A simple formula to calculate the number of lamps required for a broiler house is as follows:

$$\text{*Number of lamps} = \frac{\text{Floor area } (m^2 \text{ or } ft^2) \times \text{Maximum lux (foot candles) required}}{\text{Wattage of lamp} \times \text{K factor}}$$

*This formula is for tungsten bulbs at a height of 2 meters (6.6 feet) above bird level. Fluorescent lights provide 3 to 5 times the number of lux (or foot candles) per Watt as tungsten bulbs.

K factor depends on lamp wattage as shown below

Power of Lamp (Watts)	**K Factor**
15	3.8
25	4.2
40	4.6
60	5.0
100	6.0

Appendix 3. Efficiency Calculations

Production Efficiency Factor (PEF)*

$$\frac{\text{Livability} \times \text{Live Weight in kg}}{\text{Age in Days} \times \text{FCR}} \times 100$$

e.g.

Age: 42 days

Live weight: 2.652 kg

Livability: 97.20%

FCR: 1.75

$$\frac{97.20 \times 2.652}{42 \times 1.75} \times 100 = \mathbf{351}$$

e.g.

Age: 46 days

Live weight: 3.006 kg

Livability: 96.90%

FCR: 1.83

$$\frac{96.90 \times 3.006}{46 \times 1.83} \times 100 = \mathbf{346}$$

*Also referred to as European Efficiency Factor (EEF).

Note: The higher the value the better the technical performance.

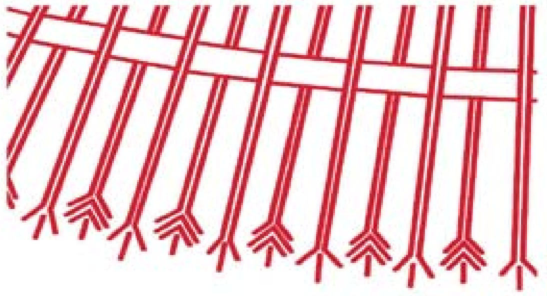
It is important to note that this calculation is heavily biased by daily gain. When comparing across different environments, comparisons should be made at similar ages at slaughter.

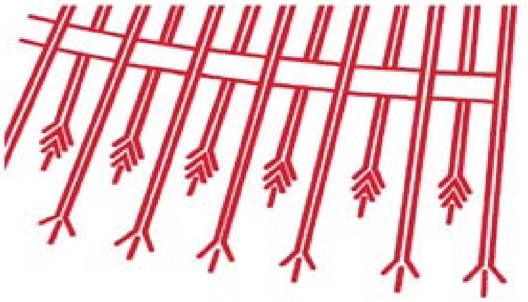
Appendix 4. Feather Sexing

Identification of males and females at day-old may be accomplished easily at the hatchery as most strains of the Arbor Acres Broiler are feather sexable. In feather sexable broilers, fast-feathering chicks are female, slow-feathering chicks are male. The type of feathering is identified by observing the relationship between coverts (upper layer) and the primaries (lower layer) which are found on the outer half of the wing.

In the slow-feathering male chick the primaries are the same length or shorter than the coverts.

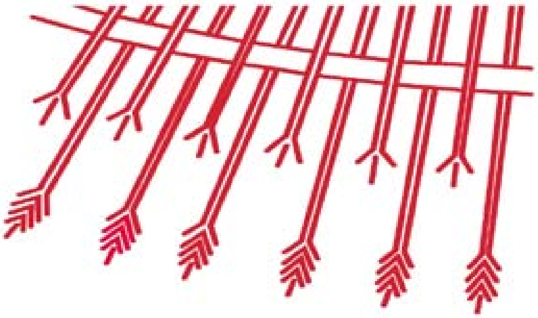
Arbor Acres Male Broiler Chick Wing Feathers





In the fast-feathering female chick the primaries are longer than the coverts.

Arbor Acres Female Broiler Chick Wing



Appendix 5. Classification of Months

Classification of Months with Regard to Northern and Southern Hemispheres

Northern Hemisphere

Winter	Spring	Summer	Autumn
December	March	June	September
January	April	July	October
February	May	August	November

Southern Hemisphere

Winter	Spring	Summer	Autumn
June	September	December	March
July	October	January	April
August	November	February	May

Appendix 6. Problem Solving

Problem	Possible causes	Action
High Early Mortality (>1% in first week)	Poor chick quality	Check hatchery practice and egg hygiene Check chick transport
	Incorrect brooding	Re-adjust brooders
	Disease	Post mortems on dead chicks, take veterinary advice
	Appetite	Measure and achieve target crop fill levels
High Mortality (post 7 days)	Metabolic diseases (ascites, sudden death syndrome)	Check ventilation rates Check feed formulation Avoid excessive early growth rates Check hatchery ventilation
	Infectious diseases	Establish cause (post mortem) Take veterinary advice on medication and vaccination Check water consumption
	Leg problems	Check calcium, phosphorus and vitamin D_3 levels in diet Use lighting programs to increase bird activity
Poor Early Growth and Uniformity	Nutrition	Check starter ration: availability and nutritional and physical quality Check water supply: availability and quality
	Chick quality	Check hatchery procedures: egg hygiene, storage, incubation conditions, hatch time, transport time and conditions
	Environmental conditions	Check temperature and humidity profiles Check daylength Check air quality: CO_2, dust, minimum ventilation rate
	Appetite	Check poor stimulation of appetite - low proportion of birds with full crops
Poor Late Growth and Uniformity	Low nutrient intake	Check feed nutritional and physical quality and formulation Check feed intake and accessibility Excessive early restriction Lighting program too restrictive
	Infectious disease	*See High Mortality*
	Environmental conditions	Check ventilation rates Check stocking density Check house temperatures Check water and feed availability

(table continued on next page)

Problem	Possible causes	Action
Poor Litter Quality	Nutrition	Poor quality fats in diet Excess salts in diet Excess protein in diet
	Environment	Insufficient litter depth at start Inappropriate litter material Drinker design and adjustment (spillage problems) Humidity too high Stocking density too high Insufficient ventilation
	Infectious disease	Causing enteritis, take veterinary advice
Poor Feed Conversion	Poor growth	*See Poor Early Growth, Poor Late Growth*
	High mortality (esp. late mortality)	*See High Mortality*
	Feed wastage	Check settings/adjustments of feeders Allow birds to clear feeders twice daily
	Environment	Check house temperature is not too low
	Infectious disease	*See High Mortality*
	Nutrition	Check feed formulation and quality
Poor Feather Cover	Environment	Check house temperature is not too high
	Nutrition	Check ration for methionine and cystine content and balance
Factory Downgrading	Ascites	*See High Mortality*
	Blisters and burns (e.g. Hock-burn)	Check stocking density Check litter quality Increase bird activity (e.g. feeding or lighting programs)
	Bruises and breaks	Check handling procedures at weighing and catching
	Scratching	Excessive light stimulation Check handling procedures at weighing and catching Check access to feed and water
	Oregon disease (deep muscular myopathy or green muscle disease)	Birds excessively disturbed during growth, e.g. at partial depletion (thinning), weighing etc. Poor feed distribution
	Excessive fatness	Check nutritional balance of diet Check house temperature not too high

Appendix 7. Ventilation Rates (per bird) and Calculations

Live Weight kg (lbs)	Minimum Ventilation Rate m^3/hour (ft^3/min)	Maximum Ventilation Rate m^3/hour (ft^3/min)
0.050 (0.110)	0.074 (0.044)	0.761 (0.448)
0.100 (0.220)	0.125 (0.074)	1.280 (0.754)
0.200 (0.441)	0.210 (0.124)	2.153 (1.268)
0.300 (0.661)	0.285 (0.168)	2.919 (1.719)
0.400 (0.882)	0.353 (0.208)	3.621 (2.133)
0.500 (1.102)	0.417 (0.246)	4.281 (2.522)
0.600 (1.323)	0.479 (0.282)	4.908 (2.891)
0.700 (1.543)	0.537 (0.316)	5.510 (3.245)
0.800 (1.764)	0.594 (0.350)	6.090 (3.587)
0.900 (1.984)	0.649 (0.382)	6.653 (3.919)
1.000 (2.205)	0.702 (0.413)	7.200 (4.241)
1.200 (2.646)	0.805 (0.474)	8.255 (4.862)
1.400 (3.086)	0.904 (0.532)	9.267 (5.458)
1.600 (3.527)	0.999 (0.588)	10.243 (6.033)
1.800 (3.968)	1.091 (0.643)	11.189 (6.590)
2.000 (4.409)	1.181 (0.696)	12.109 (7.132)
2.200 (4.850)	1.268 (0.747)	13.006 (7.661)
2.400 (5.291)	1.354 (0.798)	13.883 (8.177)
2.600 (5.732)	1.437 (0.846)	14.42 (8.683)
2.800 (6.173)	1.520 (0.895)	15.585 (9.180)
3.000 (6.614)	1.600 (0.942)	16.412 (9.667)
3.200 (7.055)	1.680 (0.990)	17.226 (10.146)
3.400 (7.496)	1.758 (1.035)	18.028 (10.618)
3.600 (7.937)	1.835 (1.081)	18.817 (11.083)
3.800 (8.377)	1.911 (1.126)	19.596 (11.542)
4.000 (8.818)	1.986 (1.170)	20.365 (11.995)
4.200 (9.259)	2.060 (1.213)	21.124 (12.442)
4.400 (9.700)	2.133 (1.256)	21.874 (12.884)

Notes:

For further explanation see Section 4: Housing and Environment.

Minimum ventilation rate is the quantity of air required per hour to supply sufficient oxygen to the birds and maintain air quality.

Maximum ventilation rate in controlled environment houses in temperate climates is the quantity of air required per hour to remove heat produced by the birds such that the temperature within the building is maintained at not greater than 3°C (5.4°F) above external temperature.

Maximum ventilation rates will be exceeded when cooling birds using convective heat loss, eg. tunnel ventilation.

Source: UK Agricultural Development and Advisory Service

Calculation for Minimum Ventilation Fan Timer Settings

To determine the interval fan timer settings for achieving minimum ventilation the following steps are employed:

- Obtain the appropriate minimum ventilation rate as recommended in Appendix 7. The exact rates will vary with breed, sex and for each individual poultry house. Check with the company of manufacture and local Aviagen Technical Services Representative for more specific information. The rates given in the Table opposite are for temperatures between -1 and 16°C (30–61°F); for lower temperatures a slightly lower rate may be required and for higher temperatures a slightly higher rate.
- Calculate the total ventilation rate required for the house (total cubic meters per hour (cmh), or total cubic feet per minute (cfm)) as:

Total minimum ventilation = Minimum ventilation rate per bird x Number of birds in the house

- Calculate the percentage time for running the fans as:

$$\textbf{Percentage of time} = \frac{\textbf{Total ventilation needed}}{\textbf{Total capacity of the fans used}}$$

- Multiply the percentage of time needed by the total fan timer cycle to give the time that the fans require to be on in each cycle.

Fan Timer Setting Calculation — Metric

Step 1: Calculate the total ventilation rate required for the house (total cubic meters per hour (cmh).

Total minimum ventilation	**=**	**Minimum ventilation rate per bird**	×	**Number of birds in the house**

Example: One house of 30,000 broilers weighing 800 g at 20 days of age.
Minimum ventilation rate is 0.594 cmh per bird (see Table on previous page).
Total ventilation required is 0.594 cmh × 30,000 birds = 17,820 cmh.

Step 2: Calculate the percentage time for running the fans.

Assuming fan combinations commonly used for minimum ventilation, e.g. three 91 cm fans each with a capacity of 16,978 cmh, the percentage of time fans need to run in order to achieve the total ventilation rate required needs to be calculated.

$$\textbf{Percentage of time} = \frac{\textbf{Total ventilation needed}}{\textbf{Total capacity of the fans used}}$$

Example: Assuming the use of three 91 cm fans each with a capacity of 16,978 cmh;
Total fan capacity = 16,978 cmh × 3 = 50,934 cmh
Percentage time = 17,820 cmh ÷ 50,934 cmh = 0.35 = 35%
Therefore, the three 91 cm fans will have to be run for 35% of the time.

Step 3: Assuming that a 5 minute timer is used, the run time setting is calculated by multiplying the percentage of time needed by the total fan timer cycle of 5 minutes (300 seconds).

Example: Using three 91 cm fans,
35% of 5 minutes (300 seconds) = 1.75 minutes or 105 seconds
The fans will be on for 105 seconds in every 5 minutes.

Fan Timer Setting Calculation — Imperial

Step 1: Calculate the total ventilation rate required for the house (total cubic feet per minute (cfm)).

Total minimum ventilation	**=**	**Minimum ventilation rate per bird**	×	**Number of birds in the house**

Example: One house of 30,000 broilers weighing 1.764 lb at 20 days of age.
Minimum ventilation rate is 0.350 cfm per bird (see Table on previous page).
Total ventilation required is 0.350 cfm × 30,000 birds = 10,500 cfm.

Step 2: Calculate the percentage time for running the fans.

Assuming fan combinations commonly used for minimum ventilation, e.g. three 36 inch fans each with a capacity of 10,000 cfm, the percentage of time fans need to run in order to achieve the total ventilation rate required needs to be calculated.

$$\textbf{Percentage of time} = \frac{\textbf{Total ventilation needed}}{\textbf{Total capacity of the fans used}}$$

Example: Assuming the use of three 36 inch fans each with a capacity of 10,000 cfm;
Total fan capacity = 10,000 cfm × 3 = 30,000 cfm
Percentage time = 10,500 cfm ÷ 30,000 cfm = 0.35 = 35%
Therefore, the three 36 inches fans will have to be run for 35% of the time.

Step 3: Assuming that a 5 minute timer is used, the run time setting is calculated by multiplying the percentage of time needed by the total fan timer cycle of 5 minutes (300 seconds).

Example: Using three 36 inch fans,
35% of 5 minutes (300 seconds) = 1.75 minutes or 105 seconds.
The fans will be on for 105 seconds in every 5 minutes.

Keyword Index

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