SOUTH AFRICAN POULTRY ASSOCIATION

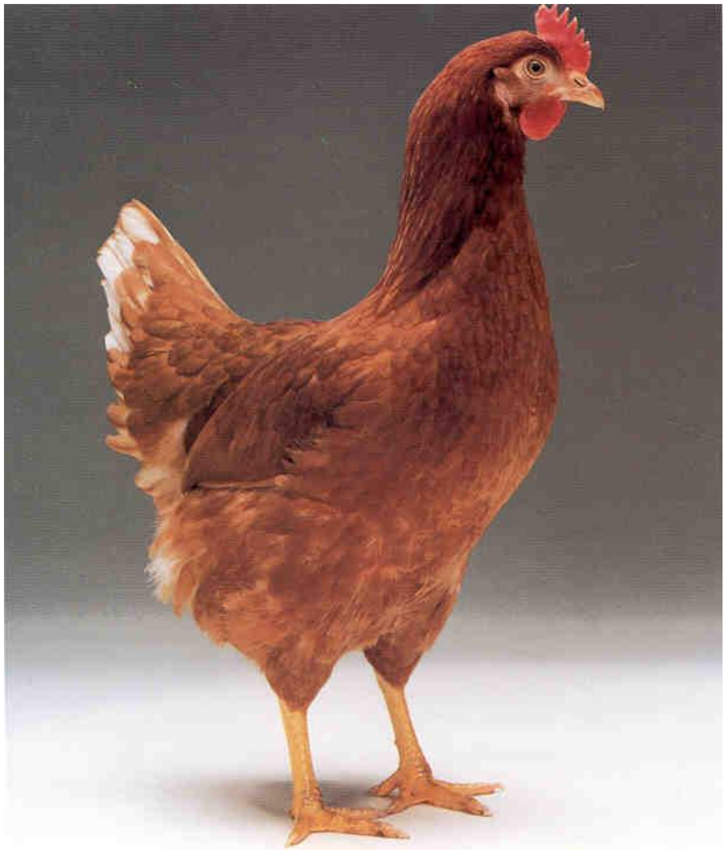
Founded 1904

Management of Commercial

Layers

in

Southern Africa



Compiled by Alan Saunders

Foreword

The layer industry has undergone phenomenal changes since the 1950's when commercialized layer farming in battery cages became a reality. The industry, in continual pursuit of improved efficiency, has demanded increased efficiency and breeding companies, the feed industry as well as equipment supply companies have all contributed significantly in the continued improvements in production efficiencies.

The modern egg layer has the genetic potential to produce in excess of 300 eggs per production cycle to 72 weeks of age. The aim of successful layer house management is to ensure that this genetic potential is achieved using as little feed as possible and ensuring eggs of the required grading and quality. This is only possible with a high level of management using good and well-maintained housing systems and equipment. A sound knowledge of equipment and systems and the functioning thereof is a prerequisite of good layer management.

Detailed knowledge of layer housing conditions, equipment, management techniques and the handling of some of the more common disease problems is essential for successful egg production.

This book shares my experiences and knowledge of management of commercial layers under Southern African conditions. It forms part of a series of books on poultry management and housing which are available from the address below.

The text should be read in conjunction with many breeder manuals available for specific breeds as well as equipment manuals specific to such equipment. This book is a guide to methods of housing and managing layers commercially and contains written text as well as photographic illustration. I am indebted to many equipment supply companies as well as day old chick supply companies and breeders who serve the local industry producer and who have assisted in supplying photos for this book.

Alan Saunders

Stellenbosch

Disclaimer

The author has made every effort to ensure the accuracy of the information herein. Appropriate information sources should be consulted, especially for new or unfamiliar procedures. The author cannot be held responsible for any typographical or other errors found in this application. Neither is any liability assumed for damages resulting from the use of information contained herein.

Developed and compiled by:

Alan Saunders

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1 Housing and Equipment

Modern poultry housing should create an environment in which the bird has the ability to express its full genetic potential. With minimum control, which is less costly to establish, the basic needs of the bird should be catered for. In more sophisticated control systems, control of the environment will be achieved more easily but the cost of establishing and maintaining such systems should be weighed up against the improved production efficiencies.

With pullet rearing the aim should be at providing the bird with a clean and hygienic environment in which temperature, condition of the air and light are as close as possible to what is required by the birds during the various stages of development. The bird needs to be given the opportunity to grow from day old to point of lay in accordance with the body weight standards and guides set by the supplier or breeder of the stock in question. The key points are to ensure that body weight development throughout the rearing period is within the guides provided for the particular breed with good flock uniformity at point of lay and that the birds have been well immunised and are disease free.

Layer cage systems have developed from rudimentary single bird cages equipped with a feed and water trough, to modern colony cages in which feed, water and egg collection is fully automated, requiring less labour to manage the birds but at the expense of large capital investment and maintenance cost. Welfare pressure has resulted in changes to the basic cage design and recent developments include supplying nest boxes, perches and a dust bath in cages. Alternate production systems have been developed in recent years especially in Western European countries. These systems have developed as a result of welfare concerns that have been raised against the keeping of layer hens in battery cages.

Whatever the housing or production system used, low cost systems should not compromised the production potential of the bird. Modern layer breeds are capable of very high levels of production and this will only be realised if the birds are housed and managed in such a manner that allows them to express this potential. In addition the welfare and health of the birds should not be compromised.

1.1 Farm Planning

1.1.1 Key Planning Points

The size of the farm and individual houses will depend on whether the complex forms part of a larger integrated commercial egg production and marketing operation or whether a smaller independent egg market is to be supplied. The size of individual sheds need to be planned in such a way that they are depopulated and re-stocked on an all-in, all-out replacement cycle. This is to ensure that the shed can be completely cleaned, the necessary maintenance after the long production cycle carried out and the facilities sanitised and prepared prior to placement of the next cycle of birds. Placement of birds on an all-in, all-out basis will furthermore ensure that specific light, vaccination and disease control programs could be followed for a particular flock.

Whilst smaller layer farms and complexes would be multi age, pullet rearing stock should preferably be reared in separate single age sites specially designed for the purpose of rearing birds from day old to point of lay. This will allow for the entire isolated site to be replaced on the basis of all-in, all-out to enable a sound biosecurity program and disease control.

Smaller egg production farms would normally purchase point of lay pullets from specialized pullet rearing farms, whilst larger operations will have their own pullet rearing farm supplying the layer operation. Large integrated companies will consist of chick production and even grandparent farms, pullet rearing as well as layer complexes.

In the case of a smaller, independent producer, the size of the individual flocks would tend to be smaller as this will result in less fluctuation in egg size and overall production that is required to supply the market when individual houses are depopulated and re-stocked. It should however also be kept in mind that the smaller the size of the shed the higher the original investment cost per bird capacity, especially when automated systems are to be considered.

If the farm is part of a larger integrated egg marketing business, the size of the individual houses may be larger as the total supply and market would tend to be larger and fluctuation caused by the cycling of individual sheds would be less.

Cash flow requirements to re-stock the building as well as the effect of having to dispose of a larger number of spent hens over a short period of time would need consideration.

Point of lay pullets should be transferred into the layer operation at least seven days prior to the onset of production. The age of the birds that are to be stocked would therefore depend on the light program followed (affects sexual maturity) and the breed of bird (certain breeds are earlier maturing than others) and will usually be between 17 and 18 weeks of age.

The age at depopulation the end of lay birds would depend on:

- The market requirements for egg size as egg size increases with age with more extra-large eggs being produced as the birds age
- Breed of bird as breeds have different egg size profiles as well as production persistency through the production cycle
- Egg quality, especially shell quality requirement as this deteriorates with flock age and breed differences exist as well
- Spent hen quality (feathering) requirement as this deteriorates as the flock ages
- The difference between the cost of point of lay and spent hens will also influence depopulation age. The bigger this difference the tendency would be to depopulate at an older age

The depopulation age could be anything between 70 and 85 weeks age and even older and a detailed economic evaluation for particular circumstances in which all the above factors are taken into consideration should be done.

Other key issues in the planning would include:

- The premises should be fenced off and the enclosed area kept clean and grass cut short
- The premises should be well drained to ensure that rain water runoff is adequate
- The premises and poultry buildings should be easily accessible to heavy vehicles (feed trucks, point of pullet vehicles, etc.)
- Access to the farm for all staff and visitors must be strictly controlled, preferably through showering but at least through change of clothing and footwear into the fenced off area. This especially so for rearing facilities
- Arrangements need to be made for adequate disposal of mortality. Mortality can be disposed of by using decomposing pits. On large complexes an incinerator or composting of dead birds may be considered
- Mortality decomposition pits should not be flooded with water through seepage or rain water flowing into the pit. Enzymes are available which are used to assist in the decomposing process and elimination of odours. In the end bone material is all that should remain in the pit. When full the concrete slab and dome could then be moved over another pit, covering the original pit with soil. These mortality pit covers allow for carcasses to be disposed of quickly, simply and hygienically. The cover should be placed on a concrete slab over the pit and the translucent fibreglass dome incorporates a fly trap/air vent, observation window and flap for inserting carcasses. Environmental consideration is however resulting in these pits no longer being favoured
- Consideration also needs to be given to the disposal of manure. Manure that has been removed from the poultry sheds should not be left on site but removed from the farm and spread onto fields as organic fertiliser as soon as possible
- In the case of multi age layer farms the buyers who collect the end of lay birds should never be allowed access to the farm unless the farm as a whole will be depopulated, cleaned and disinfected before re-stocking with birds
- Certain local municipal laws and by-laws would apply and an environmental impact assessment would be required in most instances

1.1.2 Farm Layout

1.1.2.1 Pullet Rearing Farm

The farm layout should be such that individual poultry sheds are well separated from one another (1.5 to 2.0 times the width of buildings) if two or more houses are placed on the same site. The length of the building should preferably be placed east to west (to reduce heat load through the sun shining on the walls) taking into consideration prevailing wind direction, especially in the case of natural ventilated houses. With controlled environmental houses this is less important.

The houses should also be placed in such a manner that vehicles have easy access to the sheds and preferably from outside of the site or house fenced area. Heavy vehicle traffic in the form of feed trucks should be accommodated in all weather conditions.

A number of sites may be placed on larger farms with the sites well separated from one another. The distance between sites remains debatable but in general a minimum distance of 700 to 1000 meter is considered sufficient. The site should be separate units with no direct contact between them and with ablution provided at each site.

Typical layout of a multiple site rearing farm with individual sites well separated from one another is shown in Figure 1.1 below and the layout of a single house site in Figure 1.2. This layout will have the advantage of each site being stocked and depleted on the basis of all-in, all-out with sound biosecurity measures being applied and good cleanout and rest between placements.

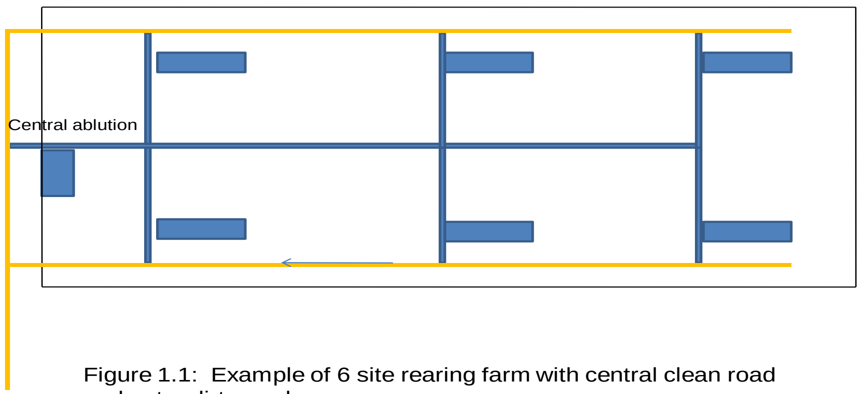

Figure 1.1: Example of 6 site rearing farm with central clean road and outer dirty road

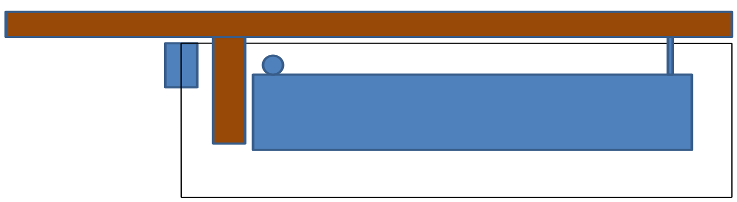

Figure 1.2: Example of single house rearing site with ablution and feed supply and manure removal from outside fenced area

1.1.2.2 Layer Farm

The farm layout should be such that poultry sheds are well separated from one another (as a rule 1.5 to 2.0 times the width of buildings) and with open sided buildings the length of the building should be east to west to reduce heat load and eliminate direct sunlight shining on the birds.

The houses should also be spaced in such manner that equipment and vehicles that remove the manure have access to the sheds or point of manure removal. Heavy vehicle traffic in the form of feed trucks, point of lay delivery vehicles and egg delivery trucks should be accommodated in all weather conditions.

Typical site layouts are illustrated in figures 1.3 and 1.4 below.

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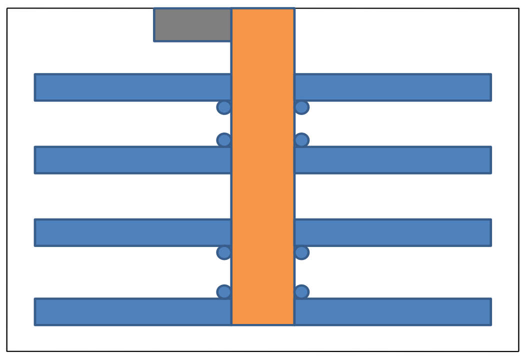


Figure 1.3: Typical small farm layout

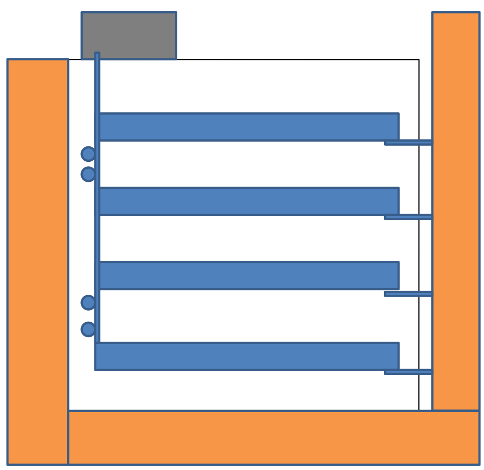


Figure 1.4: Typical large farm layout with inline egg collection and feed delivery on one side and manure removal on the opposite side

Where egg collection will be done by automated systems from the poultry sheds into a central egg packing facility, the poultry sheds should preferably be placed in line.

Any possible future expansion plans should also be considered.

Commercial layer farms will usually be multi-age with individual sheds being placed on an all-in, all-out replacement cycle. With larger operation it is possible to establish single age production farms which consist of three or four poultry sheds in which birds of more or less similar age are placed. The complete unit rather than individual houses is then depopulated and placed on an all-in, all-out basis and the larger sized farm could then have two or three units or sites situated 500 to 1000 meters from each other.

1.1.3 Supply Requirements

The main supply requirement would be the stock (chicks or point of lay birds) as well as feed and water. Other input requirement would include labour, power supply, source of heating in the case of rearing houses, vaccine supply and other minor items.

1.1.3.1 Rearing Farm

As a general rule, pullets will be transferred from rearing to the layer farm at 17 weeks of age. The potential pullet rearing capacity calculation for a rearing farm consisting of two houses each with a capacity of 11250 chicks is illustrated in Table 1.1 below.

Table 1.1: Rearing farm capacity calculations

Day old chick capacity per house	11250
Rearing houses	2
Depletion %	3.5
Point of lay birds per house	10856
Transfer age (weeks)	17
Downtime (weeks)	4
Cycle length (weeks)	21
Batches per year per house	2.48
Total batches per year	4.95
Day old chicks placed per cycle	22500
Day old chicks placed per year	55714
Point of lay pullets per year	53764

The feed requirement during the rearing phase would depend on various factors such as breed, housing system (cages or floor rearing), season, particular feed formulation, etc. As a rule the data presented in Table 1.2 could be used to calculate the feed supply requirement. Based on these calculations the rearing farm explained in Table 1.1 would require in the order of 312 ton of feed per year (53764 birds reared at 5.8 kg per birds = 311.8 ton)

Sufficient supply of clean cool water, suitable for human consumption should be available. Environmental temperature and age of the birds will affect the water consumption of commercial pullets and under normal temperature conditions the water consumption would be double the feed intake. On pullet rearing farms additional large quantities of water for washing down the poultry sheds would also require planning and the quantities required would obviously depend on the number and size of the individual sheds.

Table 1.2: Weekly and cumulative feed required for rearing commercial pullets

Week	Weekly Mortality %	Cum Mort %	Weekly Feed (g)	Cum Feed/Bird Reared (kg)
1	0.8	0.8	11	0.1
2	0.3	1.1	17	0.2
3	0.2	1.3	22	0.4
4	0.1	1.4	28	0.5
5	0.1	1.5	35	0.8
6	0.1	1.6	40	1.1
7	0.1	1.7	46	1.4
8	0.1	1.8	50	1.7
9	0.1	1.9	54	2.1
10	0.1	2.0	57	2.5
11	0.1	2.1	59	2.9
12	0.1	2.2	63	3.4
13	0.1	2.3	64	3.8
14	0.1	2.4	67	4.3
15	0.1	2.5	69	4.8
16	0.1	2.6	70	5.3
17	0.1	2.7	71	5.8
18	0.1	2.8	74	6.3

1.1.3.2 Layer Farm

A reliable supply of quality, disease free point of lay pullets from a reputable pullet rearing farm is essential. The numbers should fill the poultry shed in one batch and age of the birds within the flock should preferably not differ by more than a week. Supply requirements should therefore be arranged well in advance, normally on a yearly basis.

Layer farm capacity calculations to match the rearing farm calculations explained in Table 1.1 are set out in Table 1.2. The rearing farm consisting of two houses would therefore be able to supply sufficient point of lay pullets to a layer farm consisting of six houses, each with a capacity of 10856 birds if the placement age is 17 weeks, the depletion age is 75 weeks and a period of 5 weeks is allowed for cleaning, sanitation and preparation for the next batch of birds.

Table 1.2: Layer farm capacity calculations

Bird capacity per house	10856
Houses	6
Placement age (weeks)	17
Depletion age (weeks)	75
Production cycle (weeks)	58
Downtime (weeks)	5
Laying Cycle (weeks)	63
Batches per year	4.95
Pullets placed per cycle	65136
Pullets placed per year	53763

Quality feed from a reputable feed supplier is essential. The feed consumed by the birds would depend on the energy value of the feed, breed, age as well season and as a rule these should be taken into account when estimating the feed requirement. Layer birds consume in the order of 110 to 115 g per bird per day when kept in cage and between 120 and 125 g per bird per day when kept in floor systems. The weekly feed requirement to be planned for would be:

750 to 800 kg per 1000 birds per week for cage systems

850 to 875 kg per 1000 birds per week for floor systems

Sufficient supply of clean cool water, suitable for human consumption should be available. Environmental temperature will affect the water consumption of layers. Under normal temperature conditions the water consumption of layers is in the order of double the feed intake. The weekly water supply required is therefore calculated to be:

235 litre per 1000 birds per day or

1650 litre per 1000 birds per week

These rates will depend to a large extent on environmental temperature conditions and on extreme hot days water intake could increase to above 300 litres per 1000 birds. Water storage capacity would depend on the reliability of the supply but at least 3 to 4 days should be provided for and supply pipes should be buried at least 500 mm underground. On layer farms the need for large quantities of water required for washing should be considered, the quantities of which would depend on the number and size of the poultry houses.

Water quality requirement for layers is similar to that of rearing shown above.

1.2 Environmental Control

Heat within the poultry building originates from heat generated by the birds as well as heat entering the building through the roof and walls. During conditions where environmental temperature exceeds the temperature comfort zone of the birds, management of the environment must ensure that the heat generated in the building is removed. This is achieved by ventilation as well as the use of evaporative cooling systems.

During conditions where environmental temperatures are low, heat produced by the birds should be preserved and used to maintain house temperatures within the temperature comfort limits of the stock involved. During the first three to four weeks, supplementary heat is to be provided as chicks are unable to maintain body temperature. With older pullets and adult layers, especially when the house is reasonably insulated, the heat generated by the birds will assist to maintain house temperature close to the required norm. Under these conditions, a minimum amount of ventilation should be applied to ensure sufficient removal of moisture and metabolic gases such as ammonia and carbon dioxide and to ensure sufficient supply of oxygen. When the building is poorly insulated, heat loss will be excessive and the desired temperature will not be maintained under low outside temperature conditions.

Illumination (lights) of the building also forms part of environmental control and this is of special importance in commercial egg layers.

1.2.1 Environmental Temperature

1.2.1.1 Temperature Requirement

The environmental temperature within the building should preferably be maintained within the ranges as suggested in Table 1.3. At temperature conditions within these norms, the birds will be able to maintain body temperature without having to apply mechanisms to increase heat loss or body heat production when temperatures are above or below the norm. This is commonly referred to as the thermo neutral temperature zone of the birds. During the first three to four weeks this is of special importance as chicks are unable to adjust metabolic processes to maintain body temperature. Body temperature of chicks will soon increase or decrease if environmental temperature is outside of these ranges.

The temperatures in Table 1.3 are to be used as a guide only and chick and bird behaviour would influence finer setting.

Table 1.3: Brooding and House Temperature Requirement

Age	Whole house brooding (°C)	Spot Brooding 2 m from Brooder (°C)
Initial two to three days	31 to 32	32 to 34
3 to 7 days	30 to 31	31 to 32
8 to 21 days	28 to 30	29 to 31
21 to 28 days	25 to 28	25 to 28
29 to 35 days	22 to 25	22 to 25

36 days and older	20 to 25	20 to 25

If the environmental temperature is below or above the ideal range, especially when such temperature prevails for a long period of time, the performance and production efficiencies of birds will be affected adversely.

1.2.1.2 Effect of Low Temperature

For the first two to three weeks, chicks have difficulty controlling body temperature and during the first couple of days in fact react similarly to cold blooded animals. They just become colder and cannot adjust body temperature. Conditions that ensure cloacae temperature of 40 to 40.8°C are essential to avoid chilling of chicks. A large percentage of starve outs (non-starters) will be seen in a flock in which the chicks have been chilled. Smaller chicks originating from young parent stock are even more susceptible to cold stress.

In older pullets and adult birds, low environmental temperature would lead to increased metabolic activity which is aimed at maintaining body temperature. This results in an increase in feed intake with a consequent deterioration in feed efficiency.

Although various other factors such as energy value, rate of production, egg size, etc., will influence feed intake as well, as a rule for every °C change in temperature below the norm of 20°C, the feed consumption will change by approximately 1.5%.

1.2.1.3 Effect of High Temperature

High temperatures in chicks will soon result in heat stress as they are unable to adjust metabolic rate in order to maintain body temperature. They will become lethargic and dehydrated resulting in reduced feed intake, consequent reduction in growth rate, increased starve-outs and mortality. For the first two to three weeks, the environmental temperature for chicks has to be maintained within very narrow limits.

At temperatures above the thermo neutral zone, mechanisms are brought into effect to rid the older pullet and adult hen of increased body heat and the need for increased body heat loss through sensible heat loss increases. Higher temperature would therefore call for higher rates of ventilation for the birds to dispose of the increased heat load through convection (air movement over especially face, comb and wattle surfaces). Should temperature increase even further, heat loss through evaporation of moisture from the epithelial of the respiratory tract (latent heat loss through panting) increases and under these conditions the supply of fresh cool water as well as adequate ventilation are important. Older birds are therefore able to compensate to some degree to environmental temperatures above the norm, but this does have consequences which mainly impacts on reduced feed intake and consequent reduce growth, resulting in underweight pullets at point of lay and poor production and egg weight in commercial layers.

A further consequence of high temperatures in commercial layers is that high environmental temperature has a depressing effect on shell quality. At temperatures above 35°C shell thickness becomes significantly poorer.

Even though it is common practice to offset the lower feed consumption by feeding higher concentrations of calcium (also in a more coarse form) during summer, eggshell thickness will generally decrease during periods of high environmental temperature. The reason for this is that panting reduces the ability of blood to carry calcium that is needed for eggshell formation. This is due to blood acid/base imbalances resulting from the continued process of panting. The use of sodium bicarbonate to replace part of the normal salt in the ration has been proven to reduce this problem. Poor shell quality, especially in high production older flocks, however remains a major problem in conditions where house temperature cannot be maintained below 30°C during summer.

1.2.2 Moisture in Poultry Sheds

Control of the moisture content of the air within buildings is important in poultry buildings because it affects litter quality and overall environmental conditions within the building. The birds are kept in the houses for long periods (17 weeks in the case of pullets and in excess of a year in the case of commercial layers) and once manure has become wet and not allowed to dry, the tendency for undesirable high ammonia levels will increase.

In addition, a very dry environment could lead to drying of the epithelial tissue of the respiratory track which in turn could result in the birds being more susceptible to disease challenges.

At very high temperatures birds will also find it difficult to dispose of body heat through the process of evaporation of moisture from the epithelial tissue of the respiratory tract when panting.

1.2.2.1 Moisture Production

Moisture production in building housing pullets and layers is influenced by various factors including:

- Excessive levels of dietary salt causes increased water intake and increased kidney activity to remove the sodium from the body, resulting in wet litter conditions
- Increased energy content of the diet increases water consumption and results in faeces with higher moisture content
- Pelleted feed produces droppings with higher water content compared to mash feed
- Impurities in water could result in increased activity of the kidneys to rid the body of such impurities
- High environmental temperature increases water consumption

- Layers have the tendency to produce wet droppings at the onset of production
- Some breeds have the tendency towards wet droppings compared to others

1.2.2.2 Effect of Temperature on Humidity

Hot air can hold more moisture than cold air and the water produced by the birds can be taken up more readily by warm air in the building. Insulating poultry sheds will therefore indirectly influence the moisture content and litter conditions within the building. Maintaining the inside temperature at higher levels during winter will assist in keeping the shed not only warmer but the manure will also be drier.

It is important to understand the concepts of psychrometric science to get to grips with the concepts of controlling the moisture content of the environment. These concepts are used to illustrate the relationship between dry bulb temperature, wet bulb temperature, relative humidity and moisture and heat content of air. By viewing the Psychrometric Chart in Figure 1.5 more closely it will be seen that at 15°C and 65% relative humidity (wet bulb temperature of ±12°C) the air contains approximately 7g of water per kg dry air. If the air temperature is increased to ±22°C at the same amount of moisture (7g/kg), the RH drops to close to 40%. In order to get back to 70% RH the water content of the air has to increase to 12g/kg dry air (almost double). The warmer air is therefore able to "hold" more moisture at the same RH. Cold house temperatures will therefore not induce absorption of moisture from the manure, creating wet and unpleasant conditions in the building.

1.2.2.3 Wet litter

Excessive wet manure in commercial layer houses is conducive to excessive levels of ammonia which is not only harmful as such but any respiratory disease will be exacerbated by high level of ammonia. Manure consists of undigested biodegradable materials and over time natural fly larvae predators will occur in the manure as well. Under normal conditions decomposition will occur and depending on the humidity and density of the litter, the decomposition could be anaerobic or aerobic.

The minimum air exchange rates should therefore not only supply sufficient levels of oxygen and remove sufficient levels of carbon dioxide from the building, but should also be sufficient to maintain dry manure conditions through the removal of sufficient amount of moisture from the building, especially from the manure. Further control rests with the ability to keep the manure as dry as possible through elimination of water spillage.

1.2.2.4 Anaerobic decomposition of manure

Anaerobic decomposition of litter (oxygen deficient) is to be avoided as the by-products from this form of decomposition include harmful gases such as ammonia and methane. This form of decomposition is more prevalent when the manure is compact and wet.

1.2.2.5 Aerobic decomposition of litter

This form of litter decomposition supports the growth of bacteria and other natural predators of fly larvae. By-products from this form of decomposition will include carbon dioxide, water and nitrates but not ammonia. This form of decomposition will be more prevalent under conditions where the manure is relatively dry and well aerated.

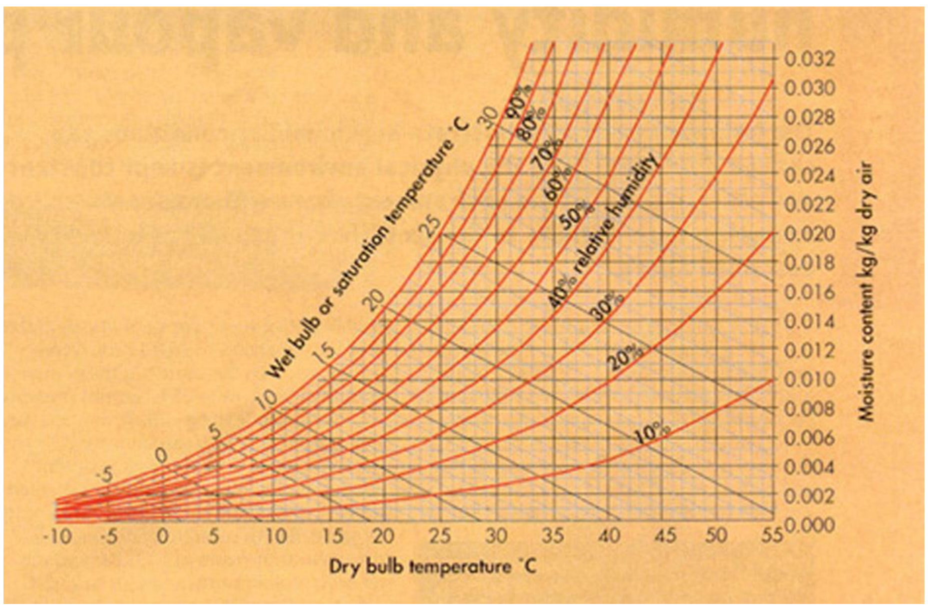
1.2.2.6 Psychrometrics of Air

The Psychrometric Chart can be used to explain the psychometrics of air. It illustrates the relationship of dry bulb temperature, wet bulb temperature, relative humidity and specific humidity.

The **specific humidity** differs from the relative humidity of the air in that it is the amount of water vapour, by weight, in the air. Specific humidity, represented as vertical lines on the chart is normally given in gram (g) of moisture per kilogram (kg) of air and read on right hand scale of the diagram.

The **dry bulb temperature** of the air is the air temperature determined by an ordinary thermometer. On the psychrometric chart the dry bulb temperature scale is located on the bottom horizontal line. The vertical lines on the diagram indicate the same dry bulb temperature.

Figure 1.3: A normal Psychrometric Chart



In managing layers it is essential to record the daily house dry-bulb temperature as well as the outside environmental dry-bulb temperature in the shade. Thermometers which record the maximum as well as the minimum temperature within the period of the instrument being "zeroed" are ideal. In the shed, the thermometer should be suspended at the probe controlling the ventilation in fan ventilated houses. In open type houses it is equally important to record house dry bulb temperature on a daily basis as this will provide information on the success of adjusting the curtains (air inlets) and the ability to maintain temperature within the temperature comfort zone of the birds.

Two or three thermometers placed at various points will provide information on temperature differences within the building.

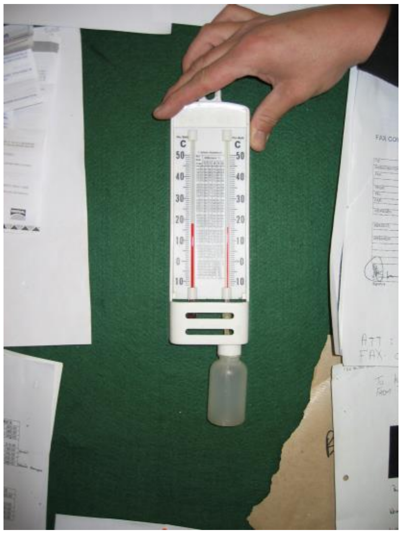
The **wet bulb temperature** would provide indication of the extent to which water is evaporating to the environment. Wet bulb temperature can be determined by passing air over a thermometer that has been wrapped with a small piece of moist cloth. The cooling effect of the evaporating water causes a lower temperature compared to the dry bulb air temperature. In the psychrometric chart the wet bulb temperature scale is located along the top most curved line and the diagonally sloping lines from the upper left-hand side to the bottom and the right hand side of the chart indicate equal wet bulb temperatures.

Wet bulb temperature can never be higher than dry bulb temperature and if equal to dry bulb temperature, the air is saturated with moisture. The point of 100% saturation is the dew point temperature scale.

Relative humidity is a measure of how much moisture is present in the air compared to how much moisture the air could hold at the specific dry bulb temperature. Relative humidity is expressed as a percentage (%) value. Lines presenting conditions of equal relative humidity sweep from the lower left to the upper right of the psychrometric chart. The 100% relative humidity (saturation) line corresponds to the wet bulb scale line. At this point the dry and wet bulb temperatures are the same. The line for zero percent relative humidity (air contains no moisture at all) falls along the dry bulb temperature scale line.

Thermometers with a dry bulb as well as wet bulb readings are available from which the RH may be read directly. Electronic thermometers that measure these traits in the air are also available. Whilst adult birds will be able to cope with a wide range in relative humidity, very low levels (<20%) as well as very high levels (>80%) should be avoided. Humidity levels above 80%, especially at high temperature and poor ventilation is potentially dangerous as the birds will not be able to dispose of adequate amount of body heat through latent heat loss via the respiratory tract.

Low humidity levels will tend to create very dry and dusty conditions, which will adversely affect the respiratory tract, especially when respiratory disorders are present.



Instruments foe measuring temperature and humidity

1.2.3 Gasses in the Air

Several gases are found in poultry sheds some of which are required at minimum levels (oxygen) and others which will result in reduced performance or even death at high concentrations. Under conditions of low ambient temperatures when the required rate of ventilation is minimal it is important to consider the possible build up of toxic gases or insufficient supply of oxygen.

Minimum and maximum tolerated gas composition of air is illustrated in Table 1.4.

Table 1.4: Tolerance of Gasses in Air

Gas	Outside air	Inside air
Oxygen (O_2)	21% by vol	Min 15% by vol
Ammonia (NH_3)		25 ppm
Carbon dioxide (CO_2)	300 ppm	2500 ppm
Carbon monoxide (CO)		40 ppm

Ammonia is produced as a by-product in the anaerobic decomposition of litter. The symptoms of extreme concentrations of ammonia are a nauseating smell to the caretaker and irritation of the eyes. Although adult layers may tolerate higher levels of ammonia as compared to for example broilers, high levels of this gas should be avoided.

Levels of ammonia should be less that 10 parts per million by volume. Levels of 10 to 20 ppm will not be harmful, provided the period during which birds are exposed to these levels are short (for example a couple of hours during early morning). Above 20 ppm production efficiency will be affected, especially when birds are subjected to such concentrations for extended periods of time.

1.2.4 Ventilation

1.2.4.1 Minimum Ventilation

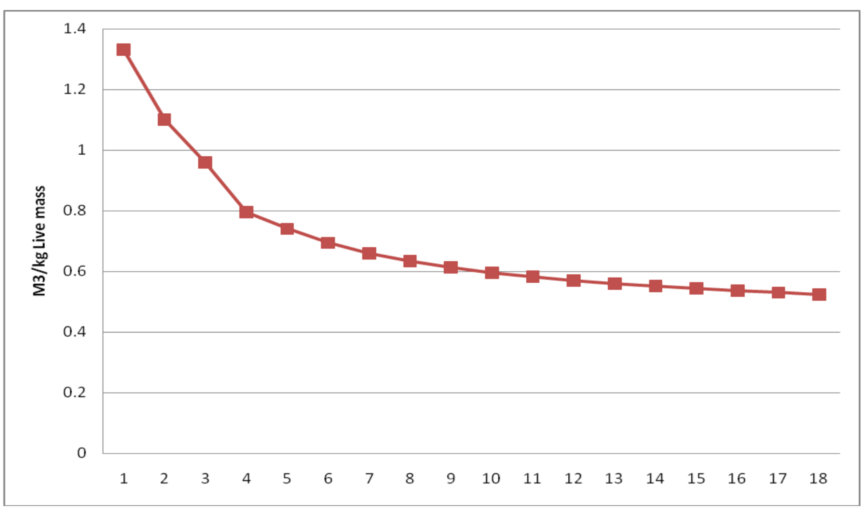
The minimum ventilation required is calculated by using the following formula suggested by Agriculture Development and Advisory Service (ADAS) in the United Kingdom.

$$V \min (m^3/sec/bird) = (1.6 \times 10^{-4} \times ALW^{0.75})$$

ALW = average live weight in kg

The formula is used to calculate the minimum ventilation rate required for growing stock provided the weight for age is known. By using the weight for age, this data can be used to calculate the minimum ventilation requirement of growing birds from day old to point of lay. By doing this, much guesswork is taken out of knowing how to set the minimum ventilation. It should be noted that when using this formula the ventilation requirement expressed as cub meter per kg live weight is higher at the beginning compared to towards the end of the growing period (See Figure 1.6 below). This is logical as the relative gain in weight during the initial stages (hence metabolic processes) is higher compared to towards the end. The above is applicable under normal conditions of temperature and humidity and should be applied irrespective of the extent to which the temperature is below the required range.

Figure 1.6: Minimum ventilation requirement of growing pullets



For a 30000 capacity pullet rearing shed at day old when chick weight is in the order of 35 g, the biomass in the building would be 1050 kg (35 x 30000 = 1050 kg). The required minimum ventilation read from Figure 1.6 in the first week is 1.35 m^3/kg/hour so the building would require to be ventilated at a rate of 1050 x 1.35 = 1400 m^3/hour.

Should the minimum ventilation fan installed on the cycle timer has a rated capacity of say 14000 m^3/hour, this fan would need to run for a period of 30 seconds in 300 seconds to supply the required amount of minimum ventilation (1400 is 10% of 14000 and 30 seconds in 300 is 10%). Should the minimum ventilation fan installed be variable speed, the fan speed selected would be reduced to the point where the air supply is 1400 m^3/hour.

By 4 weeks of age the birds in the 30000 capacity shed should have an average mass of 270 g and the biomass in the building would be 8100 kg (270 x 30000 = 8100 kg). At 4 weeks the required rate of minimum ventilation for growing pullets is 0.8 m^3/kg/hour (read from Figure 1.6) so the building would then require a minimum ventilation of 8100 x 0.8 = 6480 m^3/hour. At this point the cycle timer controlling the minimum ventilation fan would be adjusted to run for 140 seconds in 300 seconds since 6480 is 46% of 14000 and the fan therefore has to run for 46% of the time which is 140 seconds in 300. Alternately the speed control fan would be adjusted to ventilate at a rate of 6480 m^3/hour.

A table based on the above example calculations would then be set up for particular circumstance and age of the flock and placed at the control panel in the building to ensure that the minimum quantity of air supply is being achieved throughout the rearing period and in so doing all guesswork is eliminated.

For commercial layers weighing 2.0 kg this formula will equate to 0.96 m^3/bird/hour or 0.48 m^3/hour/ kg live body mass.

The minimum ventilation to be supplied in a 40000 bird capacity building would therefore be 38400 m^3 per hour (40000 x 0.96 = 38400). If the fan capacity is in the order of 36000 m^3 per hour then two fans operating at around 53% of the time or 160 seconds in a cycle time of 300 seconds. Or variable speed could be used to ventilate this calculated volume of air.

1.2.4.2 Supply of Minimum Ventilation

Minimum ventilation would be supplied under conditions when the environmental temperature is low and the air entering the building would be low. The cold minimum ventilation should therefore be introduced over the entire building as evenly as possible and directed away from the birds.

In mechanical ventilated buildings this is achieved by speed control of fans or step control where certain minimum fans are operated intermittently as explained above. When using conventional side inlets together with negative pressure fans, the inlets should be adjusted to such an extent that a negative pressure is maintained to ensure that air speed at the inlets is in the region of 250 to 300 m/min.

A plastic tube with holes (commonly referred to as a fan jet with a positive pressure fan and air intake system from outside (louver) is often used to distribute fresh air as well as circulate and mix air within the building when fresh air intake is closed. The louver opens on a timer system calculated on the fresh air requirement and a negative pressure exhaust fan extracts stale air when the louver opens. The system is often used to distribute hot air from a heat exchanger. The system has the negative of being difficult to clean but function very well. In layer cage systems especially much dust will accumulate in the plastic tube over the laying cycle.

Fan Jet on the left and side air inlet on the right

In open sided buildings the stack effect of ventilation is used to achieve a minimum rate of air movement if there is an opening in the ridge of the roof. Hot air will rise and is replaced by colder air moving in (also called the chimney effect).

In open sided houses this is achieved by opening inlets low down in the side walls and allowing the increase in air temperature to effect the movement of warm air to the top and out through outlets in the roof.

The stack effect is very appropriate in double storied buildings commonly referred to as high rise buildings. These buildings are relatively high and this assists in achieving a good chimney effect.

1.2.4.3 Maximum Ventilation

Once temperatures exceed the required temperature within the building, increasing amount of ventilation needs to be applied to remove the heat build up in the building. Various formulae may be found in the literature by which the ventilation requirement is calculated. Under conditions of reasonably well insulated buildings the suggested formula of the Agriculture Development and Advisory Service (ADAS) in the United Kingdom may be used for calculating the maximum ventilation under extreme hot conditions that prevail in South Africa.

$$V\ max\ (m^3/sec/bird) = (2.0 \times 10^{-3} \times ALW^{0.75})$$

ALW = average live weight in kg

Using the above formula for pullets being reared the maximum ventilation required would be 6.0 m^3 per kg live mass per hour. For a pullet rearing houses the 18 week old weight will be used to calculate the maximum ventilation required as these weights will be the maximum that will apply in the building. Therefore if the birds weigh 1500 g on average the maximum amount of ventilation required would be 9 m^3 per bird per hour to maintain the average temperature of a reasonably well insulated building at not more than 3°C above prevailing outside temperature. A building equipped to house 30000 pullets at 18 weeks of age will therefore require 8 fans with a rated capacity of 36000 m^3/hour (30000 x 9 = 27000 ÷ 36000 = 7.5 or then 8 fans).

For commercial layers weighing 2.0 kg this formula equates to 12.0 m^3/bird per hour or 6 m^3/kg live body mass per hour.

In mechanical ventilated buildings this will be achieved by the installation of sufficient number of fans. For a 40000 bird capacity building the amount of ventilation required would be 480,000 m^3 per hour (30000 x 2 kg x 6 m^3/hour = 360000). If the rated fan capacity is in the order of 36000 m^3 per hour the number of fans required to be installed would be 13.3 or then 14 fans.

In open sided buildings maximum ventilation is achieved by control of side inlets and allowing the wind pressure effect to ventilate the building. There is obviously less control as natural wind conditions will determine the ventilation rate.

1.2.4.4 Intermediate Ventilation

Between the required minimum and maximum ventilation, different rates of ventilation would be required, depending on temperature difference between inside and outside the building in order to find the balance between the amount of heat to be removed and maintain the desired temperature conditions inside the building.

In mechanical ventilated buildings, the amount of intermediate ventilation is obtained by means of a step control system or variable speed fans. By step control, the fans will be controlled by a thermostat and a controller which will operate increasing numbers of fans from the minimum rate, in steps, until all fans are operating at maximum. This method of control is used when use is made of 3 phase electrically driven fans with no speed control and some fans linked to a cycle timer to control the minimum as explained above. The temperature differential between steps would be in the order of 0.5 to 1.0 °C.

With single-phase fans, speed control is possible and fans are then operated at variable speeds to obtain the desired rate of ventilation between the minimum and maximum rates.

In open sided buildings intermediate ventilation is achieved by increasing or decreasing the side wall opening, depending on wind and temperature conditions.

1.2.4.5 Wind Chill

Under conditions of high environmental temperature it is advantageous to use the wind chill factor of air moving over the birds to assist in maintaining a more comfortable sensible heat albeit that house temperatures are high. The effect of air moving over birds and the effect on the sensible heat felt by the birds at an environmental temperature of 30°C is illustrated in Table 1.5.

Table 1.5: Effect of airspeed on sensible heat of birds at temperature of 30°C

Air Speed (m/sec)	1 week old °C	4 weeks old °C	Adult birds °C
0.5	-2.2	-1.1	-0.5
1.0	-6.6	-3.8	-2.2
1.5	-12.2	-7.7	-4.4
2.0		-11.1	-12.7

From: Poultry World Volume 15 No 11, 99

Table 1.5 would indicate that at an air temperature of 30°C the effective temperature for the birds would be in the order of 20°C if the air speed is in the order of 2 m per second. A temperature of 30°C is above the comfort zone whilst 20°C is within the comfort zone of the birds.

On the other hand, if air temperature in the building is 20°C (winter condition) and air speed over the birds is in the order of 1.5 to 2.0 m per second, the effective temperature for the birds would be as low as 10 to 15°C (or even greater as the wind chill effect is larger at lower temperature).

The age of the stock and temperature conditions should also be considered. Table 1.5 would indicate that wind chill has a greater effect on young stock. Young stock and chicks especially are very susceptible to wind chill and should never be subjected to high air velocity.

At colder temperatures the wind chill effect would be higher and the closer the environmental temperature is to body temperature the lower the effect.

Hence in forced ventilation systems, tunnel ventilation is the preferred system for high temperature conditions and cross ventilation the preferred system for low temperature conditions and for the rearing of chicks. The reason being that with cross ventilation the area over which a given amount of air is moved is greater compared to when air is move down the length of the building in longitudinal or tunnel ventilation. The effective air speed over the birds is therefore lower when ventilating across the building compared to when ventilating longitudinally.

Modern systems would incorporate a combination system where cross ventilation is applied during cold weather conditions and rearing of chicks and longitudinal ventilation is applied during hot weather conditions and more adult stock.

In open sided buildings equipped with layer cages, wind chill is achieved by hanging fans approximately 20 to 25 meters apart down the passages at a slight angle which will then create air movement down the passage and over the birds.

Air circulating fans installed in cage system to achieve wind chill

1.2.5 Cooling Systems

In relatively dry climates cooling of air through evaporation of water (adiabatic cooling) is an inexpensive yet effective way to reduce temperature in poultry sheds. Effective cooling systems will reduce the air temperature to within 85% of the difference between dry and wet bulb temperature.

The systems have limited use in areas where the relative humidity is high during high temperature conditions. The evaporation of water increases the relative humidity even higher and conditions may be reached where the relative humidity reaches high and dangerous levels. At high temperature and relative humidity, birds are unable to dispose of body heat through latent heat loss (evaporation of moisture from the respiratory tract) as the air already contains high levels of water vapour.

Various systems are available in which evaporation of water is used to reduce temperatures in poultry sheds and they consist mainly of wet pad systems and high pressure fogging systems.

1.2.5.1 High Pressure Fogging

In high pressure fogging systems water is turned into a fine mist through a high pressure pump and nozzle system and the fine mist is sprayed into the building which is then able to absorb heat (convert sensible heat into latent heat) thereby reducing the dry bulb temperature (sensible heat).

Micro-mist cooling system

These systems are especially popular in open sided layer houses as no forced ventilation is required for effective application. Dripping nozzles should be avoided as much as possible as this could lead to wet conditions on the floor as well as manure.

1.2.5.2 Wet Pad Systems

In these systems air is drawn over wet perforated pads where the water evaporates and these systems are therefore used in negative pressure ventilated sheds.

Water is pumped form a sump into a trough above the pad from where it flows through the pad. Surplus water is returned to the sump via a trough situated at the bottom of the pad. The water which evaporates into the air is replenished by fresh water supply into the sump.

An air speed through the pad of 100 to 120 m/min is generally recommended for adequate evaporation of water.

1.2.6 Illumination

Light intensity, the length of the daily light period (photoperiod) and the pattern of daily change, produce biological responses associated with sexual maturity and egg production in laying hens. These responses are as a result of the effect of light on the activity of the anterior lobe of the pituitary gland, located at the base of the brain and the production of hormones that in turn affect the development and production of hormones in the reproductive systems of the birds.

1.2.6.1 Light and Hormone production

Photoreceptors in the hypothalamus are the biological transducers that convert electromagnetic signals received from the eye into a hormonal message through their effect on the hypothalamic neurons that secrete Gonadotrophin Releasing Hormone (GnRH). GnRH is secreted into the hypothalamic portal system and transported to the pituitary gonadotropes of the pituitary gland.

The gonadotropes respond to this stimulation by producing Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH) in both males and females. These hormones are secreted into the blood circulatory system and in turn they activate the ovaries in the female to produce the female hormones androgen, estrogen and progesterone while in the male they stimulate the testes to produce the male hormones androgen and testosterone.

1.2.6.2 Photoperiod and Sexual maturity

Light programs are important tools in the management of commercial layers as they are used to control the sexual maturity and hence the age at onset of production. Age at sexual maturity could be measured as age at first egg or the age at say 10 or 50% production.

Age at sexual maturity is influenced by:

- The photoperiod as well as the changes in photoperiod to which the birds have been subjected to during rearing.
- Some breeds and genotypes are later (or earlier) maturing than others
- Within a genotype or flock, lighter birds will be delayed in maturity

1.2.6.3 Effect of Photoperiod during Rearing on Sexual Maturity

Much research has been conducted on the effects of various light programs on poultry and breeders and suppliers of stock have developed programs and recipes to suite particular circumstances. No single program can be prescribed for all circumstances as the ideal age of sexual maturity may differ as a result of the effect on overall production and egg weight.

Constant photoperiod during rearing

Research has shown that there is a negative correlation between age at first egg and constant hours light if the constant photoperiod is less than 10 hours. Pullets maintained at a constant photoperiod of 10 hours or less from an early age will show an advance in age at first egg (delayed maturity) of about 2 days for each hour that the photoperiod is less than 10 hours.

Above 10 hours the correlation is positive but weak. For every two hours added to 10 hours there will be a delay of one day in the age at sexual maturity.

Consequently the earliest maturity for a light program in which a constant photoperiod is applied, is achieved on a constant 10 hour photoperiod.

Decreasing photoperiod during rearing

Research has also shown that a declining photoperiod during the first part of rearing (prior to 6 weeks) will delay maturity but an increase in photoperiod prior to 6 week will not enhance maturity significantly. A gradual decline in photoperiod has a more pronounced affect (delay) compared to a single decline. The longer the declining period (that is over age), the more delay in sexual maturity will be achieved.

In practice this would mean that with a constant rearing photoperiod of say 8 hours, a more gradual decline in photoperiod to the 8 hours where the 8 hour constant photoperiod is reached at 8 weeks of age, will delay sexual maturity more compared to a more rapid decline where the 8 hour photoperiod is reached at say 3 weeks of age. If the decline occurs over an extended period to 10 weeks, the delay in maturity will be more.

Increasing photoperiod during rearing

Research has furthermore shown that the effect of increased photoperiod depends on the size of the change, the age at which it is given and the initial and final photoperiod. The largest enhancement in sexual maturity for pullets reared at a constant photoperiod of 8 to 10 hours is achieved by increasing the photoperiod to between 13 and 17 hours. Increases above this will not enhance maturity any more. The effect of an increase of 5 hours in photoperiod from 8 to 13 hours is more pronounced compared to a five hour increase from 13 to 18 hours.

Increase in photoperiod prior to 6 weeks has very little effect on maturity. Between 6 and 12 weeks there is a progressive increase in the number of birds susceptible to photoperiod.

Pullets are most responsive to increased photoperiod between the age of 12 weeks and the natural maturity age which is 18 to 20 weeks in most layer strains. However the response is reduced as the age at which the increase is given approaches the natural maturation age.

1.2.6.4 Effect of Sexual Maturity on Egg Production

Early sexual maturity may result in increased egg numbers per hen housed over a given period of production due to the onset of production. The initial egg size will however be lower due to smaller eggs being produced at the earlier age. If the body mass at onset of production is not corrected, higher rates of mortality and poor peak production could result in an overall reduction in production over the laying period. On the other hand should sexual maturity be delayed excessively, initial egg size will be increased but hen housed production will suffer as a result of production time being lost.

Specific programs are developed for particular circumstances and most modern pullet rearing houses are designed in such a manner that natural day light is excluded from the building in order to obtain a dark house. Light programs may then be developed which will result in natural seasonal changes in photoperiod having limited effect on sexual maturity.

1.2.6.5 Effect of Sexual Maturity on Egg Weight

Both photoperiod and feed restriction applied during rearing may be used to change the age of sexual maturity.

When sexual maturity is delayed by photoperiod the egg weight for age will be increased and this increase in egg weight for age will remain throughout the life of the flock. However if maturity is delayed by feed restriction, egg weight for age will not be altered but the initial eggs produced will be larger due to the delay in maturity (age of the bird).

1.2.6.6 Ovulation and Photoperiod

Ovulation is influenced by daybreak and by the change in day length. Most eggs in a conventional 24-hour day-night cycle are laid during the daylight period. Under total artificial light conditions, artificial light provided during normal night hours will result in birds laying during these hours.

The time from ovulation to the egg being laid takes just over 24 hours in most breeds. Eggs are therefore deposited slightly later every day and ovulation is also then retarded. Over a matter of time eggs will start to be produced in the night and as this does not happen, ovulation will skip a day. With modern breeds the time that it takes for the egg to pass through the oviduct is very close to 24 hours and consequently modern egg layers are capable of producing an egg a day for very long period.

1.2.6.7 Light Intensity

Light intensity is measured in foot-candles or lux. One foot-candle = 10.76 lux.

Commercial layers being kept in cages should not be exposed to the very high light intensity caused by direct sunlight. Other than more difficulty to dispose of body heat under such conditions, this very high light intensity could lead to increased pecking and cannibalism resulting in increased mortality.

Light Intensity in Commercial Layer Houses

Work done as early as 1968 by Trevor Morris in Reading (England) showed that there is evidence that there is a threshold of 5 lux to sustain maximum production in layers in dark houses. Commercial layers are however normally supplied with higher light intensity (10 to 20 lux) as poultry houses are full of equipment creating shadows that reduces the effective light intensity.

As a general rule, 1 bulb watt for every 0.37 m^2 of floor area will provide for 10 lux (1 ft candle) when incandescent lights are used. When using fluorescent light, 1 bulb watt for every 1.11 m^2 will supply the equivalent of 10 lux (three times more efficient).

In multi-tier cages it is impossible to achieve an even light intensity at all levels as cages are at different height and distance from the light source. The further the object is from the source of light, the lower the light intensity. The cages and feed troughs also create shadows. Light intensity of 10 lux in cage systems should be measured at the feed trough, at a point furthest away from two light sources in the passage. In very high cage configuration, the lights may have to be suspended at different heights to even out the differences in intensity at the various levels within the passage.

Lights in a multi-tiered cage system

Light Intensity in Dark Houses

Dark houses are used in pullet rearing to control the sexual maturity of stock more effectively and to eliminate the effect of seasonal changes in natural day length. In these houses the photoperiod used could therefore be shorter than the natural day length. Light trapping of fans and air inlets is then used to eliminate outside light from the building.

In commercial layer houses where ventilation is supplied by mechanical means, the fans and inlets may also be light trapped to eliminate any natural light entering the building. Where this is done, the light programs may be controlled much better as the effect of natural seasonal changes in day length is eliminated.

As a general rule this light trapping should provide for a light intensity which is below 0.2 lux, measured where the birds are closest to the light trapping.

1.2.7 Basic Design of Poultry Houses

Buildings used in the commercial layer industry could be either natural ventilated buildings or buildings in which there is improved control on the conditions within the building through mechanical means.

1.2.7.1 Open Sided Houses

Natural ventilated or open sided houses are buildings where the amount of air entering the building through natural forces is controlled by opening and closing of side air inlets. These natural forces are through Stack Effect and Air Pressure Effect.

The stack effect of air movement is the upward movement of warm air being replaced by colder air at the bottom and in open sided houses this is used to control conditions under minimum ventilation.

With air pressure effect wind pressure is used to create cross ventilation in the building by the control of curtains on the side walls.

Example of natural ventilated buildings

Open sided buildings are popular in South Africa for keeping of adult birds and although they are also used in the rearing of pullets, the ever increasing cost to heat these buildings and the inability to apply effective light programs to overcome the seasonal effect of natural light, is resulting in these housing systems becoming less popular for the rearing of pullets, despite the fact that they are generally less costly to construct.

This type of building is popular in South Africa for commercial egg production as they are relatively easy to construct, are less costly and simpler to operate and manage. The operating costs are lower due to less electrical power required and lower maintenance costs. These savings should however be weighed up against the better control of environmental conditions and the effect thereof on performance and feed consumption that is achievable with mechanical ventilated buildings, especially when large units are contemplated.

Typical open sided high rise commercial layer house

With open sided houses the side inlets should be easily adjusted to suite the ventilation requirement and special attention should be given to ensure that a minimum amount of ventilation through the stack effect is achieved. In these houses the roof area should be insulated.

Light programs used in open sided buildings need to take into account the seasonal changes in sunset and sunrise and the consequent changes in day length hours.

1.2.7.2 Closed Houses

Closed houses are buildings in which the amount of air entering the building is controlled by mechanical means. Fans and inlets are used to control the amount of ventilation required. In pullet rearing these houses are also ‘light trapped” to enable light programs in which the hours of light applied is less than the natural day length.

These houses are less popular in South Africa for commercial egg production as they are costly to construct, require electrical standby power and have higher maintenance costs compared to open sided buildings. Fan ventilated buildings will however provide for better control of environmental conditions, especially in very hot climates where the ventilation system is linked to an evaporative cooling system. In large buildings where stocking density would be high (4 tier and higher cages), serious consideration should be given to this type of building and the capital cost weighed up against the improved performance and production efficiency.

Typical fan ventilated buildings for commercial egg production

In fan ventilated buildings better control on the lighting program would be possible, as the natural seasonal changes in day length is eliminated, provided the inlets and fans are light trapped. If the fans and inlet areas are not light trapped then these houses are to be regarded as being similar to open houses when it comes to light programs to be used.

1.3 Cage Rearing Systems for Pullets

The majority of commercial layers are kept in cages and hence the majority of commercial pullets are reared in cages from day old to 17 weeks of age. The advantage of cage rearing compared to floor rearing is that the vertical height of the building is used in multi-tier cage systems and with good ventilation and heating, the effective density of the building is increase compared to floor rearing. There is also no need for a coccidiosis and other internal parasite control program and due to the lower activity of birds in cages, the body weight and feed intake is generally improved compared to floor rearing systems.

Rearing cages have become more intensive over the years, developing from flat deck systems which were popular in the 1960's to multi-tier cages, equipped with automatic feeder, drinker and manure removal systems.

1.3.1 Stocking Density

The South African Poultry Association guide for stocking density in pullet rearing cages is reflected in Table 1.6.

Table 1.6: Space requirement for commercial layer type birds

Age (Weeks)	Weight (g)	Cm^2 per bird	Feed Trough (cm/bird)	Water Nipples (Birds/nipple)
0 – 6	500	150	2.25	15
7 – 18	1450	300	4.50	8

(2012 South African Poultry Association Code of Practice)

1.3.2 Cage Configuration

Due to cost constraints, flat deck rearing cages are no longer popular for rearing of commercial pullets. Modern multi-tier cages have made it possible to utilise the vertical space available in the poultry building.

1.3.2.1 A-frame Cage Configuration

In the A-framed configuration the cages are placed on top of one another in the configuration of an A. The back of these cages is usually cut at an angle and manure flaps (usually plastic sheeting) deflect the manure from the top cage into a pit or some form of manure removal system below the cages.

These cages could be 2, 3 or even 4 tier.

1.3.2.2 Stack Configuration.

In the stacked configuration the cages are directly above one another with some form of mechanical manure removal system (scrapers or belts) between the cage tiers. Due to a narrow stack being possible compared to the A-frame configuration, building space is saved with stack cages in multiple tiered cages. These cages are on the other hand more costly to install due to the manure removal systems that are required.

Example of A-frame cages top left, flat deck cages top right

1.3.3 Feed Systems on Rearing Cages

Feed systems on layer cages can be classified into manual or mechanized systems.

1.3.3.1 Manual Feed Systems

Manual feeder systems will consist of a bulk feed tank from which feed is augured into a feed cart. These feed carts are then pushed down the cage rows from where feed is transferred into the feed trough situated at the front of the cage system.

With manual feeding on cages, the feed may be transferred from a feed cart either manually by means of a scoop or bucket or by an auger mounted to the feed cart.

These feed carts may be pushed or driven mechanically down the cage row, depositing feed into the feed trough.

In managing these systems care should be taken not to waste feed during transfer of feed from the bulk bin to the feed cart or from the feed cart to the feed trough.

1.3.3.2 Mechanised Feed Systems

Mechanized feed systems can be classified into two main types:

Chain Feeder

These systems consist of some form of mechanized conveyor in the feed trough, which drags the feed from the feed hopper along the feed trough. The system could be filled by corner hoppers situated on each trough which are filled by the cross auger from the bulk tank, or by a column hopper which is a larger bin situated at the end of the cage row through which the feed chain moves.

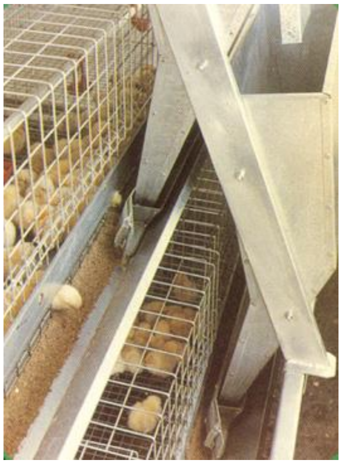
The feed level on the chain may be adjusted and the number of feedings per day is normally controlled by a

time clock. Control probes situated in the hoppers are used to control the switching of the cross auger to ensure that the hoppers remain filled with feed.

A feed hopper system will consist of a motorized feed hopper filled by a cross auger from the bulk feed bin which moves on rails down the length of the cage row depositing feed into the trough.

The amount of feed deposited by the feed hopper into the feed trough can be adjusted and the motorized hopper is then also controlled by a timer which allows for controlling the amount of feedings per given period.

The feed hopper may also be hand pushed instead of motor driven.

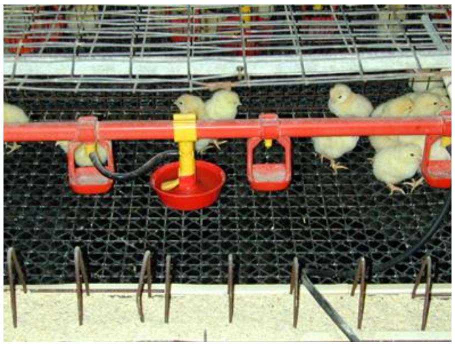


Typical feed hopper of gantry system

1.3.4 Drinker Systems on Rearing Cages

Over the years the cage drinker systems have changed from open troughs attached to the cages to smaller cup systems and the modern trend is to install some form of nipple drinker system. The main importance in rearing cage drinker systems is that the height and water pressure needs adjustment to ensure that the system is suitable for chicks as well as growing pullets. Wastage of water should also not occur.

Although nipple drinkers that are suitable for chicks as well as growing pullets are available, many pullet growers prefer to use chick fonts for the first couple of days to ensure that chicks get off to a good start. This especially in view of the treatment of beak trimming and vaccination that are performed on the chicks at the hatchery.



Example of a float cup for chicks and nipple drinkers in cage rearing

The older type of nipple drinkers require a drip cup to eliminate spillage and hence wet litter but more modern nipples without the need of a drip cup are available.

1.3.5 Heating Systems

In pullet rearing cage systems the entire building needs to be heated and in addition with multi tier cages especially, proper circulation of the air is essential to ensure that the vertical as well as longitudinal temperature difference is kept to a minimum.

1.3.5.1 Heat Exchangers

Heat exchangers use gas, oil or coal fired burners as source of heat to heat an entire building. Air is passed through the heat exchanger before being blown into the poultry shed. The heated air is often blown into a plastic sock (fan jet) with holes down the length which distributes the heated air evenly throughout the brooding area. This fan jet could be coupled to the minimum ventilation system to distribute the minimum amount of air required as evenly as possible. In the absence of a fan jet, air circulating fans could be used to assist in distributing the air throughout the building.

Various sizes of heat exchangers are available to suite smaller and larger house conditions.

1.3.5.2 Open Flame Heaters

Open flame heaters which are usually gas or oil fired burners could also be used together with air circulating fans to heat the entire building.

1.4 Floor Rearing of Pullets

Although the majority of pullets are reared in cages from day old to point of transfer, some smaller farms may still rear pullets on the floor. Due to the increased activity pullets reared on the floor are generally lighter compared to sisters reared in cage systems and in addition coccidiosis and other internal parasite control programs need to be introduced in floor rearing systems. The added disadvantage is that when transferred to cages, the pullets would need to undergo an adaptation period in order to find the drinker and feed system. This is especially problematic when pullets have for example been reared on Bell drinkers and need to adapt to nipple drinkers on the cages.

Welfare considerations are creating the opportunity for producers to develop niche markets such as “Free Range Eggs” and “Barn Eggs” and some retail outlets selling such eggs are also demanding that pullets destined for these systems are not reared in cages. This is resulting in some larger production systems reverting to floor rearing of pullets destined for alternate layer production systems.

In some instances a brooder houses that rears birds to around 6 weeks could be installed and birds then transferred to either a cage system or floor system. In these systems the increased down time of the two systems as well as the effect of the environmental change at the critical age of 6 weeks should be weighed up against the possible saving in capital investment.

1.4.1 Feeding Systems

Feed remains the single most costly item in poultry production and the equipment must ensure proper supply without feed wastage.

1.4.1.1 Stocking Density

The stocking density for floor rearing systems would depend on the age of the birds (body weight) as well as environmental conditions and the extent to which the ventilation and temperature within the building can be controlled.

Table 1.7: Stocking density for floor rearing

Age (Weeks)	Weight (g)	Hens (birds/m2)	Feed Trough (cm/hen)	Water Trough (cm/hen)	Nipple Drinkers (Hens/nipple)
0 – 6	500	24	2.5	1.25	20
7 – 20	1450	12	3.5	1.25	12

(2012 South African Poultry Association Code of Practice)

1.4.1.2 Feeding Space

The feeding space required would normally be provided by breeder companies of the stock involved. As a general rule the feeder space for layer rearing pullets presented in Table 1.7 can be used.

1.4.1.3 Chick Feeders

These feeders consist of flat containers with a 2.5 cm edge, usually made of plastic. These feeders are concentrated in the brooder area and feed is placed in the container and chicks will jump into the container and feed. These chick feeders are removed as soon as the birds are able to feed from the larger feeders.. Feed may also be scattered on paper in the brooding area.

Example of chick feeders and drinkers

1.4.1.4 Manual Feeders

In floor rearing operations hand feeders may consist of open, long troughs into which feed is placed from which the birds may then feed. Tube feeders are also used which consists of a tube 20 to 40 cm in diameter and 500 cm high to which an adjustable pan is fitted at the bottom. The gap between the tube and the pan is adjustable so as to set the amount of feed that will flow from the tube and therefore the level of feed in the pan. The advantage of hand filled tube feeders compared to hand filled trough feeders is that the tube serves as a reservoir for feed, requiring feed to be replenished less often.

Example of manual feeding in floor rearing

1.4.1.5 Automated Feeders

Automated floor feeders consist of many types and makes. The more popular feeders can be classified into chain feeders, pan and auger feeder and scatter feeders. The choice of feeding system would depend on personal preference.

Chain feeders consist of a continuous open trough around the shed fitted with a flat chain that drags feed from a central hopper which acts as a reservoir of feed. The central hopper is filled by an auger, which conveys feed from a bulk feed bin. The hopper is also fitted with high and low censors, which will cause the auger motor to switch of and on as required. The motor, which drives the chain in the trough, is in turn controlled by a time clock. This enables automated and controlled setting on the amount of feedings required in the case of *ad libitum* feeding. Single, double, as well as three track feeders are available to allow for increased feed space as required. Slow and high-speed feeders allow for various conditions such as feeding young chicks or older pullets. The entire system can be suspended from the building by cables and a wincing system if crossbeams are able to carry the weight or the troughs may be fitted to carrier legs which allows for height adjustment.

Example of chain feeding systems for floor operations

Pan feeders consist of a tube (or other form of feed conveyor) in which an auger conveys feed from one end to which a feed hopper has been fitted. Openings made at the bottom of the tube then allow feed to drop from the tube to a pan fitted to the tube. The gap between the pan and tube is adjustable so as to set the amount of feed deposited into the pan. The pans are therefore filled from the hopper end as feed is conveyed down the length of the tube. A limit switch is fitted to the last pan on the tube. This switches the drive motor on and off, depending on the height of feed in the last pan. An auger from the bulk feed bin fills the hopper and the amount of feed in the hopper is controlled by high and low limit switches.

The required feeder space is achieved by increasing the number of pans fitted to the tube or increasing the amount of feeder lines (tubes) in the shed. The system is suspended from the ceiling on cables and a wincing system so as to allow for adjustment of feeder height as well as lifting the feeder system out of the way for cleaning.

Examples of pan feeder systems

Pan feeders may be relatively expensive but feed is distributed immediately into all pans from feed remaining in the tube. The system is then filled from the end but again the feeder length should not be too long. Pan feeders are generally more difficult to manage as each pan needs to be adjusted to ensure even distribution of feed.

1.4.2 Drinker Systems

In floor rearing the water supply equipment has developed from open troughs and bell shaped drinkers which become dirty and contaminated and are difficult to keep clean. The more modern nipple drinker systems are entirely closed and the water in these systems remains clean. These closed systems would also reduce the risk of disease spreading within the flock as compared to open drinkers.

1.4.2.1 Drinker Space Requirement

The drinker space required would normally be provided by breeder companies of the stock involved.

As a general rule the drinker space for pullets presented in Table 1.7 can be used.

1.4.2.2 Drinker systems for Chicks

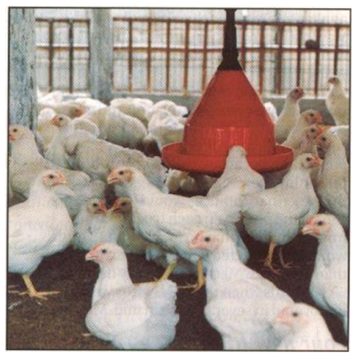
Chicks should be started off with equipment specially designed to ensure that water intake is not limited during the initial stages of development.

Chick fonts are manually filled pan and jar drinkers and are popular for young chicks. Water is placed in the jar which when turned will feed water into the trough. These drinker systems are normally used for the first week to 10 days to ensure that chicks get off to a good start.

Low pressure nipples suitable for starting chicks and growing of the birds and which are suspended on drinker lines are popular in large-scale floor operations as they are less labour intensive (no cleaning required) and considered to reduce spreading of disease as the system is closed. Some types of nipples are equipped with drip cups to eliminate dripping onto litter while others operate without drip cups.

1.4.2.3 Drinker systems for older pullets

Bell drinkers are plastic drinkers and hang from the ceiling on adjustable nylon cables to suite bird height. They are popular in floor systems. The drinker is equipped with a valve mechanism and spring, which controls the water flow into the trough by means of the weight of water in the trough. These drinkers are often ballasted by a weight in the bell (usually a container with filled with water), which reduces swinging and water spillage.



Bell drinkers require regular cleaning

Nipple drinkers have become very popular in both cage and floor systems. The older type of nipple drinkers required a drip cup to eliminate spillage and wet litter. More modern nipples exist which are used without drip cups with a minimal amount of spillage. In floor systems the nipples are suspended on hanging water lines and due to the nipples requiring a constant set pressure, a pressure control mechanism is usually supplied. Water pressure adjusters are also installed where water lines are long and the floor is sloped to one side of the building.

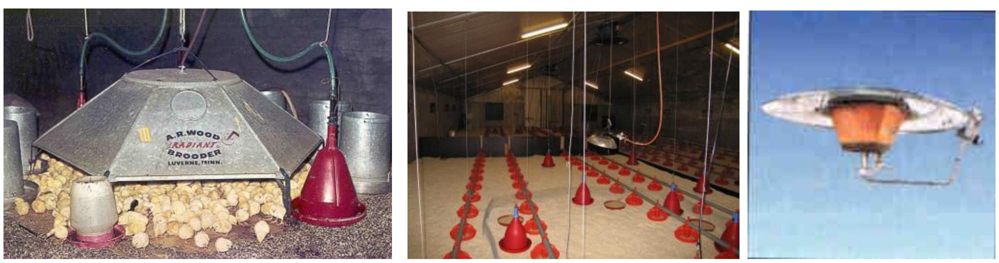
Nipple drinker application in floor rearing of breeders

Various types and makes are available for floor rearing and breeder systems and should be checked as being suitable for what the use is intended for.

1.4.3 Heater System

In floor rearing of pullets, heat exchangers as explained above could be used to heat the entire building or part of the building in which chicks are being brooded.

Smaller canopy type haters coul also be used in floor rearing.



Examples of a hover brooder, infrared gas brooder and a pancake brooder

These brooders have a steel canopy fitted with a heater element which could be heated by a gas flame or electrical element. The heater is suspended about 1 to 1.5 meters above the chicks and the chicks should be confined to a brooding area around the brooder, especially in open sided houses. Suspended plastic curtains are often used to conserve heat to the part of the building in which chicks are brooded. These brooders are available in various sizes (1000 to 5000 chicks per brooder) and manufacturer recommendations and application should be used.

1.5 Layer Cage Systems

Layer cages have become more intensive over the years, developing from single 9 x 18 inch wire mesh cages equipped with a feed and water trough, to multi-tier colony cages, equipped with automatic feeder, drinker, manure removal and egg collection systems. Modifications are continuously being made which are aimed at improved welfare considerations as well as improved productivity in terms of production, feed efficiency and first grade eggs produced.

1.5.1 Stocking Density in Layer Cages

The basic dimensions of cage systems have changed over the years. Originally most welfare regulations and practices accepted a density of 450 cm^2 per bird as being the minimum norm and this is at present the density as recommended in the Code of Practice of the South African Poultry Association. This stocking density has been generally accepted as the minimum density for brown egg layers but welfare pressure in many countries has resulted in the density being increased to 550 cm^2 per bird and even higher.

Older cages with a configuration of 50 cm wide by 45 cm deep were suitable to house 5 birds under the current South African Poultry Association Code of practice (50 x 45 = 2250 cm^2 for 5 birds = 450 cm^2 per bird). More modern type cages have a configuration of 60 cm wide and 55 cm deep and placement of 7 birds in such cages would provide for 471 cm^2 per bird whilst 6 birds per cage would comply with regulations calling for a density of 550 cm^2 per bird.

More recent trends in layer cage design have been aimed at addressing the added welfare concerns of battery cages and this has led to the development of Enriched Cage Systems explained below.

1.5.2 Cage Configuration

Due to cost constraints, single tier cages are no longer popular for commercial egg productions systems and cages would normally be stacked in multiple tiers of 2, 3, 4 and even higher in order to utilise the vertical height of the building.

1.5.2.1 A-frame Cage Configuration

In the A-framed configuration the cages are placed on top of one another in the configuration of an A. The back of these cages is usually cut at an angle and manure flaps (usually plastic sheeting) deflect the manure from the top cage into a pit or some form of manure removal system below the cages. The A-frame configuration has become less popular as the height of the cage, which has been accepted as being a minimum of 45 cm, is determined by area excluding the sloped area. Should the manure flap be done away with the A-frame stack become very wide in three and four tier systems. The A-frame configuration does however remain popular for smaller poultry sheds where two and possibly three tier systems would be installed.

Typical A-frame configuration on the left and stack cages on the right

1.5.2.2 Stack Configuration.

In the stacked configuration the cages are directly above one another with some form of mechanical manure removal system (scrapers or belts) between the cage tiers. Due to a narrow stack being possible compared to the A-frame configuration, building space is saved with stack cages in multiple tiered cages. These cages are on the other hand more costly to install due to the manure removal system that is required on each tier.

1.5.3 Drinker Systems on Layer Cages

Over the years the cage drinker systems have changed from open troughs attached to the cages to smaller cup systems and the modern trend is to install some form of nipple drinker system, with or without a drip cup. Drinker systems should not waste (wet manure) yet they should provide sufficient flow for adequate rates of consumption especially in hot climatic conditions.

1.5.3.1 Cup Drinkers

Cup drinkers on older types of battery cages are small drinker cups equipped with a spring valve and trigger mechanism or trigger, plunger and small pressure valve. Cup drinkers used to be popular in cage operations but have largely been replaced by nipple drinkers due to high level of maintenance required on cups and the cups being pecked through as well as nipple systems being more hygienic (closed system).

Typical cup drinker system in cages

1.5.3.2 Nipple Drinkers

Nipple drinkers have become very popular in cage operations. The older type of nipple drinkers require a drip cup to eliminate spillage and hence wet litter but more modern nipples without the need of a drip cup are available.

Nipple drinkers requiring a constant water pressure and this is achieved by a small header tank or pressure regulators for each tier.

Typical nipple drinker equipped with drip trough

The Code of Practice of the South African Poultry Association stipulates that birds should have access to two nipples, hence the placement of nipples within the cage partition in most instances. .

1.5.4 Feed Systems on Layer Cages

Feed systems on layer cages can be classified into manual or mechanized systems.

1.5.4.1 Manual Feed Systems

Manual feeder systems will consist of a bulk feed tank from which feed is augured into a feed cart. These feed carts are then pushed down the cage rows from where feed is transferred into the feed trough. In the absence of a bulk feed tank, feed could be purchased in bags from feed suppliers.

With manual feeding on cages, the feed may be transferred from a feed cart either manually by means of a scoop or bucket or by an auger mounted to the feed cart.

Example of a motorised feed cart

These automated feed carts may be pushed or driven mechanically down the cage row, depositing feed into the feed trough.

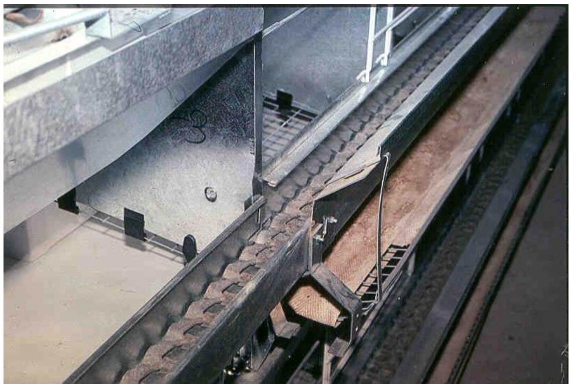
In managing these systems care should be taken not to waste feed during transfer of feed from the bulk bin to the feed cart or from the feed cart to the feed trough.

1.5.4.2 Mechanised Feed Systems

Mechanized feed systems could be classified into two main types:

Chain Feeder

These systems consist of some form of mechanized conveyor in the feed trough, which drags the feed from the feed hopper along the feed trough. The system could be filled by corner hoppers situated on each trough which are filled by the cross auger from the bulk tank, or by a column hopper which is a larger bin situated at the end of the cage row, through which the feed chain moves.

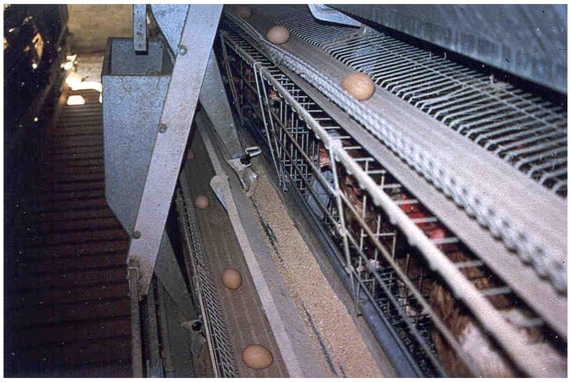


Typical chain feeder system on layer cages

The feed level on the chain may be adjusted and the number of feedings per day is normally controlled by time clock. Control probes situated in the hoppers are used to control the switching of the cross auger to ensure that the hoppers remain filled with feed.

Travelling Feed Hopper

A feed hopper system will consist of a motorized feed hopper filled by a cross auger from the bulk feed bin which moves on rails down the length of the cage row depositing feed into the trough.



Typical feed hopper or gantry system

The amount of feed deposited by the feed hopper into the feed trough can be adjusted and the motorized hopper is then also controlled by a timer which allows for controlling the amount of feedings per given period.

The feed hopper may also be hand pushed instead of motor driven in the case of smaller stacks of two and three tiers.

1.5.4.3 Measuring Feed Consumption

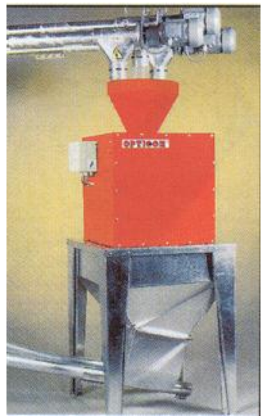
It is essential to know the feed consumption to ensure that birds are feeding normally and that production will be optimized. Should feed weighing equipment such as dump scales or load cells not be available, then feed usage should at least be estimated volumetrically.

Dump Scales

Dump scales weigh off a fixed amount of feed at a time (20kg tips) into a mini bin from where the feed is conveyed into the feeding system in the poultry shed.

The number of weighing within a given period may then be recorded manually or electronically into a central data base system for calculation of feed consumption or allocation within the period.

These systems are fairly accurate but should be assize regularly to ensure correctness. A weight equal to the tip required is used for test weighing from time to time.



A Dump scale

Load Cells

Load cells are placed under the bulk feed bin for accurate weighing of the feed within the feed bin. This information may be recorded manually or electronically into a data base system for accurate determination of feed intake within a given period. It is the most costly but most accurate measure of feed intake and may even provide for calculation of feed intake on an ongoing basis. If linked to frequent weighing of birds and production, the progress of the flock is monitored very closely and potential problems may be corrected timeously.

Load cells under a feed bin

Volumetric Estimation

If the volumetric weight (kg/m^3) of the feed is known, the feed stock in the bin may be estimated. By subtracting the feed stock from the sum total of the opening stock and any feed delivered in the time period, the feed intake within that period may be estimated. This would normally be done weekly.

The volume of a round bulk tank is calculated by adding the

Volume of the cone part = height of the cone x 1/3 of the area of the base
to
Volume of the cylindric part = area of the base x height
where

Area of the base = (Diameter of the tank)^2 x 0.7854

Although rather crude, it at least provides for some estimation of feed consumption provided the volumetric feed weight is obtained from the feed supplier on a regular basis.

The use of double feed tanks will assist further in that feed is then allowed to be emptied from the bin providing for correction of interim calculation and estimation.

1.5.5 Egg Collection Systems

Egg collection from layer cages could consist of either manual or mechanical collection. The choice between manual and automated egg collection would depend on the size of the operation as well as the relative cost of labour compared to the more expensive cost of egg collection equipment. Automated systems have to be well maintained and managed. If not, good first quality eggs may be broken or become dirty on the collection and conveying system, resulting in large financial loss.

1.5.5.1 Manual Egg Collection

In manual collection the eggs are removed from the cages and placed onto egg trays and trolleys on which eggs are then transported to the egg grading and packing plant.

Manual egg collection

1.5.5.2 Mechanical Egg Collection

In automated egg collection egg belts and transfer systems are used to collect eggs from the cage rows and convey the eggs into egg packer or grading machines.

A fully automated egg collection system would consist of the following main components:

Egg Belts

Continuous egg belts onto which the eggs roll from the cages are normally made from woven nylon material and by means of a drive unit situated at the front end of the cage stack, transport eggs to the front of the cage stack.

The use of egg belts in automated egg collection systems

Brushes are often installed to assist in keeping the belts free of dust.

The tension of the belts should never be set too tight as this results in stretching and damage. On the other hand insufficient tension will result in slipping on the drive unit, especially when production is high.

Egg Transfer

The transfer system is the most complex part of the collection system as the eggs have to be transferred from various levels in multi tiered cages to one level and then placed onto the cross conveyor. Various ways of achieving this have been developed and the systems available can be categorized into:

- **Elevator systems** which consist of circulating belts or chains in the vertical plane at the end of the cage row to which cups, fingers, buckets or baskets are fitted. They receive the eggs from the egg belts before being transferred onto the cross conveyor which could be situated above head height or at floor level or below floor level. The eggs are transferred twice with this system, first from the belts to the vertical transfer system (the elevator) and then again from the elevator to the cross conveyor

Elevator transfer system on the left and lift system on the right

The system must be properly synchronized between the egg belts and transfer system to prevent egg build up and excessive breakages on the belts. A major advantage of the elevator system is that the cross conveyor can be placed above head height or below floor level to enable the passageways to be clear for movement of traffic.

- **The lift systems** can be described as flexible cross conveyers, which move from one tier (level) of cages to the next, collecting eggs from one level across the cage stacks at the same time. Only one transfer takes place (from the belts to the conveyer) but this system has the disadvantage that as only one level of the cages stack is collected at a time the belt speed has to be increased to maintain an adequate flow of eggs into the farm packer. This could result in increased egg breakages at transfer if the system is not properly installed.
- **The inclined conveye**r systems consists of individual conveyers bringing the eggs from the various levels at an angle to the cross conveyer at floor level. This system handles eggs very gently but more space is required at the front of the cage row to allow for an adequate angle of the mini conveyers

A typical incline conveyer

Cross Conveyer

The cross conveyer receives eggs from the transfer system and transports the eggs to a central collection point. The conveyer would consist of stainless steel or plastic coated rods fixed to a link chain or gear chain. When mounted to a link chain, the system is able to make 90 degree bends while the gear chain mechanism is not able to do so.

Over short distances (20 to 30 meters) only one drive unit would be installed but over longer distances, interim drive units need to be installed to avoid chain stretching as a result of the load.

Egg Packer

Egg packers transfer the eggs from the cross conveyer into egg trays. These machines may be equipped with de-nesters for loading egg trays in bulk. Stackers are available which will stack the packed egg trays in stacks for mass handling onto egg trolleys.

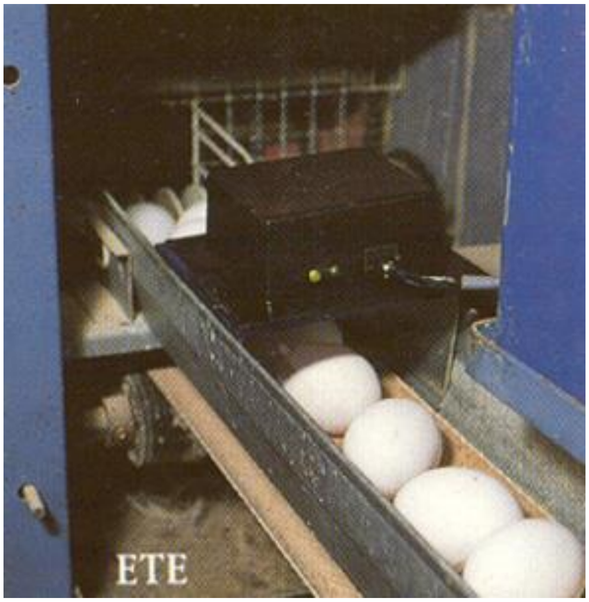
Farm egg packer

Different sizes and makes of machines are available and on large complexes an egg grader for direct grading and packing of eggs may replace the farm packer.

Egg Counting

Numerous makes of electronic and mechanical egg counters are available for installing into automated egg collection systems. These counters may also be linked into central computer and data processing systems.

These counters may be installed on the egg belts which would provide for records per cage row or on the cross conveyer, which then provides for records on a house basis.



Egg counter mounted on the egg belt system

1.5.6 Manure Removal

Other than removing manure manually from the floor below the cages by shovel and wheelbarrow, manure may also be removed by mechanical means. This is however complicated especially with stack cage systems.

1.5.6.1 Manure Scrapers

Scraper systems consist of scraper blades drawn by stainless steel cable under the cages in a shallow manure pit. The depth of the pit and type of blade would depend on the frequency of removal and two basic types are used:

Roll over scrapers consist of a blade which rolls into a horizontal position when the blade is pulled back, thereby being pulled over the manure. When the blade is drawn forward, the blade moves into the vertical position and draws the manure forward from under the cages into a cross conveyer system at the end of the building. This system does not allow manure to be built up very high as the blade has to move over the manure. It has to be operated frequently and therefore produces wet manure that is still high in moisture content.

Step manure systems operate in very much the same manner except that the blade consists of a flat plate drawn in under the manure for the length of the plate (1 meter) and then forward to the end of the building. Since manure can be allowed to build up under the cage in the pit, this system will produce dryer manure but the pits have to be deeper to hold such manure under the cages.

Both these systems would deposit the manure on a flat surface at the end of the building from where it could be loaded mechanically or the manure could be deposited onto a cross conveyor belt system which will deposit the manure into vehicles for removal from the premises. Manure scraper systems have become less popular due to wet manure being produced from these systems as well as the mechanical nature of the systems.

Manure cross conveyer

1.5.6.2 Manure Belts

Manure belts are currently more popular in intensive systems. This system consists of belts on rollers under the cage decks, which are activated from time to time so as to deliver the manure from under the cages to the end of the cage rows. They are of particular use in stack cages where this system could be linked to a manure drying tube situated in the cage deck so as to assist in drying the manure.

The use of manure belt system in cages

The belt under the cages then deposits the manure onto a cross conveyor belt system which will in turn deposit the manure onto vehicles outside the building by means of an elevator.

1.5.6.3 High Rise Buildings

Buildings could also be built in such a way so as to have a double storey building, with cages on the top deck and the bottom deck being used as a manure pit. These building are commonly referred to as "High Rise" houses. The cages could then be either "A-framed" or equipped with a scraper system on the cage decks as described above which pushes the manure into the pit.

The lower deck then serves as manure storage. The manure is dry and removed by tractor or bobcat and front end loader less often, usually at the end of a cycle.

Manure pit section of a High Rise building

1.5.6.4 Manure Production

The manure produced by cages layers, both on a volumetric as well as weight basis, will vary depending on the amount of drying and decomposition that is allowed to take place and also the ratio between feed and water consumption. For all practical purposes, the amount of manure produced on a daily basis is assumed to be equal to the feed consumed.

Therefore birds consuming 110 to 115 g feed per day should under normal circumstances produce 750 to 800 kg of manure per 1000 birds per week at 80% moisture. If allowed to dry the volume and weight of manure to be removed will reduce significantly.

The amount of fresh manure produced per 1000 birds over a cycle of 52 weeks (18 week placement and 70 week depletion ages) containing 80% moisture is in the order of 525 m^3 with each cubic meter of manure weighing in the order of 800 kg. As the manure is allowed to accumulate and dry the weight will reduce and the corresponding volumetric weight of the manure will also reduce, due to the loss in moisture. Assuming that the dry matter content remains the same Table 1.10 is a presentation of the loss in moisture as manure dries and the amount of manure to be removed at various levels of moisture loss.

Table 1.10: Effect of drying on the manure volumes to be removed per 10000 birds

Moisture %	80	70	60	50	40
Total manure per year (ton)	440	293	220	176	146
Moisture	352	205	132	88	58
Dry matter	88	88	88	88	88
% of original weight	100	67	50	40	33
Estimated kg/cub meter	834	774	718	655	596
Estimated volume per year m^3	526	377	307	268	245
Estimated volume per month m^3	43	31	25	22	20
Estimated volume per week m^3	10	7	6	5	5

It is therefore of great benefit to allow manure to dry and decompose as much as possible, as the manure should not only then have a better value for fertilizer purposes, but far less volume will need to be removed from the premises.

Table 1.11: Average Plant Nutrients of Cage Layer Poultry Manure

From North (Fourth Edition)

Manure Condition	Moisture %	Nitrogen %	Phosphorus %	Potash %
Wet, sticky	75	1.3	1.1	0.6
Moist	50	2.0	2.3	1.2
Crumbly but not dusty	25	3.0	3.3	1.8
Dry and Dusty	15	3.5	3.5	2.3
Completely dry no moisture	0	4.0	4.5	2.8

1.6 Alternative Layer Systems

The European Union has regulated for conventional cage not to be used for the production of eggs as of 2012 and many other countries such as Australia and USA are moving towards allowing for more bird space in layer cages. This together with pressure from poultry welfare activists to satisfy the birds need for dust bathing and nesting behaviour has stimulated research into finding suitable alternative systems for keeping layer hens for the production of table eggs.

In trying to find alternative management systems for layers, research in this field has taken two directions. There are those who have taken the view that a cage system offers distinct advantages over any floor system and have opted to develop an alternate cage that will satisfy animal welfare, commonly referred to as “enriched cages” while others are of opinion that the cage in any form will be banned in the long term and have moved away from cages.

1.6.1 Modified Enriched Cages

These cages are being referred to as Modified Enriched Cages (MEC). MEC are equipped with perches, nesting boxes and dust bathing facilities and allow for larger colony sizes than conventional cage systems. Research work on MEC has been aimed mainly towards finding the correct size of nest, position of nest and dust bath and reducing the number of second grade eggs in these cages. Larger group sized cages reduces investment cost and makes more space available for bird movement but research has indicated this to impact negatively on peck order and cannibalism when birds are not beak trimmed.

MEC are commercially available but the concern does remain that in some time in the future, even such cages will be considered to be inadequate in terms of bird welfare.

Enriched cage equipped with perches, dust bath and nest box

1.6.2 Alternative Floor Systems

Three systems are used fairly extensively in Europe as alternative to cage systems each of which may incorporate free range.

1.6.2.1 Barn or Deep Litter Systems

Deep litter systems are commonly referred to as Barn Systems in which commercial egg layers are kept in very much the same manner as conventional breeder hens. Birds walk around freely in the building of which the entire floor area is covered with litter.

1.6.2.2 Slatted Floor Systems

These systems were originally developed for the breeder industry in which a portion of the floor (60 to 70 percent) is covered with wood, wire or plastic slats. Wood shaving is then placed in the remaining floor area for dust bathing. Perches have been added to satisfy European Union Regulations that birds should be able to perch. The main cost disadvantage with slatted floor systems in EU is that because birds cannot move in the vertical plane, usable floor area and hence overall stocking density for the shed is limited.

A typical slatted floor system on the left and an aviary system on the right

1.6.2.3 Aviaries

Aviaries allow birds to make use of the vertical space within the building. The perching system is equipped with feeders and drinkers and a manure belt is installed between decks. The fact that birds are able to move in the vertical plane as well, enables increased stocking density per unit area of building, compared to other floor systems.

In these systems the floor passage area between the perching systems is covered with shavings which then serve as the dust bathing area.

Nests are installed in the centre as well as along the side walls of the building.

1.6.2.4 Free Range

Any of the three basic floor systems may incorporate free range which allows birds access to pastured range outside.

A further development has been the incorporation of a veranda to the building.

2 Pullet Rearing Management

The main objective in rearing of pullets intended to be used in the production of commercial eggs is to achieve the correct weight for age as prescribed by the supplier of the stock, with good flock uniformity, immunity and flock health at point of lay. Most programs would recommend good growth during the initial period to ensure good development of the immune system and a good body frame and skeletal development. From 6 to 8 weeks of age, and during the middle part of the growing out period the body weight gain eases off and then as sexual maturity is approached and the development of the reproductive organs commence the daily gain accelerates again.

2.1 Management during Brooding

The brooding period normally describes the period during which chicks are confined to smaller areas within the building and supplementary heat is being supplied. With floor rearing certain equipment specially designed for chicks are concentrated within the brooding area. In cage rearing the middle tier cages would normally be used for brooding and the chicks will be split into the rest of the system at 4 to 6 weeks, depending on the cage type.

2.1.1 House preparation

Although day old chicks carry some parental immunity, the chick has very little resistance to most common diseases. It is essential therefore for the poultry shed to have been properly cleaned, disinfected and prepared for the new batch of birds. This will reduce the likelihood of diseases being carried over from the previous flock. The cleaning and disinfecting include areas such as the ablution and shower facilities to the site as well as removal of all litter and manure from the site.

2.1.1.1 Floor Rearing

In floor rearing systems, fresh clean shavings or chopped straw is placed at a depth of 5 to 6 cm after the house has been properly cleaned, disinfected and allowed to dry. Materials used should be absorbent (wood shavings, chopped straw) and not too fine. All equipment is reassembled or dropped from the ceilings and it is essential to ensure that the brooding area has been prepared for the chicks. Of special importance is to ensure that all nipple drinker lines have been de-scaled and flushed.

All equipment should be serviced and checked after being cleaned and re-assembled. The heaters should be operating before chick placement and house temperature especially that of the floor and bedding should be warm when chicks arrive. Chicks are very easily chilled by a cold floor.

The brooding area is that area to which the day old chicks will be confined, as they require additional heating, different feeders and drinkers and a higher light intensity compared to older birds. Such chick equipment is to be evenly spaced throughout the brooding area.

The size of the brooding area would vary according to the brooding method but as a rule 20 to 30 breeder chicks per m^2 should be allowed for. With whole house brooding, half the building area could therefore serve as the brooding area by hanging of a curtain in the centre of the building.

Example of preparing the brooding area

The brooding area should be warmed prior to arrival of chicks and the heaters and ventilation systems should therefore be operational at least the day before expected chick arrival. Limited quantity of feed is placed on the paper strips (if used) as well as into chick feed pans and the normal feeder system where such feeder system is within the confines of the brooding area. Prior to chick arrival, the drinker system is checked for pressure and height and chick fonts (if used) are filled.

2.1.1.2 Cage Rearing

In cage systems the floor brooding tier cages could have a different wire mesh size compared to the cages into which birds will be moved at a later stage. In order to create a warm floor area for the chicks in the brooding cages, the cage floor should preferably be covered with coarse brown paper.

Of special importance is to ensure that all nipple drinker lines have been de-scaled and flushed. The nipple drinker system should be lowered to the expected chick height and chick fonts placed in the cages if used. In some cage systems the feeder has a grid mechanism that allows chicks easier access to feed trough and these plates are to be lowered into place before chicks arrive and the system filled. A small amount of feed is scattered onto the paper.

The house should be pre-warmed at least 24 hours prior to the expected chick arrival and all ventilation systems checked for correct operation and setting.

2.1.2 Chick Placement

It is essential that brooder houses should be well heated prior to chick arrival. Because chicks are poikilotherm (cold blooded) during at least the first week, they lose heat very easily. The floor requires special attention as much heat is lost trough the chick's feet.

The bedding in floor systems and the paper in the cages of cage systems should be warm on chick arrival and the building should therefore have been be pre-warmed for at least 24 hours prior to expected chick arrival.

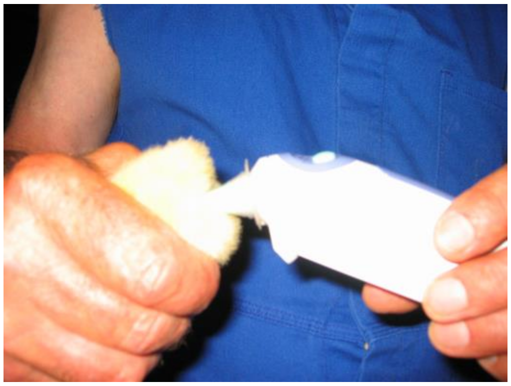
Chicks should preferably arrive during the morning. This will ensure proper supervision during the initial couple of hours after placement prior to staff going off duty. Upon arrival and during placement the chicks are to be examined for first grade quality thriftiness and mortality in the boxes.

It is also advisable to check the chick temperature on arrival, especially if chicks have travelled over a long distance. A Braun or similar thermometer is used for this and the tip of the thermometer should be placed into the cloacae. Sample around 100 chicks and should the temperature be below 39°C consider increasing the brooding temperature by a couple of degrees for an hour or two to assist in increasing the chick temperature back to normal.

Sufficient staff should be available for the offloading of chicks and placement in the brooding area or cages as quickly as possible.

Chicks should not remain in closed boxes in heated areas and lids of chick boxes should be removed if chicks cannot be unpacked within a short period of time. Chick boxes are designed to cater for colder environmental condition and chicks could overheat when kept in closed boxes for too long within the stationary chick truck or in a heated building.

With nipple systems on floor, chicks should be placed on rough paper below nipple lines. This will ensure that chicks find the nipple drinkers as soon as possible. The chicks are placed by gently tipping the chick boxes and spreading the load evenly over the brooding area.



Measuring chick temperature with a Braun Thermometer

In cage systems the chick trolleys on which the chicks arrive are wheeled into the passages between the cage rows and chicks counted out in the correct numbers per brooding cage.

Once all chicks have been placed the cardboard boxes are to be burned and returnable baskets and trolleys are returned with the chick truck to the hatchery.

At least a random number of (if not all) boxes should be counted to verify numbers of chicks with the supplier. The supply hatchery should be notified as soon as possible of any abnormal findings.

The minimum ventilation system should operate and brooder temperature set to operate at the level required for brooding.

The chicks are then left to settle for an hour or two with lights on to ensure that they become accustomed to the new environment. Thereafter a check should be made to see that chicks have easy access to feed and water. The necessary finer adjustment to temperature and ventilation is also done. Cold chicks will huddle into smaller groups while chicks that are contented will be quiet, active and evenly spread out.

2.1.3 Chick Quality

There should be no deformities such as skewed beaks, eye or head deformities, etc.

Chicks should have properly healed and dry navels and individual weight should be a minimum weight of 32 grams. This is on the bases that the hatchery could have used eggs of 50 gram weight.

Chicks should not be dehydrated and craving for water, they should stand up well on normal surfaces, be lively and alert and not be wet and covered with hatch debris.

2.1.4 Brooding Temperature

The objective during brooding is to get chicks off to a good start and accustom chicks to the normal drinker and feed systems. With spot brooding on the floor rearing the brooding temperature would be slightly higher compared to when practicing whole house brooding as the chicks are able to move closer to and away from the source of heat as required. In multi-tiered cage systems it is important to ensure that the chicks are comfortable on all of the brooding tiers and also down the length of the building. In some large poorly designed pullet rearing houses a noticeable difference in the house temperature down the length as well as between cage tiers is noticeable. It is advisable to place thermometers at various strategic points and to record the maximum and minimum temperatures in these areas and if possible to make adjustment. In cage systems individual chicks cannot move to or away from the heat as they are confined to a particular cage. Special care should be taken to ensure correct and even temperature throughout the building. Poor body weight and uniformity at 6 weeks of age can often be traced back to large temperature differences in the cage system.

Maximum and minimum brooding temperature at chick level and in various positions should be recorded daily and the thermometer re-adjusted. Ensure that a good record is available of what temperature fluctuation occurred within the recording period.

The objective during the brooding period is to

- Achieve normal weight gain as per the breeder guide during the first week
- Ensure that mortality during the first week is below 0.5% and below 1% at 14 days
- Achieve good flock uniformity and even if parent flock is young (producing chicks of 32 to 35 g) very few chicks should be culled out at 14 days (<0.25%).

House and brooding temperature (maximum and minimum) should be recorded daily and gradually reduced. No fixed rules can be applied but Table 1.2 provides a rough guide of what is to be achieved. In open type houses, the temperature close to the brooders is more important than the house temperature and the latter will always be lower than the comfortable brooding temperature. With whole house or partial house brooding, care should be taken not to create very hot and uncomfortable conditions as the chicks cannot escape from the hot area. Chicks should soon be evenly spread over the brooding area and the noise level should signify contentment.

Key indicators to brooding temperature include:

- Chicks that are hot will be noisy, pant with drooping wings and try to move away from heat.
- Chicks that are cold will be noisy and crowd
- Contented chicks are evenly spread over the brooding area or cage and the noise level should signify contentment

Chick behaviour during brooding should be used to make suitable adjustment to temperature conditions. Very often the thermometer reading is not in accordance to the needs of the chickens. When measuring temperature and humidity it must be done as close as possible to chick level but also not right amongst the chicks as the instrument then picks up heat generated by the chicks and a false reading will be obtained. Thermometers are used as guide and it is more important to check the behaviour of the chickens to see if the temperature is correct.

If chickens are evenly spread out and are eating and appearing comfortable and not chirping, then the temperature is correct. However if they form a wide circle away from the heat source then it is too hot. When chicks are crowding in a corner or huddle together in groups, then it is too cold.

When chickens are exposed to too high or too low temperatures, a condition known as vent pasting could occur. The excrement accumulates around the vent (cloacae) and the condition could become so bad that the chick is unable to pass urine or faeces, it will stop eating and will die. Chickens must be able to move closer to and away from the heat source and this is the reason why with whole house brooding or rearing chicks in cage system, slightly lower temperatures are used as chicks cannot move away from heat should temperatures be marginally high

When chicks originate from young parent flocks (less than 35 weeks of age), special attention should be given to brooding temperature. They are smaller (originate from smaller eggs) and have relatively lower rate of heat production. Such chicks require slightly higher temperature (1 to 2 °C) compared to chicks that originate from older flocks. When these smaller chicks are cold they do not show the normal behaviour of huddling and the indication of them being cold is not so obvious.

It is advisable that such chicks are placed in separate brooding areas. In cage systems it is advisable to place such chicks in the warmer part of the building.

They also have the tendency to have been overstressed during the incubation process and extra emphasis should be given to feeding and water supply. They should be brooded separate from chicks that originate from older flocks and if not in separate buildings, at least in separate brooding areas. If not, they will be dominated by the larger chicks and increased mortality and cull rate will result.

2.1.5 Increasing the Brooding Area

In floor systems the brooding area is increased gradually until birds have access to the entire building. During winter the increase in brooding area will be slower than during summer and in open type houses it will be slower compared to closed houses. Feed and drinker equipment should not be limiting in this area. On the other hand, the area should not be increased too rapidly as chicks then tend to "get lost" in the larger house area. This could often happen between the outermost chain feeder lines and wall of the building which is normally much colder than towards the middle of the floor area.

In cage systems the chicks will be split and moved into all cages between the ages of 4 to 6 weeks, depending on the particular cage system. It is essential that this occurs at the correct age. In some systems, if the move is at an age that is too young the birds might not reach the feeder and drinker systems, while in other systems if the age is too late, the density would be excessive.

2.1.6 Feed Management during Brooding

Chicks should have free and easy access to fresh feed at all times. During the initial period, chick feeders and feed on paper is to be replenished regularly (twice daily). The feeders should not be overfilled as this leads to feed soon becoming stale and less palatable to the chicks which will result in reduced feed intake and poor weight gain.

In the case of floor rearing chick feeders and paper are normally removed from about 4 to 7 days, depending on the accessibility of the chicks to the normal feeder system. In cage systems this would also occur at 4 to 7 days. It is essential that chicks are feeding comfortably from the larger feed system before the removal of any chick feeder system.

Check weights at the end of the first week are to serve as guide whether feeding and brooding technique is good. During this period mass weighing is done and the average weight compared to that supplied by the breeder company.

Automated feeding systems should be switched on manually at the beginning on a "stop-start" basis to ensure that chicks are not caught up in the system.

2.1.7 Water Management during Brooding

Chicks should have access to clean fresh water at all times. Where chick fonts are used, they should be cleaned daily and replenished with fresh water. The water level in Bell drinkers should not be excessively high as this leads to water spillage. These drinkers are also to be cleaned regularly as there is a tendency for shavings and droppings to land up in these open drinker systems when set low enough for chicks to have easy access to the water. Wet patches should be removed and the cause of leaking systems should be attended to immediately. Chicks that are wet will be uncomfortable and cold.

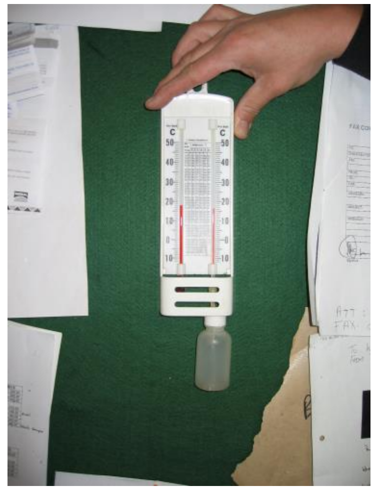
Nipple and cup drinkers are to be checked for sufficient supply of water and especially in the case of nipple systems, the height of the nipples should be set to ensure that chicks drink with heads in an upward direction but not stretching for the nipple. A 30° angel with the beak is normally recommended by nipple suppliers. With nipple and cup drinker system the water pressure is of extreme importance and supplier recommendations should be incorporated into schedules and checklists to remind staff to make these adjustments timeously. Water pressure will be low at the start to ensure that nipples can be easily activated by the chicks and that in fact a small water droplet forms to attract chicks to the drinker. As the chicks age, the water pressure is increased to increase the flow rate of water from the nipple.

Where chick founts are used, a change is to be made from such fonts by 7 to 10 days of age. It is advisable not to make this change at the time of beak trimming. When removing chick fonts, this should be done over a period of a day or two to accustom chicks to the normal drinker system

2.1.8 Ventilation and Humidity during Brooding

Ventilation is often neglected during brooding as there is the belief that chicks do not require much ventilation. During the brooding stage of chick management, ventilation is normally confined to the supply of adequate minimum ventilation. This rate of ventilation must be supplied from the first day within the limit of maintaining correct house and brooding temperature. Applying the correct amount of minimum ventilation (not excessive) will also conserve moisture.

It is important to avoid low humidity of the atmosphere during brooding. The ideal is a Relative Humidity (RH) of between 55 and 65%. This will prevent mucous membranes of the respiratory tract from drying out. Dehydration of the chick causes these membranes to dry out and the movement of cilia lining the membranes are retarded. Viruses and bacteria can thus easily penetrate the body.



In areas where humidity is normally low additional water troughs can assist to increase the RH. Gas burners also contribute moisture as opposed to hot water heat exchangers that do not. The end products of combustion of propane gas are CO_2 and H_2O. In cage systems, slight wetting of floors could assist in correcting low levels of humidity.

2.1.8.1 Open Sided Buildings

In natural ventilated buildings less control on ventilation is possible and side curtains or control mechanism is used to control air movement. During brooding, the stack effect of air dynamics is used mainly to control minimum ventilation. This is achieved by closing side curtains leaving minimum opening at the top of the curtain to allow for some air movement upwards and out of the building. Care should be taken that there is sufficient "leakage" through doors and the bottom of the curtain to allow for such air to be replaced from outside.

During brooding the extent of opening the side curtains should be minimal and this will depend on age of birds, outside environmental temperature as well as wind pressure. Chicks should not be subjected to high air movement created by pressure effect of air movement (wind) as they are more susceptible to wind chill, even at normal temperatures. The wind side of the building should therefore be kept more closed than the non-wind side to reduce direct wind into the building during brooding.

The building should also not be kept completely closed to conserve heat as this may soon lead to an under ventilated building during the brooding period

2.1.8.2 Fan ventilated Buildings

In closed houses where ventilation is achieved by mechanical means (fans), there is better control on the fresh air supply into the building and extraction of stale air from the building.

A minimum rate of ventilation must be applied, irrespective of temperature. Such minimum rates of ventilation should be described on ventilation schedules and not judged by conditions in the poultry shed only. Once wet litter conditions and high concentrations of ammonia appear as a result of under ventilation (or too cold conditions) it is normally too late to correct.

Schedules on how to set the minimum ventilation should be calculated for the particular application and applied from the first day. These schedules may be calculated from information presented in the Housing and Ventilation section of this book, using the expected weight for age and the number of birds (biomass) in the building.

Air speed over chicks should be kept below 0.5 m/sec. Note that this is not the inlet air speed but the air movement over the chicks. This is especially important in tunnel type ventilation systems.

Incoming air must be diverted away from chicks and distributed as evenly and quickly as possible throughout the brooding area.

2.1.9 Key Points during Brooding

Some key points during brooding include:

- Check behaviour of chicks. Cold chicks would tend to huddle while hot chicks will move away from the heat sources
- Chicks should be evenly spread out, active and quiet
- Light intensity to be relatively high in the first 7 days (above 20 Lux) and reduced thereafter to around 5 Lux to keep birds calm
- Check condition of manure and litter. Manure should be firm and no sign of blood should be noted
- Adjust feeders and drinkers (height and pressure in the case of nipple drinkers) regularly and remove chick equipment gradually. Birds should be on automatic equipment as soon as possible without undue stress
- Reduce heat supply gradually from the brooding temperature of 32 to 34°C to the required house temperature of 20 to 25°C at 4 to 5 weeks of age
- The aim is to have a uniform flock by 4 weeks of age with low mortality and body weights that agree to the breeder recommendation

2.2 Management during Growout

The main objective in the period 4 to 17 weeks of age is to achieve the correct body mass for age with high flock uniformity and to prepare the flock for sexual maturity and egg production.

Circumstances would differ but some main points include:

- Birds should be weighed weekly to monitor the body weight development. Rapid growth takes place between day old and 8 weeks of age and it is important to ensure that the breed standards are achieved in this period. Skeletal development in this period is of major importance. Daily weight gain decreases in the period 8 to 14 weeks and again starts to accelerate from 14 weeks of age

- Regular adjustments should be made to equipment such as feeder height, drinker height and water pressure in the case of nipple drinkers. In the case of open drinkers, such drinkers should be kept clean
- In the case of floor rearing the litter should be kept dry and any wet patches removed. Wet litter should normally not be a problem with commercial pullets
- The correct environmental conditions including temperature and minimum ventilation should be maintained. It is advisable to have an environmental control programme set up in accordance with particular conditions and house design. Do not guess how to set fans and temperature
- Bird activity and behaviour should be monitored daily
- The recommended light programme should be followed and the required adjustments made as and when required
- The feed program should be adhered to and changes in feed type made timeously
- The flock should be inspected regularly and all mortality and birds showing sign of distress or abnormal development removed. Such birds should be disposed of humanely as soon as is practically possible and not allowed to suffer. This should be ongoing to ensure that at point of lay all sexing errors and cull birds have been removed and disposed of humanely
- Fresh, clean water and feed should be available at all times. Especially with cage system the water supply and pressure at the end of cage rows should receive attention
- Adjustment to feeders and drinkers or any other equipment should be gradual to allow for birds to adjust to the changing circumstances
- In floor rearing systems where birds are destined to be housed in alternate floor laying systems, it is advisable to introduce perches. This will assist in training birds to jump onto the perch structure on the nests

2.2.1 Growth and Body Development

In the rearing period to 18 weeks of age the object is to achieve the body weight for age as suggested by the particular breeder and guides and recommendations of the breeder company should be studied and applied. The weight of individual birds should be as close as possible to this ideal weight for age (high uniformity). This is normally achieved by feeding appropriate feeds for age on an *ad lib* basis. Controlled feeding is seldom practiced but may be required if body weights persist to be in excess of the standards suggested. In most instances in the warm climate prevailing in Southern Africa the difficulty is more often to ensure sufficient growth on body weight development during rearing especially during the initial stages and also with floor rearing systems.

Feed standards and the stages for feeding the various diets would be prescribed by the breeder and this is best left in the hands of reputable feed companies and technical advisors. A two phase feeding regime using a Chick Starter followed by a Grower Feed is normally prescribed for warmer climates and floor operations to ensure good body weight development. A third diet (Developer Feed) may also be incorporated by the feed company in cage rearing systems. These diets are formulated in such a manner that the correct body weight for age is achieved when fed *ad lib*. In instances where the initial body weight gain is not satisfactory, a Pre-starter type of feed for the first three weeks could be considered.

Most breeder companies would also prescribe a Pre-layer diet which is a diet containing higher levels of calcium compared to the rearing diet but not as high as the layer diet. This feed is fed for a very short period (10 to 14 days) before the onset of production.

Possible reasons for poor weights and poor uniformity of pullets could include:

- Poor feed and water quality
- Poor chick quality
- Insufficient feed and drinker space
- Feeders and drinkers not operating properly
- Limited water and feed consumption (supply systems)
- Diseased flock
- Extreme high temperature conditions
- Overcrowding and high stocking densities and late moving of birds from the brooder cages
- Poor housing and ventilation conditions
- Varying methods of weighing

2.2.2 Weighing Procedures

The objective is to rear the flock in such a way that the bird weight for age as per the breed specifications is achieved and that the flock is uniform in body mass. Birds are therefore weighed regularly (weekly) from 4 weeks of age and such weights are compared to the breed standard.

At 1, 2 and 3 weeks of age a sample mass weight is advisable to ensure that the brooding management is allowing chicks to grow normal to the desired weight at 4 weeks of age. With this procedure, chicks are not weighed individually but in mass in boxes or containers and the average weight calculated.

From 4 weeks of age, birds are weighed individually to enable calculation of the average weight as well as the flock uniformity by weighing a representative sample of the flock.

- Irrespective of the flock size at least 150 to 200 birds are to be weighed
- In floor systems the estimated number of birds should be penned off and all of the birds penned off must be weighed. When driving birds into the pens, this should

be done gently without frightening and stampeding. Select at least three spots for penning the birds and pen off an estimated 50 to 70 birds per pen (150 to 200 birds in total) irrespective of house size.

- In cage systems select individual cages randomly throughout the building to total 150 to 200 birds. Weigh all the birds in the cages selected
- The scales used are either 5 kg dial scales with 10 or 20 g weight interval or electronic scales
- The process of bird weighing should occur at the same time and day for individual houses on a weekly basis and in the case of a dial scale being used, recorded on weight charts normally provided by the breeding company
- Once all weights are recorded on the chart, the average weight is calculated. This is the sum total of the number of birds within a particular range multiplied with the range and dividing this with the total number of birds
- When using an electronic scale the calculations are normally done by the scale's software and in some instances the results may even be printed from the scale

2.2.3 Flock Body Weight Uniformity

When weighing birds with a dial scale the flock uniformity is calculated by calculating two cut off points, 10% below and 10% above the mean. The number of birds outside these two cut off points are then added and expressed as a percentage of the total number of birds. The aim should be to have at least 80% of the birds within 10% below and above the mean weight.

With most electronic bird weighing scales the data is calculated automatically. Some makes of scales are equipped with small printers which will print the individual weights recorded as well as the mean weight and coefficient of variation. Although more costly as compared to dial scales they are very useful on larger rearing operations as the process is speeded up and data is much more accurate and reliable.

With electronic weighing, the uniformity is calculated mathematically and expressed as coefficient of variation (CV).

$$CV\% = \frac{\text{Standard Deviation x 100}}{\text{Average weight}}$$

A CV of 8% and lower should be aimed for.

2.2.4 Body Weight and Uniformity Problem Solving

The following key indicators could assist in establishing the possible reason for various problems:

Poor weight gain

- Poor feed and water quality
- Poor chick quality
- Insufficient feed and drinker space
- Feeders and drinkers not operating properly
- Limited water consumption
- Insufficient feed intake
- Diseased flock
- Extreme high temperature conditions
- High stocking densities
- Poor housing and ventilation conditions
- Inaccurate and faulty scales

Overweight birds

- Excessive feed intake
- Incorrect nutrition
- Inaccurate and faulty scales

Poor Uniformity

- Poor chick quality
- Large variation in Parent flock ages from which chicks are supplied
- Insufficient feed and drinker space
- Irregular adjustment to feed increments
- Feeders and drinkers not operating properly
- Diseased flock
- Poor brooding management
- Poor housing and ventilation conditions

- Varying methods of weighing
- Inaccurate and faulty scales
- High stocking density

2.3 Beak Trimming

Pecking is a normal behaviour of poultry and when housed together in large flocks, especially in open sided buildings where light intensity is high, birds should be beak trimmed to reduce the incidence of pecking and cannibalism.

Most breeders would prefer this procedure to be carried out at an early age (before 10 days of age) but it may also be carried out at a later age (4 to 6 weeks), using special machines. The general welfare consensus is that this procedure should be performed at the earliest age possible.

Whatever procedure is followed, beak trimming must always be carried out by properly trained staff using well maintained equipment that is specially designed for this procedure and at as young an age as possible.

2.3.1 Beak Trimming with Hot Blade

Beak trimming is normally done at 6 to 10 days of age using a beak trimmer machine with guide plates and hot blade. The machine is equipped with special guide plates and hot blade for cauterization, which is activated by a switch and moved by means of a camshaft attachment. Chicks at this age are easier to handle but considerable experience is required and staff performing this should be well trained.

Beak trimming at 7 days of age

The beaks are cut with a sharp hot blade with the beaks inserted into a 0.44-cm hole. The thumb is placed behind the head of the chick with the forefinger placed under the throat, pulling the tongue back and tilting the head downwards. The bottom beak should be slightly longer than the upper beak. The beak is to be kept against the hot blade for a period of 2 seconds and most machines have a timed cam shaft which keeps the blade in the downward position for this length of time.

Approximately one third of the beak measured from the front of the nostril is removed. This would however depend on the breed as some breeds may require a more severe beak trimming compared to others. The objective should be to remove as little as possible keeping in mind the effect on pecking and cannibalism. Males are normally trimmed less than females and for broiler breeder males, the beaks are often just tipped.

Key points are:

- Keep a steady rate and do not rush
- Blade must be hot. Most suppliers of machines recommend the blade to be a cherry red colour
- Keep guide holes clean with a brush. Note that over time these guide plates wear out and become larger in size, resulting in excessive cut. Guide plates are to be replaced from time to time
- Blade must be sharp. Replace after every 3000 chicks. Note that different blades are used for early and later beak trimming and ensure that the correct blades are being used
- Always maintain the same procedure and make adjustments in accordance with what observations are made later during the layer stage. Beaks must be rounded and upper beak slightly shorter than lower beak

A second method is to apply beak trimming at 4 to 6 weeks of age but most people concerned with welfare are opposed to beak trimming birds at this age as it is considered to be more stressful for the birds. It is a much slower process as birds are more difficult to handle but a more precise cut is obtained, as there is a larger area by which the length of the beak remaining may be judged. The same machine is used as for 7 day beak trimming but a bar, onto which the blade cuts, replaces the guide plate. The blade would also be different.

The thumb is placed behind the head and the forefinger inserted into the mouth so as to open the beak. The upper beak is then placed on the bar with the head being tilted downwards so as to obtain a cut towards the inside of the beak. The hot blade is pressed downward, cutting and cauterizing the cut for a period of 2 seconds. After cutting the upper beak, the lower beak is placed onto the bar and cut at a length slightly longer than the upper beak (1mm longer).

The length of the cut will depend on conditions and generally one would cut as much as may be required so as not to experience problems in the breeding period. This is usually achieved by removing no more than one third of the upper beak.

Some key points in solving problems include:

- Soft beaks cut back to close to the nostril is caused by blades being too hot (over cauterized) or the beak being cut too short (too large guide plate hole, chicks too young or small)

- Split beaks are caused by blunt blades
- Beaks not rounded and showing signs of pointed growth are caused by the cut not being short enough and blade possibly being too cold. Cauterizing time could also be too short
- Bottom beak shorter than upper beak is caused by head being tilted too far with 6 to 10 day beak trimming or cut and cauterized too much with beak trimming at a later stage
- When the bottom beak tends to grow out much longer than the top beak, then the head was not tilted enough at 6 to 10 day beak trimming or not cut and cauterized enough with beak trimming at a later stage
- If beaks are too long or too short then consider changing the age at which beak trimming is done

2.3.2 Infrared Beak trimming

Hatcheries are increasingly making use of day-old beak trimming with the infrared beak trimming machine available from Nova-Tech. Traditional beak trimming with a hot blade cuts off approximately one third of the upper and lower beak and cauterization seals the blood vessels and prevents bleeding. Infrared beak trimming results in heat coagulation in the tissue culture and the necrosis involves about a third of the upper beak and a quarter of the lower beak in chicks. An important welfare advantage of this method is that research has shown that no neuromas develop, which is relevant with phantom pain after amputation.

With infrared beak trimming at the hatchery the beak is morphologically left intact until the dead tissue drops off at around two weeks of age. A further advantage is that the beak treatment machine is fitted to carry out Mareks vaccination as well. An additional handling on the rearing farm to carry out the 10-day beak trimming is eliminated and chicks do not undergo the stress of the beak treatment at 10 days.

2.4 Light Management

Breeders and suppliers of stock are in a position to advise more closely in this regard to suite particular requirements. Whatever the program used, it is advisable for the time clock settings to be placed in the poultry shed close to the clock controlling the light so as to ensure correct setting and checks throughout the life of the flock.

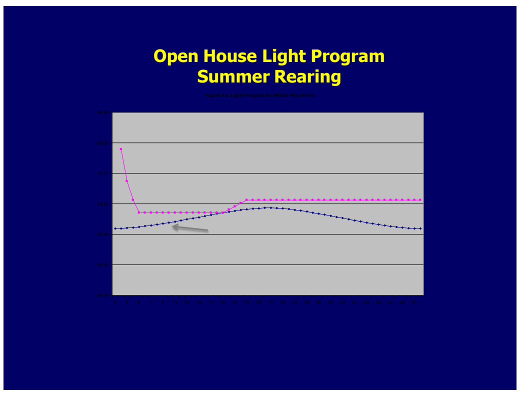
2.4.1 Light Programs for Open Rearing Houses

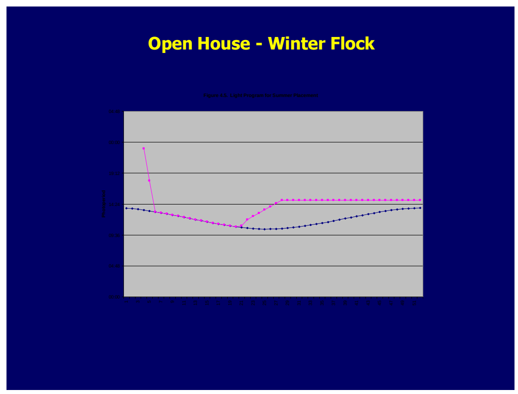
In open type rearing houses the light programme will take cognizance of the seasonal change in natural day length and will be set up in such a manner that the total light (natural and artificial) never increases during the rearing period. A combination of short light periods as well as declining light periods will be followed, depending on the time of year as is indicated in the examples for a summer and winter reared flock, starting with 23 hours for the first week.

The basic principle in such houses is to use the short winter days to delay maturity but during periods of longer day lengths (summer), a declining or combination of constant and declining photoperiod will be used to overcome the effect of the increasing and longer day lengths. In such rearing conditions, it will be difficult to have a constant age at sexual maturity for all flocks throughout the year. Flocks reared during autumn and winter will be later into production compared to spring and summer reared flocks.

An increasing photoperiod is followed at the onset of production and when moving to open laying houses, the total photoperiod provided should be longer that the longest day within the laying cycle, which in South Africa would be in the order of 15 hours. It serves very little purpose to provide for longer than 15½ hours light which is more than providing for twilight period as well.

Some areas such as for example Western Cape have a long summer day length compared to the central and northern regions.

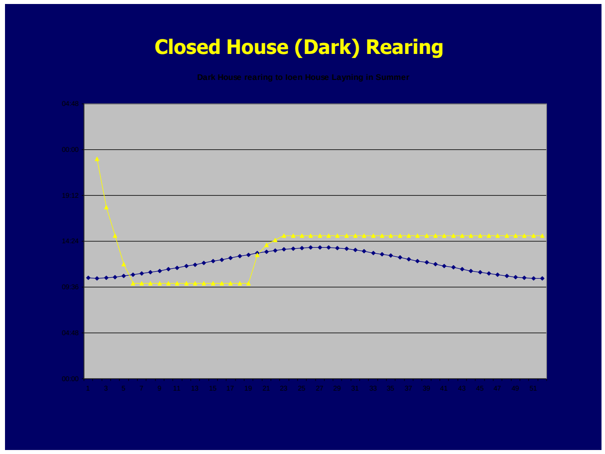




2.4.2 Light Programs for Closed Rearing Houses

In dark houses, the programs will start off with 23 hours light and 1-hour darkness so as to get chicks used to the environment and off to a good start, yet accustoms them to darkness as well.   From 7 days of age the light period will be reduced in weekly steps down to 10 or 8 hours at 4 to 6 weeks of age. Eight hour light and 16 hour darkness will generally delay sexual maturity compared to 10 hours light and 14 hours darkness whilst the longer the period taken in getting down to this level from 1 week of age will also delay sexual maturity more than a quicker period of time.   More detail discussion is presented in the sub heading Environmental Control of the section of Housing and Equipment.

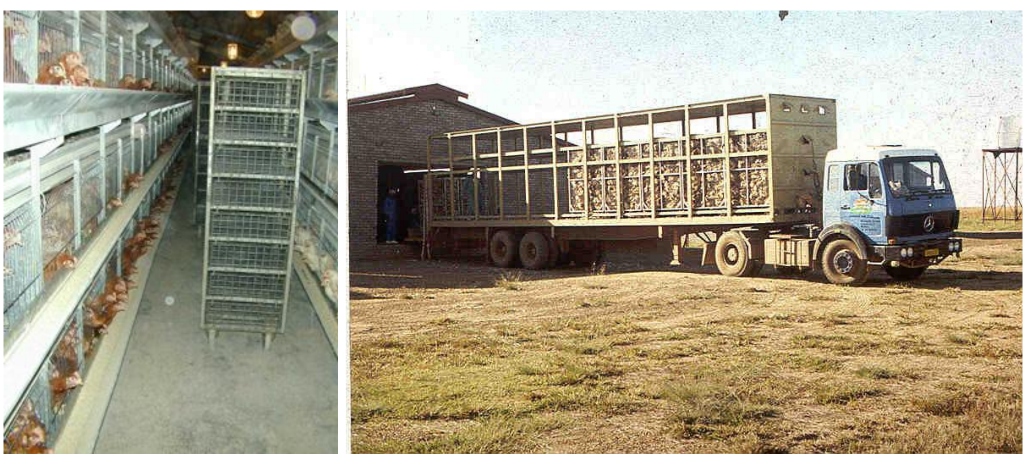
Dark house light programs provide for better control on the sexual maturity of the stock and although some slight seasonal variation may still occur, it is by far less compared to where pullets are reared in open houses. A typical dark house rearing program is presented in the figure below.



When moving pullets to open layer houses the light program will increase to natural day length when this is longer than 12 to 13 hours and at least by 1 hour, when natural day length is less than 13 hours. Thereafter 30 minute to 1 hour increment per week is given depending on the season. In summer the increase to maximum will be rapid while in winter the stimulation could be over a longer period, reaching maximum by 24 to 26 weeks of age.

2.5 Pullet Transport

Birds should always be handled as gently as possible and are normally transported in plastic crates or custom made trolleys.



Transferring pullets to and from custom made trolleys and special vehicles

Some key guidelines need to be followed to ensure animal welfare and good product quality.

- Cull birds should have been removed through constant removal and humane disposal of such birds during the growing cycle
- There is no need to withdraw feed prior to catching of commercial pullets.

- In some instances pullets are transported over great distances and in such instances birds must have had access to feed and water up to the time of loading and the vehicle should also then not be held up unnecessarily
- In floor systems portable wire frames will assist in reducing herding and overcrowding
- Where possible crates and trolleys should be wheeled into the poultry house and birds transferred directly into the crates and trolleys without having to be carried
- Birds are to be caught by the shank and feet (not by the thigh) and gently placed in crates and trolleys
- Avoid trucks standing in direct sunlight and extreme wind and cold conditions. Adequate ventilation through the load is important

3 Layer Management

The modern layer has the genetic potential to produce in excess of 320 eggs within the production cycle to 72 weeks of age with a feed conversion of 2.20 kg feed per kg of eggs or 1.60 kg per dozen.

This will only be possible under conditions of good management in which conditions are created which allows the bird to express this potential. This includes environmental control to ensure that conditions are maintained within the comfort zone of the birds, good preparation of the equipment and housing to received pullets, good management of feed and drinker systems, proper control of lighting to ensure maximum production and the desired egg grading and good overall flock health.

An appropriate record system should be designed to ensure that timeous and properly judged assessment of production and possible problems can be made. These records could vary from keeping of basic information to sophisticated computerized systems which are interlinked to feed weighing, water meters, house temperature and egg counting and weighing devices.

Whatever system is employed, the management of the bird remains the key issue in successful keeping of commercial laying hens.

3.1 House Preparation

Poultry sheds should be properly cleaned with high pressure spray and detergent and disinfected at the end of the laying cycle after all birds and manure have been removed from the building. At the same time flushing, de-scaling and cleaning of the drinker system and cleaning out the feeder system, including the bulk feed tanks should be done.

This is also the stage during which all major maintenance is to be carried out to ensure that all mechanical parts and components are in good working order, prior to placement of the new flock.

At least on a house basis an all-in, all-out replacement schedule must be followed.

3.2 Pullet Placement

Most modern breeds are early maturing and commence production around 19 weeks of age. Birds should be moved to the layer house not less than a week before production commences. Depending on the light program applied in the rearing shed, this would normally be between 119 and 128 days of age (within the 18th week but birds not yet 18 weeks old).

When off-loading pullets the following should be considered:

- Cage gates should be opened before the process starts. It is difficult to open gates with birds in hand and this could result in damage to legs and wings

- Birds should not be handled in the heat of day and should preferably arrive early in the morning. There should be good liaison between the pullet farm and layer farm to ensure that birds do not stand on the truck for unnecessary long periods
- Sufficient staff should be available to have the load offloaded as quickly as possible and where possible wheel trolleys into the shed to enable birds to be transferred directly from the transport system into the cages
- Birds are to be removed one at a time from trolleys and placed into the cages, handling the pullets by both legs and supporting the body where possible.
- Where trolleys cannot be wheeled into the sheds birds are to be carried on both legs into the building
- Do not allow birds to stand in direct sun for any length of time
- The process should be carried out as gently as possible in as little time as possible
- Once the process is complete ensure that all cage doors are properly secure and that the bird numbers per cage are correct. This could be done while activating the drinker system
- Be on the lookout for any cull pullets missed by the rearing farm as well as sexing errors. Such birds, if any, should be moved to the front section of the cages into separate cages for ease of identification and humane disposal if required
- Some feeder systems are controlled by a specific cage row or tier. Birds should be placed into these cages first, especially in larger houses that could take a couple of days or loads to fill
- Once the drinker system has been activated and the birds have settled down (after two or three hours), the feed system should be activated. The initial activation of the feed system should be done manually to ensure that birds are not frightened and injured as the feed system could be different to what the birds have been accustomed to during rearing. Initial feed levels could also be increased to enable birds to feed more easily
- Pullets could lose up to 10% of their body weight at the time of transfer mainly through dehydration and it is essential to ensure that birds start drinking soon after being placed in the cages. Do not weigh birds upon arrival, as this weight will in any event not correspond with the rearing farm weights because of dehydration. For this reason many farmers will not feed birds immediately but rather ensure that birds are drinking. This especially if the travelling distance between the rearing and layer farm is large. It is more important to ensure that birds are taking to the drinker system
- Immediately after placement it is advisable to check all drinkers by activating each nipple drinker manually and ensuring that at least one bird in each cage has found the water system. It is advisable to know what drinker system was used in rearing the flock as birds reared on nipples will adjust to new nipples systems in the layer cage much more easily than birds reared on drinker cups and other open

systems. Birds from floor systems will also take longer to adapt to the new caged environment.

- After placement, the cage passageways are normally dirty and should be cleaned and the house tidied up

3.3 Feeding Layers

Layers should have free access to fresh clean feed at all times. At onset of production a large difference in feed consumption will exist between birds already into production and those lagging in sexual maturity. This is even more so in an uneven flock. Individual consumption will be different from the average indicated by the consumption of the flock.

Once production commences, feed consumption increases rapidly. For this reason adequate feed levels should be provided by the feed system. Regular activation of the feed system or manually levelling the feed in the manually fed troughs will ensure that individual birds receive adequate amounts of feed on a daily basis.

3.3.1 Commercial Layer Feed

Commercial layers will generally be allowed free access to feed and provided the feed is balanced in nutrients, the birds will adjust feed intake to satisfy their energy needs. Diets of varying energy levels may be fed and it is best to discuss this with the feed supplier to ensure that least cost diets are fed. As dietary levels of energy increases, the diets become more dense and costly but feed intake on such a diet decreases. There is a point where the increased feed cost offsets the reduced intake and this point is referred to as the least cost point of nutrient density.

The daily nutrient requirement for amino acids, vitamins and minerals will be determined by the rate of production, egg weight, maintenance requirement and change in body weight. Various models and calculations that have been developed through scientific research are used by feed suppliers. Feed companies have developed tables for the energy, amino acid and mineral content of ingredients used and this information is updated regularly on an ongoing basis to ensure correct information in formulating feeds.

The aspect of feed formulation is best left in the hands of competent feed manufacturers.

3.3.2 Feed Supply

Layer feeds should be formulated to ensure the correct balance between energy, amino acids, minerals and vitamins. The composition of the feed will have a significant effect on performance and profitability as feed cost would normally represent 70 to 80 percent of the farm production cost. Feeds sourced from reputable feed companies should be used and continuous discussion with technical representatives from such companies should be held to ensure correct application of the appropriate feeds.

Feed companies and breeders all have their own formulations and feeding regimes. Generally a program whereby different feeds are fed to suite various feed consumption and production levels are favoured. This ensures that the nutrient intake matches nutrient requirement more closely.

In case of poor performance, it is often impossible to make reference to the particular feed used at the time due to samples of feed not being available. It is therefore good practice to establish a feed sampling procedure for every delivery of feed and to keep such samples for a period of time for reference should this be required. A good sampling procedure would be to take samples of feed at three points (time) during delivery, to thoroughly mix these samples and to then draw a 1 kg sample from this mix to be stored in bottles or plastic packets with the required identification.

3.3.3 Feed Texture

The texture of layer feed is also of importance. Feed will normally be in the form of a mash and it is essential to ensure that the components making up the feed are evenly milled. The feed texture should not be fine and dusty and on the other hand also not very coarse and uneven in particle size.

Very fine material will be dusty and such fine material will tend to settle out during transport and distribution in the feed system. Selective feeding will then occur, resulting in birds not consuming a balanced ration.

For this reason it is good practice to run the feeder troughs very low from time to time to ensure that fine feed material is being consumed and not remaining in the feed troughs for any length of time.

3.3.4 Managing Feed Systems

The objective of any feed system on commercial laying cages is to ensure that fresh feed is available to the birds at all times in such a manner that no wastage of feed occurs. In hot climatic conditions it is also beneficial to stimulate feed intake by activating the feeding system more often. Every time that feeding is activated (by levelling of feed in manual systems and activating the feeders in mechanical systems) the birds will tend to commence feeding.

3.3.4.1 Managing Manual Feed Systems

With manual feed systems feed is replenished on a daily basis, normally in the morning prior to egg collection. Management aspects to be considered in manual systems include:

- Feed should be levelled regularly. Birds tend to scoop feed towards them leaving bare patches. High producing birds consume more feed and if feed is not levelled regularly, their level of consumption could be restricted. This should especially receive attention during early morning before topping up of feed levels commences and again towards the end of the working day
- There should be enough feed in the feed through at the end of the working day to see the birds through to the following morning’s feed time. Feed levels should therefore be monitored early morning before feeding

- Any caked feed should be removed from the feed trough. This especially in the early stages of production when some breeds have the tendency to re-gurgitate feed in especially hot weather conditions causing caked areas in the trough
- Over filling of the troughs results in feed wastage
- From time to time feed levels should be run very low with proper feed levelling to ensure that old feed is consumed and not allowed to build up in the feed troughs
- Damaged troughs should be repaired
- Self drive feed carts are used to speed up the process of feeding but the same principles of feed levels and feed levelling will apply

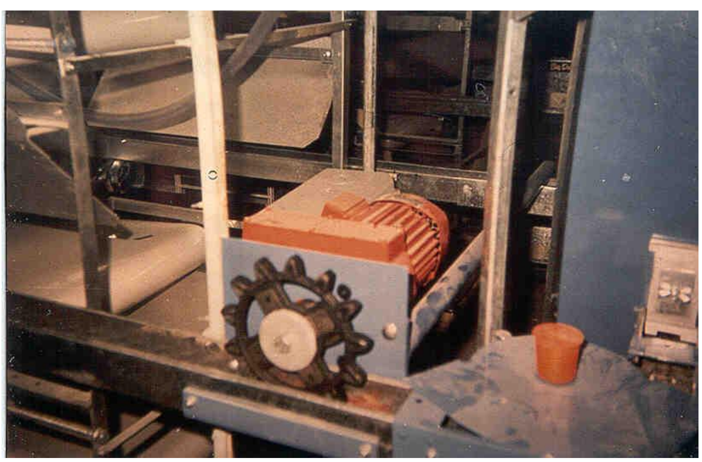
3.3.4.2 Managing Chain Feeder Systems

When placing a new batch of pullets it is advisable to have established what feeding system they have been reared on. Hens that are not used to chain feeders find this very disruptive for the first couple of days. This means that only one stack of cages at a time is fed and the system is to be activated manually and under supervision.

Some basic principles in managing chain feeder systems include:

- Irrespective of how the hens have been fed in rearing the first feeding of new pullets must be done by operating the chain manually. If mass hysteria ensues, continue activating individual feeders manually for a couple of days or until birds are calm and are used the chain
- The level of feed in a chain feeder should be just enough feed to cover the chain by 1cm. This level could be increased for the first couple of days when feeding young pullets not accustomed to chain feeder systems
- When the birds are used to the operation of the chain the system can be set on automatic

- The feeder should run for a period of time with every feeding that allows for the chain to complete a full circuit around the cage row. To measure this place a marker on the chain at the exit from the hopper and time it to when the marker has made a full circuit and is approximately 6 meters beyond its starting point. This is the point at which the system should switch off
- Four feedings per day is normal but could be increased to six feedings if feed consumption is considered to be too low to sustain maximum production. The first feeding should be done when the lights are switched on in the mornings followed by a second feeding soon after as the feeder system could be relatively empty. The second feed is aimed at ensuring the system is properly filled
- During the middle of the day the feeding intervals could be reduced to ensure that the feed level runs relatively low to ensure that all feed is consumed including the finer particles in the feed
- The feeding of birds in the late afternoon is of extreme importance as this is the time of day that the egg and egg shell is being formed in the oviduct. At this stage feed intake will be high as will be the water intake. Ensure that the feed trough is maintained full of feed by running the feeder more often late afternoon
- Ensure that a feed program with operating times is available at the control unit to eliminate all guesswork. Feeder clocks are to be checked daily for running times and settings as well as time
- The feed hopper and feed tank are to be inspected regularly for any blockages and bridging. String and labels often get caught up in the feed hopper resulting in insufficient feed being taken up by the chain when passing through the hopper



The tension of the feed chain should be tested regularly, especially with new installation or major repairs. Excessive tension will result in excessive wear on corner wheels. If the chain is too slack it will be noisy at the drive gear resulting in excessive wear on this gear.

- Switch on chain motor and stand approximately one to one and a half meters away at the outgoing end to the hopper.
- Try to bend links towards each other with the thumb and middle finger. Tension is correct if you can set this gap at 1 cm.
- If looser remove links and if these cannot be bent insert other links. This can only be established when the chain is in motion and care should be taken not to get fingers caught up in the chain.

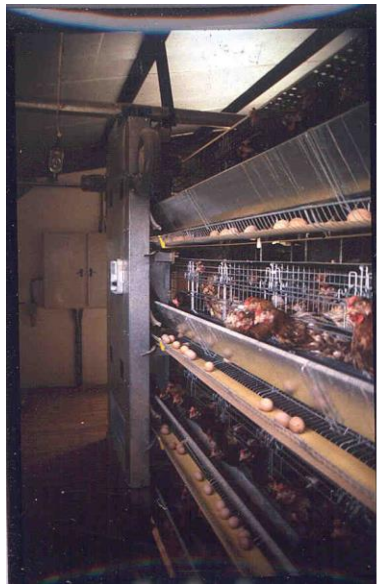
3.3.4.3 Managing Gantry Feeder Systems

The setting of the feed level with gantries is far more sensitive than with chain and some types set more finely than others.

Some basic principles in managing gantry systems include:

- Gantry feeders can be operated more often (6 to 8 times per day, with a feeding being one run down the length of cages) but feeding very low levels at a time which results in less feed wastage
- Again as in the case of chain feeders, it is important to run the feeders at short consecutive interval in the early morning as well as late afternoon and early evening and less often in the middle of the day
- During the stages immediately after placement of the flock, feed levels may be increased to assist the birds in finding the feed in the new environment
- The system should be activated manually during the initial stages after placement until the flock has settled
- Gantry systems are normally installed by having a control mechanism, which ensures that the cross augur will only operate when all of the gantries are parked under the auger
- A safer system is to park the feeders at the non-auger end with the last feeding and to fill the feeders after the first feeding in the morning. Should there be a problem the feed pumped out by the auger will be noticed earlier. It is not advisable to run gantry feeders with lights off as birds could be caught and injured or even killed by the system by getting their heads stuck in the dark between the gantry feeder and cage front
- Gantry bins should be inspected regularly for blockage and bridging of feed.
- Feed in the troughs in a gantry system should be allowed to run very low from time to time to allow birds to consume old feed and fine particles which settle at the bottom of the trough. When replenish feed troughs with low feed levels ensure that the feeder is operated at short consecutive intervals to ensure complete refilling of the trough to the required level

- Any areas where feed has caked should be removed. This especially in the early stages of production when some breeds have the tendency to re-gurgitate feed in especially hot weather conditions causing wet areas in the trough



3.3.4.4 Managing Bulk Feed Bins

The most common problems encountered in management of the bulk feed bins include:

- Bridging of feed which is commonly due to high moisture level in the feed, very fine feed as well as design of the feed bin and boot to the auger
- Leaking bins (water from outside) which results in feed to adhere to the side walls and development of mouldy feed and possible toxins being produced
- High moisture content in feed causing mould growth in the feed bin

From time to time the bulk bins should be allowed to empty for inspection of any leaks and feed sticking to the side walls. With larger buildings it is of great benefit to have two feed bins in tandem so that bins can be run empty and inspected prior to re-filling.

3.3.5 Feeding during Extreme Heat Conditions

Where houses are not equipped with adequate temperature control systems (cooling not possible) certain practices may be suggested to reduce the effects of the high temperature.

- Excess levels of amino acids and imbalances thereof should be avoided. The metabolism of excess amino acids leads to increased body heat production
- The feed should be easily digested and during summer diets with a lower heat increment (higher levels of fat) but similar in energy level are preferred
- The calcium level should be adjusted to compensate for the lower feed intake and it would be beneficial if a coarse source of calcium is used
- Additional feeding of coarse calcium during the late afternoon may also prove to be of benefit as the calcium will be absorbed into the blood stream at a time when it is needed most for shell deposition
- Keep birds calm and do not work with them during periods of hot weather and ensure clean fresh and cool water is freely available

3.3.6 Midnight Feeding

Midnight feeding is the provision of feed during the cooler period of the night for roughly an hour together with lights to improve the feed consumption. This not only to compensate for the low intake during a very hot day but also ensure that the hen receives calcium at a time which allows it to be absorbed into the blood stream to be mobilized directly at the shell gland. This prevents the mobilizing calcium from the medullary bone during the evening and replenishing this calcium later during the hot day.

Midnight feeding is particularly effective during heat stress conditions. During heat stress conditions the hen tends to pant and this fast breathing rate results in a loss of CO^2 from the blood and also a loss of bicarbonate. These bicarbonates are essential for shell formation and are not readily replaced during the dark period. Feeding of sodium bicarbonate during hot climatic conditions will therefore assist as well.

Secondly, hens normally reduce feed intake on hot days in order to reduce their body heat production. As a result there is a reduction in energy, amino acid and calcium intake and consequently a decrease in egg production, egg size and shell quality. By providing feed during the cooler time of the day, the hen is provided with the opportunity to obtain the required nutrients for egg production and bodily functions.

The feeding time should be at least 1.5 to 2 hours and at least 3 hours darkness must be allowed before and after the light period. Therefore, if the maximum photoperiod is 16 hours the 8 hour dark period could consist of 3 hours dark, 2 hours light and then again 3 hours dark.

This additional light has no effect on the normal light program being applied. The midnight feeding can be started whenever the feed intake starts to decline due to hot weather conditions and could be stopped when feed intake is again normal.

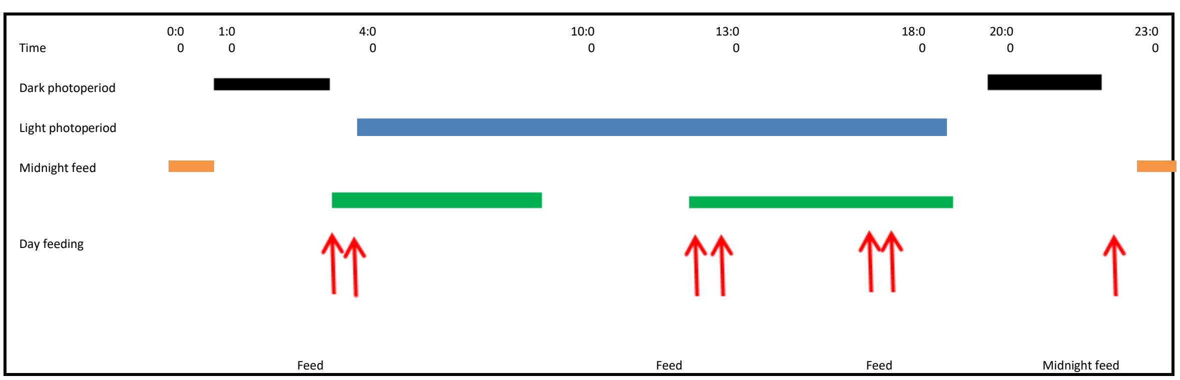
In manual houses the practice is not successful as the feeder system cannot be operated to stimulate to birds to feed. It serves very little purpose to merely switch on the lights without the added stimulation of feeders operating.

3.3.7 Stack Feeding

Most breeders are advocating the practice of stack or meal feeding. This practice consists of operating the feeders twice at short interval early morning when the lights come on and then allowing the feeders to run relatively low during the middle part of day. At around 8 hours into the photoperiod the feeders are again operated twice at short intervals as the feed is then low and this stimulates the birds to feed. The process is again repeated at around 14 hours into the photoperiod of 16 hours in total.

The idea behind this practice is to ensure that birds are fed early morning to allow all feed to be consumed from the troughs mid day and so reduce selective feeding and then to ensure adequate levels of fresh feed later in the day and early evening when the eggs is moving down the oviduct and the shell is being formed.

An example of incorporating midnight feeding and stack feeding into a 24 hour total photoperiod with three hours dark on either side of the light photoperiod is illustrated below.



3.4 Water Management

3.4.1 Managing the Drinker System

Water is an essential part of the daily requirement of stock. As a general rule, at normal temperatures, birds will consume about 1.8 to 2 times the amount of water in millimetres per day, compared to the figure for feed consumption expressed as gram per bird. In other words if the feed consumption is 110 gram per bird, the water consumption will be in the order of 200 to 220 millimetres per day. This ratio will obviously change with colder or warmer temperatures.

Some aspects to be considered in water management will include:

- The flock is to be inspected daily ensuring that all nipple drinkers are functioning properly. Individual cages are to be checked for any bird showing signs of being dehydrated
- Water pressure and supply, especially at cages at opposite end to the water supply side should be checked at least early morning, midday and again before end of the work day. This is especially important late afternoon when water intake is high
- Water consumption is as important, if not more important than feed consumption and accurate water meters are of great assistance in management of layer flocks.
- Birds should have free access to clean fresh and cool water at all times
- Water restriction, if considered, should only be practised under very good management conditions and should not be applied in hot weather conditions or late afternoon
- Inadequate water consumption may not necessarily be reflected in poor production but egg weight could suffer severely
- All reservoirs on farms should be kept free of foreign matter and the entire water reticulation system should be closed from direct sunlight. This includes the header tanks inside the building
- Water storage and reservoirs should be checked daily
- Water from earth dams or rivers should be filtered and chlorinated. In some instances water from boreholes may also require chlorination
- Water with high levels of dissolved solids and salt, should be softened by using water treatment plants
- At least on an annual basis, but preferably more often, the water should be checked for quality (bacterial as well as chemical). Some boreholes have been known to have high microbial counts
- On an annual basis at the end of a cycle water lines are to be flushed out, de-scaled and sanitized

3.4.2 Water Quality

The quality of water used in modern poultry production should preferable comply with that required for human consumption. The numerical limits for various determinants suggested by the South African National Standard for water that, if met, will safeguard the consumer over a lifetime of consumption is presented in Table 3.1.

Table 3.1: Physical, aesthetic, operational and chemical determinants for water (From SANS 241-1:2011 Edition 1)

Determinand	Unit	Standard
Physical and Aesthetic		
Free chorine	mg/L	≤5
Monochloramine	mg/L	≤3
Colour	mg/L Pt-Co	≤15
Conductivity at 25°C	mS/m	≤170
Odor and taste	-	Inoffensive
Total disolved solids	mg/L	≤1200
Turbidity (Operational)	NTU	≤1
Tubidity (Aesthetic)	NTU	≤5
pH at 25°C	pH units	≥5 to ≤9.7
Macro Chemical		
Nitrate as N	mg/L	≤11
Nitrite as N	mg/L	≤0.9
Sulfate as SO_4	mg/L	≤500
Fluoride as F	mg/L	≤1.5
Ammonia as N	mg/L	≤1.5
Chloride as Cl	mg/L	≤300
Sodium as Na	mg/L	≤200
Zinc as Zn	mg/L	≤5
Micro Chemical		
Antimony as Sb	µg/L	≤20
Arsenic as As	µg/L	≤10
Cadmium as Cd	µg/L	≤3
Total chromium as Cr	µg/L	≤50
Cobalt as Co	µg/L	≤500
Copper as Cu	µg/L	≤2000
Cyanide as CN	µg/L	≤70
Iron as Fe	µg/L	≤2000
Lead as Pb	µg/L	≤10
Manganese as Mn	µg/L	≤500
Mercury as Hg	µg/L	≤6
Nickel as Ni	µg/L	≤70
Selenium as Se	µg/L	≤10
Uranium as U	µg/L	≤15
Vanadium as V	µg/L	≤200
Aluminium as Al	µg/L	≤300
Organic		
Total organic carbon as C	mg/L	≤10
Trihalomethanes		
Chloroform	mg/L	≤0.3
Bromoform	mg/L	≤0.1
Dibromochloromethane	mg/L	≤0.1
Bromodichloromethane	mg/L	≤0.06
Microcystine as LR	mg/L	≤1
Phenois	mg/L	≤10

3.5 Light Management

The effect of light on laying stock is discussed in the sub heading Environmental Control of the section of Housing and Equipment. This section deals more with specific light programs. Breeders and suppliers of stock are in a position to advise more closely in this regard to suite particular requirements.

Whatever the program used, it is advisable for the time clock settings to be placed in the poultry shed close to the clock controlling the light so as to ensure correct setting and checks throughout the life of the flock.

3.5.1 Light Programs for Open Rearing Houses

In open type rearing houses the light programme will take cognizance of the varying natural day length and will be set up in such a manner that the total light (natural and artificial) never increases during the rearing period. A combination of creating a constant photoperiod by adding a period of artificial light to the natural photoperiod or using the natural declining photoperiod will be followed, depending on the time of year as is indicated in the examples for a spring and autumn reared flocks, starting with 23 hours for the first week.

The basic principle in such houses is to use the shorter day length in winter as well as the declining photoperiod to delay maturity. During periods of increasing and longer day lengths (spring and summer), a constant photo period will be used to overcome the effect of the increasing day lengths by adding artificial light. When flocks are placed at a time when the natural day length will be both declining and increasing in the 17 week period, for example chicks placed in May and maturing in August, a constant photoperiod will be used which will be based on the longest natural day in the 17 weeks.

With open house rearing, it is not possible ensure a constant age at sexual maturity for all flocks throughout the year. Flocks reared during autumn will be delayed in maturity compared to flocks reared in the spring.

An increasing photoperiod is followed at the onset of production and when moving to open laying houses, the total photoperiod provided should be longer that the longest day within the laying cycle, which in South Africa would be in the order of 15 hours. It serves very little purpose to provide for longer than 15½ hours light which is more than providing for twilight period as well.

Some areas such as for example Western Cape have a long summer day length compared to the central and northern regions.

3.5.2 Light Programs for Closed Rearing Houses

In dark houses, the programs will start off with 23 hours light and 1-hour darkness so as to get chicks used to the environment and off to a good start yet accustoms them to darkness as well. From 7 days of age the light period will be reduced in weekly steps down to 10 or 8 hours at 4 to 6 weeks of age. Eight hour light and 16 hour darkness will generally delay sexual maturity compared to 10 hours light and 14 hours darkness whilst the longer the period taken in getting down to this level from 1 week of age will also delay sexual maturity more than a quicker period of time.

Dark house light programs provide for better control on the sexual maturity of the stock and although some slight seasonal variation may still occur, it is by far less compared to where pullets are reared in open houses. A typical dark house rearing program is presented in figure below.

When moving pullets to open layer houses, the light program will increase to natural day length when this is longer than 12 to 13 hours and at least by 1 hour when natural day length is less than 13 hours. Thereafter 30 minute to 1 hour increment per week is given, depending on the season. In summer the increase to maximum will be rapid while in winter the stimulation could be over a longer period, reaching maximum by 24 to 26 weeks of age.

3.5.3 Light Programs for Closed Laying Houses

When birds are housed in dark laying houses, the light program following rearing may also be altered and controlled better compared to when birds are transferred to open laying houses. In such laying houses the natural changing day length has little influence on the birds.

With such conditions the photoperiod will be increased by one hour steps from the 8 to 10 hour constant photoperiod during rearing to a maximum of 13 to 14 hours. There is no benefit in increasing the photoperiod beyond this. Depending on the rate of decline during the first three to six weeks of rearing, the onset of production may be delayed or enhanced to suite requirements.

An early light stimulation from 15 weeks may also be considered provided body weight profile of the pullets is altered to ensure correct weight at onset of production.

3.5.4 Maintaining Correct Light Intensity

In multi tier cages it is impossible to achieve an even light intensity at all levels as cages are at different height and distance from the light source. The further the object is from the source of light, the lower the light intensity will become. The cages also create shadows.

Some key issues for light intensity include:

- Keep light bulbs clean
- The further the object moves away from the light source the lower the intensity. It is therefore more difficult to ensure correct light intensity and distribution in caged systems, especially multiple tier systems
- Do not expose birds to direct sunlight
- Replace faulty lamps regularly
- Measure light intensity at the feed trough at a point furthest away from the light source, which would be between two light bulbs or fluorescent tubes. At a point midway between two light points at the lowest feed trough, the light intensity should be in the order of 10 lux minimum

3.6 Environmental Control

The objective of ventilation in commercial layer houses is to ensure removal of heat, dust and waste products such as carbon dioxide, ammonia and moisture and to introduce sufficient quantities of fresh air without allowing the temperature inside the building to drop below the comfort zone of the birds.

Temperature conditions would therefore normally determine the amount of ventilation that is to be applied but finer adjustment should be made, taking into account other environmental conditions in the building. Poor ventilation could easily result in respiratory problems due to excessive dust, ammonia and other waste products and insufficient levels of oxygen, which will enhance the susceptibility to respiratory diseases.

3.6.1 Managing Open Sided Buildings

The design and principles on which open sided houses function and operate has been explained in the section on housing. In this type of building less control is possible and side curtains are normally used to control air movement through the building.

Principles of controlling the ventilation in open sided houses include:

- The stack effect of air dynamics is used to control minimum ventilation, if the building has been equipped with a ridge opening. This is achieved by closing side curtains leaving minimum opening to allow for some air movement and the warmed air rising and escaping through the roof ridge opening. The extent of opening the side curtains would depend on environmental temperature as well as wind pressure
- As temperatures increase, side curtains are opened more, the extent of which again would depend on amount of wind, wind direction and environmental temperature
- Under low wind pressure, side curtains will be opened evenly on both sides but under high wind pressure the wind side will be opened less than the opposite side
- Under low temperature conditions, the wind should be diverted away from the birds
- Under high temperature conditions the wind over the birds may be increased to increase sensible heat loss

In the picture below the side inlets for the high rise building to the right have been set relatively closed at the bottom (pit section) with the side curtains at the top closed. The air is therefore allowed in from the bottom and as air in the building picks up heat from the birds, the air will rise and escape out through the vent opening in the roof, allowing more fresh air to enter into the bottom section of the building. The same principle will apply in single storey buildings but the stack effect is less due to the building being lower.

The extent of opening and closing the inlets would depend on temperatures and wind pressure. A sound knowledge of inside as well as outside temperature is of importance to assess the extent of the setting. Do not be too alarmed about some ammonia during early morning.

The side inlets for the high rise building to the left in the picture above have been set open, both in the top and bottom section of the building. The air is therefore allowed in from the side, using cross ventilation (wind pressure) to ventilate the building. The same principle will apply in single storey buildings.

The extent of opening and closing the inlets would depend on temperatures and wind pressure. The higher the temperature, the more open and under very high wind the wind side will be closed off slightly to reduce excessive wind over the birds.

In many areas the prevailing winds may not allow for sufficient ventilation and air movement over the birds. Under these conditions it may be of benefit to place air circulating fans down the passage ways spaced 20 to 25 meters apart within the open sided buildings which, assist in moving the air over the birds.

Example of air circulating fans in cage systems

This air movement over the birds will increase the sensible heat loss and even though the environmental temperature remains relatively high, birds will feel more comfortable due to the movement of air. In cage operations such fans are mounted in the passage ways and slanting downwards to move air longitudinally down the building as illustrated. It is important to note that the building is not being ventilated. This concept simply increases the airflow over birds and in so doing increase the sensible heat loss.

3.6.2 Managing Fan Ventilated Buildings

The ventilation requirement in commercial layer houses equipped with fans will change due to outside environmental conditions. The rate of ventilation is normally activated by the temperature differential between set point required and the actual temperature in the building and will pass through stages of ventilation or speed control of fans to maximum ventilation at a differential of 5 to 6 °C above the set point. Maximum ventilation is therefore reached at a temperature of 4 to 5 °C above set point or at approximately 25°C to 26°C if set point is 20°C .

The design and description of fan ventilated systems have been noted in the section on housing.

Some aspects to be noted in managing mechanically ventilated poultry sheds include:

- An adequate negative pressure of around 30 Pascal must be maintained to ensure proper mixing of air in the building and this is generally achieved when the air speed at the inlets is maintained at 300 to 350 meters per minute. Note this is the air speed at the inlets and not over the birds
- Air speed over adult birds should be low when the air temperature is close to set point (max 0.5 m/sec). Under cold weather conditions the cold incoming air should therefore be diverted away from the birds
- When temperature increases above set point the air speed over the birds can be increased to increase wind chill effect. At an environmental temperature of 30°C an air speed of 2 m/sec will produce a wind chill factor of around 10 °C for adult birds. That is birds will feel 10°C cooler than actual air temperature and in this instance the birds would "feel" as being at 20°C
- A minimum rate of ventilation must be applied, irrespective of temperature. Such minimum rates of ventilation should be described on ventilation schedules and not judged by conditions in the poultry shed. Once wet manure conditions appear as a result of under ventilation (or too cold conditions) it normally will be too late to correct
- As fans increase speed or more fans operate, inlet area must be increased simultaneously, maintaining the desired negative pressure of around 30 Pa or air inlet speed of around 350 m/min

- Fan shutters are to be properly maintained as adjacent fans will be short circuited if shutters do not close properly when fans are not operating
- Often individual fans are equipped with light proofing cassettes. These should be kept clean as dust accumulation will impair air flow. This is of special importance in commercial layer houses as the production period is relatively long and dust will accumulate in these areas
- Fan blades are to be kept clean as dust accumulation will impair the capacity of the fan. This is of special importance in commercial layer houses as the production period is relatively long and dust will accumulate in these areas
- Do not allow doors, especially large entrance doors to stand open as this negates the negative pressure and results in improper ventilation (dead spots) in the shed

- Ensure that the systems is tested and that all shutters and inlets open in accordance with the ventilation program and design of the system
- Properly designed fan ventilated houses will normally produce very good results with good maintenance and management control. A poor understanding of the system however often results in poor performance due to incorrect setting and operation.

3.6.3 Managing Micro Mist Cooling Systems

Most Micro mist systems operate at high pressure through fine nozzles. This forms a fine mist and through the process of vaporization of the water, cooling of the air is achieved. Because of the very fine nozzles used, the water quality is critical and most systems would have their own built in water treatment system. Where water quality is suspect it may be advisable to assist with larger sand filters and water treatment units.

The booster pump ensures adequate water supply to the system and the high-pressure pump ensures the high water pressure, which will create the mist through the nozzles. If pressure and water supply is inadequate, the cooling ability of the system will be influenced.

The point at which the system is operated should not be too low and is generally set at 30°C. The system should not be allowed to operate continuously and should switch off after a given time or sufficient drop in temperature. If not it could result in the system causing wet conditions within the building.

Humidity should not increase above 75%. High humidity will result in the birds finding it impossible to reduce body temperature through latent heat loss via the respiratory system.

The units should undergo a major service at the start of summer and blocked nozzles are cleaned by leaving overnight in an acidic solution such as citric acid or vinegar.

3.6.4 Managing Wet Pad Cooling Systems

Cool pads operate on the basis that water is pumped from a sump into a trough with a V-shaped bottom in which holes have been made. The water flows from the trough onto the pad and any surplus water overflows into the trough at the bottom, from where it flows back into the sump. An amount of water should always be allowed to overflow to ensure that the pad is continuously being flushed. This is achieved by an adjustment valve. The more hard the water (higher in dissolved salts) the more drain off water should be allowed for. Air drawn through the pad then vaporizes the water from the pad, causing the air to be cooled.

Insufficient wetting of the pad results in poor cooling and possible reasons include: -

- Faulty pump
- Incorrect setting of control valve causing dry areas on the pad
- Blocked holes in the trough above the pad resulting in dry areas on the pad

- Blocked pad (dust and calcified mineral deposit). Good water quality (low in dissolved solids) is therefore important in these systems and hard water should preferably be softened through chemical treatment

At the end of the crop, especially during summer, the sump should be drained and filled with fresh water to eliminate build up of minerals in the water. The pads should be regularly rinsed with a light acidic solution to dissolve and flush out any mineral deposit.

Humidity should not be allowed to increase above 75%. High humidity will result in the birds finding it impossible to reduce body temperature through latent heat loss via the respiratory system.

3.7 Routine Checks

Commercial layers are to be inspected at least twice daily, noting any abnormalities and changes in behaviour patterns. It is sound practise to move any suspect or cull birds closer to the front end of the cages from where they can be permanently removed and disposed of in a humane manner, should they remain culls.

Mortality should be removed daily and placed in appropriate disposal systems such as mortality pits. During the process of looking for and removal of mortality, individual cull birds should be removed and disposed of humanely as soon as possible.

The flock should be closely scrutinized, noting the following points:

- Behaviour of the birds. Most modern breeds are reasonably docile and signs of nervousness points to stress which should be investigated further. Be on the lookout for changes in behaviour. Birds should not be quiet.
- Remove mortality at least daily

- Inspect birds for any signs of culls. Remove such birds and dispose of humanely as soon as possible
- Inspect water system and ensure that all birds are receiving adequate supply of water, especially towards the end furthest from the supply end. This especially in hot weather conditions when flow of water and water pressure may be insufficient to provide sufficient water towards the end of the cage row
- Inspect feed system for proper functioning and correct feed levels. Feed should be fresh and no caking in troughs should be noticed. Be on the lookout for bridging of feed in feed tanks and feed hoppers
- Inspect the manure for any signs of change in texture and colour as well as for wet patches caused by leaking drinkers. Signs of dry manure indicate water deprivation. This is of special importance in high rise buildings where manure drops into the pit and is out of sight of normal observation
- Regularly inspect for parasites such as mite and lice
- Inspect eggs noting any areas where eggs seem fewer and also note shell quality
- Check all time clocks for correct time as well as settings
- Check for light bulb failure and replace where necessary
- Check environmental temperature and fan setting where applicable

4 Record management

Analysis and interpretation of production performance data are vital in ensuring upgrading and improvement of performance levels. It is essential to continuously assess the effectiveness of nutrition and management practices. Breeding companies and pullet suppliers will supply standard performance guides and charts and these together with historical data are to be used as benchmark.

Any basic flock record system would consist of data being recorded on a daily basis which is then used to calculate meaningful data daily, weekly as well as for the entire production period. Often key production performance indicators would be displayed and recorded in graphic format in which actual performance can be visually compared to breed standards.

Any basic record system would incorporate the following:

Placement Statistics - number of pullets placed, origin of pullets and hatch date.

Mortality - recorded daily and expressed as a percentage of the stock on hand. This is also cumulated and again expressed as a percentage of the number placed.

Feed - quantities and date of feed deliveries for each feed type should be recorded. A check on the daily feed intake will assist in monitoring progress and timeous reaction to optimize flock performance.

Water - a check on the daily water consumption and comparing it to expected standards will further assist in monitoring progress and taking timeous and appropriate action in case of problems. A decline in water intake can be an early indicator of poor feed quality, disease challenge and other stress.

Body Weight - an awareness of the body weight increase during the period from placement leading up to peak production is of benefit. Layers only reach mature body weight by 40 weeks of age and adequate body weight increase during the pre-peak period is an indication of correct feed and other management procedures. All birds in sampled cages are to be weighed.

Egg Production - daily egg production should be recorded and expressed as a percentage of the number of birds in lay. This data is accumulated on a weekly as well as flock record basis.

Egg Weight - an awareness of the average egg weight and comparing this to the breed standard will be of benefit. Egg weight is an additional tool in monitoring flock performance and satisfactory feed and flock management.

FCR - feed conversion is calculated by dividing the amount of feed used by the eggs produced. If egg weight is available, this can be expressed as kg feed per kg egg basis and if not on the basis of kg feed per dozen eggs.

Vaccination - all vaccinations that are carried out should be recorded, reflecting the date of the vaccination, vaccine type used, batch number of the vaccine as well as a check on the expiry date of the vaccine.

Environment - daily checks on the minimum and maximum temperature should be recorded. This should be evaluated against external temperature

Flock Performance - Flock performance is cumulated on flock records and certain key data is then also reflected graphically on charts.

Computer programs are available to the industry or they could also be developed for particular circumstances.

Hen day production for the day (%)

$$HD\% = \frac{\text{Production for the day}}{\text{Number of hens}} \times 100$$

If monitored daily, it provides quick reference to production at the time and may be compared to breed standard, previous week as well as previous day's production.

Hen day production for the week (%)

$$HD\% = \frac{\text{Production for the week}}{\text{Stock on hand}} \times 100$$

The stock on may be opening or closing stock, average of opening and closing stock or more accurately, the number of hens added over the seven days to take into account mortality.

This record is an indication of what is happening at the time and does not take into account the effect of previous problems as for example mortality rate. The figure is normally plotted against the standard of the breed for the given age.

Cumulative hen housed production (Eggs per Hen Housed)

$$HH\ (\text{number}) = \frac{\text{Cumulative egg numbers}}{\text{Original number of birds placed}}$$

The weekly egg numbers produced are accumulated every week and this figure expresses the performance of the flock to date and as the deviser is the original number of birds placed, it takes into account the effect of mortality. On a hen day basis the flock may be performing on or close to standard, but due to stock losses, for whatever reason, the hen housed production may be below standard.

Weekly mortality %

$$\text{Weekly \% mortality} = \frac{\text{Numbers lost for the week}}{\text{Opening stock for the week}} \times 100$$

Cumulative mortality %

$$\text{Cum Mortality \%} = \frac{\text{Accumulated mortality}}{\text{Number of birds placed}} \times 100$$

5 Egg Formation and Collection

Eggs are produced as food source for human consumption, either for direct consumption as shell eggs or indirect as processed egg products used in food catering. Processed egg products are also used extensively as ingredients in the manufacture of many other food and non-food products.

A thorough understanding of the makeup of the egg and the process by which the egg develops in the oviduct is needed in order to understand the management requirements needed to ensure the production of first grade egg quality for human consumption.

The process of egg collection and conditions in which eggs are stored will affect the ability of the egg to maintain an acceptable level of quality.

5.1 Female Reproductive Organs

The female reproductive organs consist of two main parts, namely the ovary and the oviduct**.**

5.1.1 Ovaries

At the time of early embryonic development, two ovaries and two oviducts develop in the female chick, but the right set atrophies, leaving only the left ovary and oviduct at time of hatching. Prior to sexual maturity the ovary is a mass of small follicles containing ova. Several thousand are present in each female, which is many times the number that will eventually develop into full size yolks in the lifetime of the bird.

At sexual maturity the ovary undergoes many changes due to hormonal activity. Follicle-stimulating hormone (FSH) is produced by the anterior pituitary gland situated just below the brain. In turn the active ovary begins to produce other hormones such as estrogen and progesterone called sex steroids.

It is the higher level of estrogen in the blood which leads to the development of medullary bone, stimulates yolk protein and lipid formation in the liver and the increase in the size of the oviduct. This enables the production of albumen proteins, shell membranes and the cuticle and calcium carbonate for shell formation. Many ova are in different stages of development and about 10 days are required for a single yolk to mature. The yolk consists mainly of fats (lipids) and proteins, which combine to form the lipoproteins. This yolk material is laid down adjacent to the germinal disc that continues to remain on the surface of the yolk mass.

The yolk is not the true reproductive cell but rather the source of food supply from which the minute cell (blastoderm) and its resultant embryo will sustain its growth. Where birds are kept in cages with no males present no fertilization will occur and the blastodisc will be similar in appearance to that of an unfertilized breeder egg.

The Ovaries

5.1.2 Oviduct

The oviduct is a long tube through which the yolk passes and in which the rest of the egg is formed. In growing pullets this organ is relatively small but increases in size with onset of sexual maturity. The segments of the oviduct are the Infundibulum, Magnum, Isthmus, Uterus and Vagina.

5.1.2.1 Infundibulum

The Infundibulum is the funnel shaped upper part of the oviduct and its purpose is to "catch" the yolk as it is released from the cluster of ova. The yolk remains in this section for only approximately 15 minutes, before being forced further down the oviduct by contractions.

If birds are kept in the presence of males within 15 minutes of ovulation a few sperm will find their way to the area of the pronucleus on the surface of the yolk. Three or four sperm may enter but only one eventually unites with the female egg cell to form a new individual, the zygote.

5.1.2.2 Magnum

The magnum is the albumen-secreting portion of the oviduct and is approximately 30 cm in length. The developing egg spends about 3 hours in the magnum during which the albumen is deposited.

Upon breaking an egg, two twisted cords known as the chalazae can be seen extending from opposite poles of the yolk through the albumen. The chalaziferous albumen is produced when the yolk first enters the magnum, but the twisting to form the two chalazae occurs later as the egg rotates in the lower end of the oviduct. The purpose of the chalazae which is twisted in opposite directions is to keep the yolk to the centre of the egg.

As the developing egg passes through the magnum the inner white followed by the dense white and outer white is deposited.

The dense white makes up the largest portion of the egg albumen. This dense white contains mucin that tends to hold the albumen together.

After the egg has been laid, there is a constant change in the interior content of the egg. The thick white does not retain its viscous composition and its volume decreases in relation to the thin white. High storage temperatures enhance this process.

5.1.2.3 Isthmus

The isthmus part of the oviduct is short and the egg remains in this part for approximately 75 minutes. The inner and outer membranes are formed in the isthmus. The shell membranes are not completely filled with contents at this stage and the egg resembles a sack that is partially filled with fluid.

The shell membranes are papery and composed of protein fibres, the inner shell membrane being deposited first. The membranes are held close together but separate at the rounded end of the egg where the air cell will be formed. This air cell only develops after the egg has been laid and increases in size to about 1.8 cm.

As the egg ages, the interior contents dehydrate and the air cell increase in diameter and depth. Conditions, under which the egg is held (temperature and humidity) as well as shell thickness, will affect the rate of dehydration of the egg content and hence the rate at which the size of the air cell will increase.

5.1.2.4 Uterus

The uterus part of the oviduct is primarily the shell gland. The developing egg remains in the uterus for 18 to 20 hours.

By a process of osmosis, water and salt are added through the shell membranes to ”plump” out the loosely adhering shell membranes forming the fourth layer, the outer thin white.

Small clusters of calcium appear on the outer shell membrane just before the egg leaves the isthmus. These are the initiation grains for calcium deposition and their number is probably inherited and plays an important role in amount of calcium deposition that will occur later. They disappear a short while after the egg enters the uterus. The shell consists of the initial mamillary layer (spongy calcite crystals) and the outer shell, which is made up of hard crystals. The completed shell consists almost entirely of calcium carbonate with small deposits of sodium, potassium and magnesium.

The sources of calcium are the calcium in the bloodstream originating from absorption from the intestinal track and from certain bones. Medullary bone serves as a calcium reservoir, especially at night when birds are not eating and shell is being deposited.

Several factors influence shell quality and include:

- Age of the bird. This is believed to be due the bird not being able to deposit sufficient calcium carbonate to cover the larger egg
- Increased environmental temperatures
- Stress could affect shell quality

- Certain poultry disease will affect shell quality
- Certain drugs will affect shell quality
- Certain breeds have poorer shell quality than others
- Nutrition will affect shell quality. This includes availability of calcium in the raw materials as well as other nutrients such as especially phosphorus and vitamin D.
- The size of the calcium source is also believed to play a role. Coarse calcium will remain in the intestinal tract for a longer period which makes calcium available in the blood stream later at night when shell is being deposited

5.1.2.5 Vagina

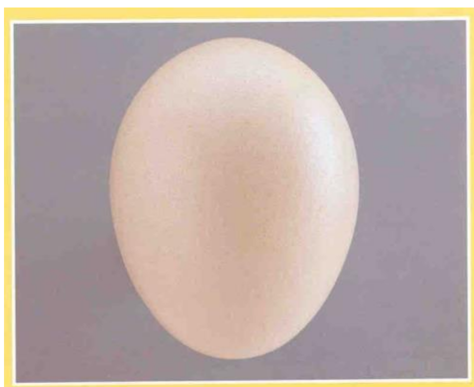
The vagina is the last section of the oviduct prior to the cloacae and vent and is about 12 cm in length.

In this part the cuticle, which gives the shell a shiny/waxy appearance, is deposited.

The egg eventually passes through the cloacae and vent, roughly 25 to 26 hours after ovulation.

5.2 The Chicken Egg

The egg consists of four main parts namely the Shell, the Shell Membranes, the Albumen and the Yolk. In eggs produced for human consumption no males are kept with the females so the eggs will not have been fertilised.



5.2.1 The Shell

The shell consists almost entirely of calcium carbonate (90 to 95%) and comprises 10 to 12% of the weight of the whole egg. The shell consists of an inner mamilliary layer and an outer spongy layer.

The spongy or crystalline layer is the main part of the avian shell and is largely responsible for its mechanical strength. It consists of elongated structures that are perpendicular to the shell surface. Pores through the calcified layer permit diffusion of gases and water vapour.

Chemically the calcified layer is mainly calcium carbonate.

5.2.1.1 Shell Cuticle

The cuticle is a thin layer on the outside of the shell which gives the freshly laid egg a glossy-like appearance (bloom). The function of the cuticle is not clear but it may be speculated that it helps repel water, it may assist in increasing shell strength and it could also play a role in preventing microbial penetration.

5.2.1.2 Shell Pigments

Pigments in the eggshell are confined to the cuticle and outer part of the calcified layer. The only commercial importance of shell colour is that certain geographic regions (markets) have preference for brown-shelled eggs as opposed to white shelled eggs. The brown pigment in brown egg layer strains are porphyrin derivatives of haemoglobin metabolism and are deposited during the last two hours of shell formation. The three main pigments are protoporphyrin, biliverdin IX and its zinc chelate. Protoporphyrin tends to give a more brownish shell colour and the biliverdins blues and greens. Breeders of brown shell layers are continuously selecting for more uniform and intense brown shell colour. The brown pigmentation declines towards the end of lay. White eggshells contain a very small amount of pigment.

5.2.1.3 Shell Strength

Shell Strength is an important genetic trait and especially so in layer breeders.
Methods used by breeders to determine shell strength include:

- Specific gravity
- Deformation
- Compression (laterally and longitudinally)
- Puncture (with fast and slow moving objects)
- Impact

Selection for improved shell strength, especially towards the latter part of the production cycle remains a priority for all layer breeders. It is not such an important trait in broiler breeding but is nevertheless not ignored in these breeding programs.

5.2.2 The Shell Membranes

Two shell membranes, the inner and outer membranes, are found just below the shell. They are adjacent to one another except for the broad end where they are separated by the air cell. The membranes retain the fluid of the albumin and other biological functions include the anchoring of the embryo and resistance to penetration of micro-organisms.

The two shell membranes are separated at the round end of the egg to form the air cell. In a fresh egg, the cell is approximately 15 to 20 mm in diameter and 3 to 4 mm in depth. As the egg ages the diameter and depth of the cell will increase and the speed at which this happens will depend primarily on the temperature at which the egg is kept. At colder temperatures, the increase in size will be retarded while it is enhanced at higher temperatures.

The air cell can be seen when candling and enlarges during the process of incubation. This is also the area into which the beak of the developed chick will move during hatching when the process of respiration starts towards the end of the incubation process. This is the reason why embryonic development must occur in the correct position to ensure that pipping is in the correct place of the egg and that the chick is properly orientated in respect of the air cell when hatching.

5.2.3 The Albumen

The albumen makes up the larger portion (58%) of the avian egg and may be described as a transparent gelatinous mass surrounding the yolk, consisting of 88% water and 12% dry matter. The functions of the albumen include:

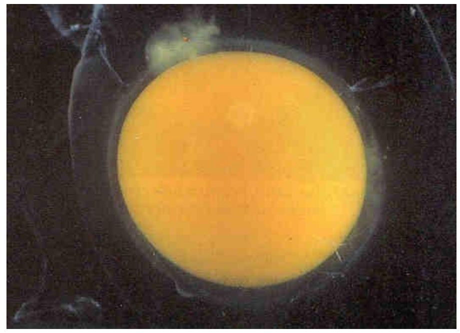
- Prevention of growth of micro-organisms
- Provide water, proteins and other nutrients for the developing embryo
- The Chelazae holds the inner thick and yolk to the centre of the egg

The albumin consists of different layers of outer and inner thin white, the percentage of which could vary but in general would be found in the following proportion:

Outer thin	23%
Outer thick	55%
Inner thin	20%
Inner thick	2%
Chelazae	(< 0.5%)

On a flat surface the albumen of a fresh egg has a heaped jellylike appearance. By contrast, the albumen of an old egg, especially when stored under poor conditions is more fluid and less viscous. A fluid like albumen is an indication of an old egg, although some birds will produce eggs with watery whites, especially when certain diseases are present.

This firmness of the albumen is used as an indicator of freshness of or interior quality of the egg and the measure is generally known as the Haugh Unit Measure.



An electronic Haugh meter with egg yolk showing the chalazae and firm white

5.2.4 The Yolk

The proteins and lipoproteins of the yolk are not synthesized by the ovarian tissue but in the liver from where they are transported by the blood system to the ovaries. The liver undergoes major changes during the few weeks prior to commencement of production in which anabolic activity intensifies and this activity ceases completely once lay no longer occurs. Liver disorders are often associated with egg layers and commonly referred to as fatty liver syndrome.

Yolk comprises mainly of water, lipids and protein. It makes up roughly 31% of the whole egg and contains 48% water and 52% dry matter.

The main function of yolk material is to provide metabolic energy and nutrients to the developing embryo.

5.3 Egg Quality

Quality will always remain a subjective issue but in the context of this book quality may be defined as the desired characteristics of shell eggs as preferred or desired by the consumer.

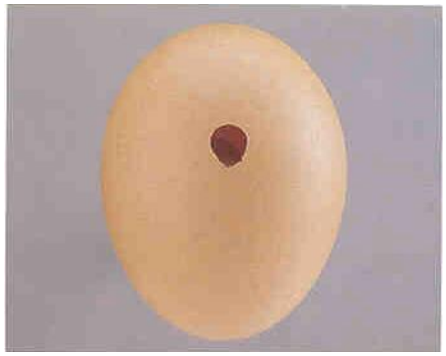
5.3.1 External Egg Quality

External egg quality normally relates to imperfections of the shell. There are many causes of poor shell quality and although breeders have paid much attention to this trait in the breeding programs the shell quality (strength) deteriorates with flock age, especially after 60 weeks of age.

5.3.1.1 Open Cracks

Open cracks are large cracks associated with the shell membranes being damaged or broken and the content of the egg being exposed. These eggs should preferably be removed during collection to ensure that other clean eggs are not dirtied and stained.

Most open cracks are toe cracks, which are eggs that have been caught up in the cage floor resulting in the hen's toe to punch through the shell and also breaking the shell membrane. Cage design, as well as increased stocking density is the most likely cause when this is noted at high levels with normal shell strength.

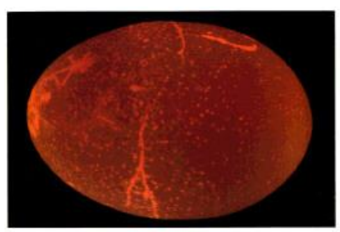


5.3.1.2 Hairline Cracks

Hairline cracks are very fine cracks and are normally detectable by candling only. Poor shell quality will result in an increase in hairline cracks.

Hairline cracks often develop with undue pressure being exerted on the egg by poor egg collection systems. Areas to be looked at include infrequent collection resulting in excessive eggs on the egg collection system, poor transfer from one system to the other (egg belts to cross conveyors to egg packers, etc.) as well as poor maintenance and setting of egg packing machines.

With manual egg collection hairline cracks would also develop by poor and rough handling of the eggs, poor condition of egg trays as well as stacking egg trays excessively high.



5.3.1.3 Impact Cracks

Impact cracks develop outwards from the central point of impact and are caused by eggs hitting other eggs or objects at a force causing the shell to crack but the shell membranes remain intact. With severe impact, especially against sharp objects, the shell membranes will be damaged as well.

Infrequent egg collection (high number of eggs on the egg belts) as well as poor cage design and maintenance of egg handling systems would cause an increase in impact cracks.

5.3.1.4 Thin-shelled Eggs

A high incidence of thin-shelled eggs is normally associated with poor calcium deposition and factors such as nutrition (calcium, vitamin D) and diseases (IB, NCD) could be implicated. In brown shell layer the deterioration in shell quality due to disease would normally be associated with more white eggs being produced including rough ends and poor egg shape. Genetics could play a role but in most modern breeds shell strength as well as thickness is considered to be an important trait selected for in the breeding program and most modern breeds are known to have good shell quality traits.

Usually the production of eggs without shell (eggs only have the shell membranes formed) is associated with Egg Drop Syndrome (EDS).

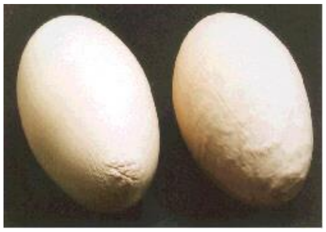
5.3.1.5 Effect of Flock Age and Temperature

As the flock ages the shell strength will deteriorate and especially from 60 weeks of age and older the shell quality deteriorates more rapidly. This is exacerbated by very hot environmental temperature conditions. Panting reduces the ability of the blood to transport calcium needed for shell formation due to the lowering of CO_2 caused by the panting. The effect of high environmental temperature is rapid and recovery when temperature returns to normal is as rapid as the decline in quality.

Feeding of additional levels of calcium and vitamins has some positive effect especially if the feeding of additional calcium is in the form of courser source of calcium in the late afternoon. The reason for this is that the release of calcium from the digestive track into the blood stream occurs at the time when shell formation is taking place (peak blood calcium level) and this makes the calcium directly available for shell formation.

5.3.1.6 Misshapen Eggs

Misshapen eggs are those eggs with flat sides, round eggs and eggs that show ribs or grooves. The causes are generally overcrowding of the cage (stocking density), disturbances (flightiness) and diseases such as especially IB. The latter is then usually associated with an increase in the number of eggs with poor shell quality (rough rounded ends) and pale shell colour eggs (in brown egg layers).



5.3.1.7 Windowed Eggs

Windowed eggs show small translucent streaks on the shell when candled. They are often referred to as potential cracks as the area of translucency is the weakest point on the shell. Moisture moves into these areas much easier, causing shell weakness at this point.

Under normal circumstances some translucent eggs will occur, but it should never be higher than 1% and egg-packing plants will normally not remove these eggs.

The reason for translucent spots/streaks is described as being due to moisture penetrating the shell shortly after the shell has been formed. It is usually coupled to genetics but the incidence also increases when calcium deposition is impeded. A shortage of copper has also been documented as a possible reason but occurs very seldom. This should be distinguished from thin-shelled eggs since the translucent area is normal in thickness but this is however a weak area in the shell. Any pressure on the shell (poorly maintained egg graders, poor egg collection systems, rough handling, etc.) will cause the eggs to crack at this point.

5.3.1.8 Rough-shelled Eggs

Rough-shelled eggs are those eggs with rough textured areas. The whole surface or only part thereof, especially the round end could show this rough texture. This is normally associated with diseases such as IB and NCD and is often seen in association with general poor shell quality.

5.3.1.9 Banded Eggs

These eggs show an imperfection around the centre part and the imperfection encircles the entire egg. The hardening process of the shell takes about 12 hours and crowding and flightiness places more pressure on the sides of the birds themselves and so also the egg which is in the uterus. The larger diameter of the eggs is affected more and may crack, to be covered later with more shell material. Any excessive bird activity during late afternoon and early evening should be avoided. More banded eggs will be seen during IB breaks but other stress factors such as overcrowding and flightiness will also result in an increased number of banded eggs.

5.3.1.10 Pimples

Pimples are small lumps of calcified material on the shell and the incidence varies with age and breed. It is normally not associated with a disease, but is the result of particles of calcium on the shell surface. A small pinhole will result, should the pimple be removed. A high incidence of pimpled eggs is associated with stress factors causing a disturbance in calcium deposition.

Pimples should however be distinguished from rough shelled eggs normally associated with thin shelled eggs (poor calcium deposition).

5.3.1.11 Pinholes

Pinholes are very small holes in the shell and possible causes are genetics, removal or breaking away of a pimple described above as well as general stress causing interference of normal calcium deposition. Sharp objects on the cage floor (poor galvanizing and welding of the wire mesh) could also be a possible cause.

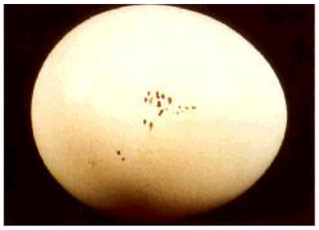
5.3.1.12 Bloom on the Shell

The shell surface should have a bloom or shiny appearance, especially so with younger flocks. Dull eggs are normally associated with stress and disease. This bloom is brought about by the waxy-like cuticle deposited at the end of egg formation.

The bloom does deteriorate as the flock ages. Washing of eggs will remove the cuticle and the egg will also then lose this bloom. This can be restored by oiling the eggs.

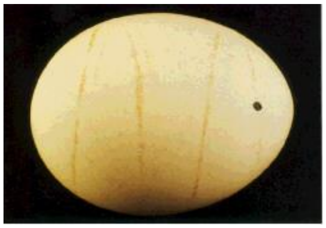
5.3.1.13 Fly Droppings

Severe fly infestation on the farm resulting in fly droppings on shell surfaces could pose a major problem in poorly managed operations.



5.3.1.14 Wire and Dirty Marks

Wire and dirt marks (lines) on the shell surface are caused by dirty cage floors, especially when relative humidity is high.



5.3.1.15 Fungus and Mildew

Fungus and mildew on the shell surface may be seen under extremely poor storage conditions. This is a green coating of powdery like material (sometimes black) seen on the shell surface.

5.3.1.16 Stains on Shell Surface

Staining on the shell surface could be as a result of various substances such as blood, faeces and contamination from broken egg matter. White eggs would show such staining much easier. Possible problems may include:

- Excessive wet litter (diarrhoea) which results in staining as a result of faeces adhering to the shell. Nutrition and water quality could be possible causes.
- Prolaps and pecking will result in increased number of eggs showing blood stains.
- Poor maintenance on egg collection systems as well as diseases (or any other factor) causing poor shell quality which in turn results in increased egg breakage on egg collection systems. All of these factors will result in increased staining of eggs by internal egg material (yolk and albumen).

5.3.2 Internal Egg Quality

Internal egg quality is measured and perceived by the consumer in many different ways.

Some of these factors may be seen when candling eggs but for most internal quality characteristics, the egg has to be broken.

5.3.2.1 Air Cell

The two shell membranes are separated at the round end of the egg to form the air cell. In a fresh egg the cell is approximately 15 to 20 mm in diameter and 3 to 4 mm in depth. As the egg ages the diameter and depth of the cell will increase and the speed at which this happens will depend primarily on the temperature at which the egg is kept. At colder temperatures, the increase in size will be retarded while it is enhanced at higher temperatures.

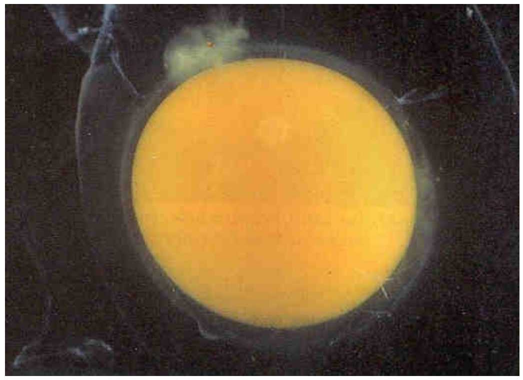
The air cell can be seen when candling and size of the air cell is used in grading regulation standards.

5.3.2.2 Yolk Quality

Yolk quality is normally associated with the following traits:

- **Yolk Colour** - The density of the yellow pigment in the yolk is closely related to the xantophylls in the ration. Consumers vary in their preference for yolk colour and in many cases the diet is altered to meet consumer demand. The measurement of yolk colouring has been standardized by the "Roche" colour fan.

This is a set of yellow coloured blades varying from a very light yellow (1) to a dark or almost reddish yellow (14)



- **Yolk Mottling** - Mottled yolks occur when the colouring on the yolk is patchy and uneven. Some degree of mottling occurs is most eggs but it becomes more severe and noticeable with poor handling and storage, thin shells and high levels of cottonseed meal in the diet
- **Double Yolk Eggs** - At the onset of production especially, a higher degree of double yolk eggs will be noticeable. Once the birds metabolic system has settled down the incidence of double yolk eggs will decrease

5.3.2.3 Albumen Quality

The quality of the albumen as perceived by the consumer relates to the physical attributes such as viscosity of the albumen and the ratio of thick and thin albumen. The albumen quality measurement has been standardized in the Haugh unit measure which in effect takes into account the height of the thick albumin in relation to the size of the egg. A standardized micrometer is used to determine this. A figure above 70 and higher is considered as being indicative of acceptable albumen quality.

As the egg ages the albumen is broken down and becomes watery. The Haugh unit value will deteriorate and the rate of deterioration is affected by higher storage temperature.

Albumen quality of a young flock should be in the region of 85 plus and this deteriorates in a straight line to about 70 to 75 by the end if the laying cycle at 72 weeks of age.

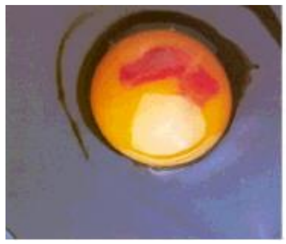
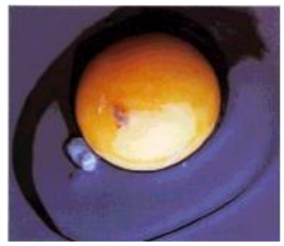
Factors such as flock age, storage temperature, disease challenge (IB and NCD) all play a role in the Haugh value at the time the egg is laid.

Discolouring of the white is seldom seen. The normal, slightly yellow-green colour of the white may darken to an objectionable yellow or green colour and could even become pink. Excess levels of riboflavin, cottonseed and ageing as well as very poor storage could play a role.

5.3.2.4 Blood and Meat Spots

Varying sizes of blood spots may be seen and this would normally be in the region of 1 to 2%. Abnormal levels of blood spots and larger appearance of blood in the egg could be due to vitamin K and A shortage and fungal toxins in the feed. Some breeds are more prone to the production of blood spots and flightiness may also be the cause. The origin of the blood is at the point of the ova being ruptured from the ovaries.

Most meat spots are small pieces of tissue but some may be broken-down blood spots. The incidence could vary from the norm of less than 3%. Breed (brown egg layers higher that white egg layers) and bird age plays a role.

5.3.2.5 Odours and Flavours

Some eggs may have an unusual and unacceptable odour or taste. Eggs have a large capacity to absorb odours from surrounding atmosphere as the shell is porous. When stored in proximity to fruit, gasoline, decaying material, etc., the odour from these will soon be noticeable in the egg when the shell is broken.

Off-flavouring may also be caused by the diet. Poor quality fish meal, weed seeds which may land up in cereals used will cause off-flavours. These odours are often found in the yolk as many of the compounds producing the off-flavour are fat soluble.

5.3.3 Candling Eggs

Egg candling is the process of passing eggs over high intensity lights for easier detection of shell imperfections and larger blood and meat spots.

Individual candling lights are used for egg quality control and inspection of individual eggs.

Egg grading machines are equipped with candling lights and more modern larger machines with crack detectors, the sensitivity of which may be adjusted.

Brown shelled eggs are more difficult to candle compared to white shell eggs. When an egg is candled, the yolk creates a definite shadow, which is more pronounced in white-shelled eggs as compared to brown-shelled eggs. In a fresh egg the shadow of the yolk is light as the thick albumen keeps the yolk more to the centre of the egg and therefore away from the shell. In older egg, the albumen becomes thinner, allowing the yolk to move closer to the shell when rotated and creating more of a shadow.

The air cell can also be seen when the egg is held over a candling light.

Blood and meat spots will appear as dark objects

5.4 Egg Collection

Egg collection may be done manually or through the use of egg collection systems. Whatever the method, the objective is to perform this as often as possible (daily) and as gently as possible, placing visually clean and non-broken eggs onto pulp or plastic egg trays, usually holding 30 eggs. Eggs should be placed round ends up. This is the end at which the air cell is situated and the packaging material is shaped to hold and support the egg in this position.

5.4.1 Manual Egg Collection

With manual systems eggs are gathered from the front of the cages onto 30-egg trays, moving down the aisle with a cart onto which the egg trays are stacked. At the front of the house the egg trays are then transferred onto egg trolleys, which are used to transport the eggs to the egg holding room and then onto the egg grading and packing factory.

During the process of gathering eggs the following principles are important to ensure maximum quality:

- Eggs should be placed with round ends up as this improves the egg holding quality and when handled in this manner breakage is reduced
- Visual broken and dirty eggs, as well as very large eggs that may break on the egg tray are to be placed onto separate egg trays during the process of collection
- Egg trays should not be stacked higher than 6 to 8 trays per stack, especially with older flocks

The speed of collection will vary according to degree of selection for quality eggs during the gathering process. Experienced staff should gather between 3000 and 4000 eggs per hour.

A high incidence of cracked eggs in manual collection systems could be due to:

- Cage floors too steep
- Infrequent gathering of eggs
- Poor shell quality (nutrition, water, disease)
- Damaged cage floors
- High stocking densities
- Old flock
- Poorly trained staff and rough handling
- Stacking egg trays too high
- Poor quality egg trays

5.4.2 Mechanical Egg Collection

Most of the egg breakage and damage occur on the battery cage itself (60 to 75%). Should the incidence of breakage be higher on the collection belts and collection systems poor maintenance and settings of the system should be investigated.

The egg collection system should be cleaned regularly to ensure a high percentage of good quality first grade eggs. This is of special importance when the flock is old or when a disease or other causes result in poor shell quality and a higher percentage of eggs breaking and soiling the system.

This cleaning of the system is best carried out by hand using cloth and detergent. High pressure washing is not recommended as this may result in damage to moving parts.

5.4.2.1 Cleaning and Maintenance of Egg Belts

In the management of egg belts the following aspects should be considered:

- Egg belts should not be torn and stitching of joints should be such that the overlap does not move against the cage wire and brackets
- Belts should not be tensioned too tight
- Brushes and cleaning gear should be maintained in serviceable condition to ensure that belts are being brushed clean of dust and dry egg material. Most systems have brushes at the end of the cage row and dust and debris should be removed regularly.
- Woven jute or nylon belts are often preferred to plastic belts as yolk material is absorbed by the woven material, causing less spoilage of other eggs.

5.4.2.2 Cleaning and Maintenance of the Transfer System

The transfer of eggs from the belts to the transfer system should be smooth without causing damage to eggs. Eggs should not be pushed onto the transfer system as this result in breakages.

Elevator systems should be kept clean and trays into which eggs with no shells drop are to be cleaned and replaced daily.

The cross conveyor system is most difficult to keep clean. Chain conveyers require lubrication and special drip oilers are installed at the end of the system. Do not over oil and use high quality food grade oil only. Over oiling results in the rods becoming soiled and dirty and together with dust creates dirty grime on the conveyor increasing friction and drag. With most systems brushes are installed under the packer where the conveyor returns to the building after eggs have been removed by the packer. These brushes are to be cleaned daily after collection process is complete.

Transferring of eggs from the transfer system to the cross conveyor should be smooth without eggs rolling out fast onto the cross conveyor and hitting other eggs already on the cross conveyor.

Regular inspection and maintenance of the cross conveyor includes checking for friction on bearings, drive gear and chains. Ensure that rods are not bent and adjust tension where necessary.

Do not overload the cross conveyor and ensure that the speed of collection is such that the packer is kept full without unnecessary stop and starting. This places a tremendous strain on the drive units and chain.

5.4.2.3 Cleaning and Maintenance of the Egg Packer

The packer system should have sufficient capacity to have time available for cleaning of the system at the end of the day and at least a portion of the conveyor as well

Farm packers are specialized machines and are to be regularly serviced by competent people. Suppliers of such equipment will have maintenance manuals available.

Eggs should be transferred from one system to the other in a smooth manner and not by eggs being "pushed".

The machines should be cleaned daily and floor the area surrounding the machine where egg breakage will occur is to be washed daily, ensuring that water does not spill onto critical electric and other parts of the machine. A suitable detergent that will not result in odours being left and picked up by eggs should be used.

5.5 Egg Washing and Oiling

5.5.1 Egg Washing

Egg washing to remove stains and dirt should only be done with specially designed washing machines. Poor washing of eggs will destroy the cuticle on the shell surface and when not stored correctly after washing the risk of bacterial contamination is increased.

Wash water temperature should be 10°C warmer than egg temperature. This is to assist in reducing the possibility of microbial penetration into the eggs. The wash water temperature would therefore depend on the egg temperature. Specialized detergents are available from chemical supply companies for use in egg washing machines. After washing, the eggs should be rinsed with water which again is higher in temperature (2 to 3°C) than the wash water. This water should contain an appropriate sanitizing agent such as sodium hypo chloride. Immediately after rinsing the eggs should be dried by fans blowing air over the eggs to avoid possible microbial penetration.

Washing of eggs damages the cuticle and washed eggs should preferably be oiled to restore the capability of the shell to reduce bacterial contamination as well as deterioration of the albumen quality.

5.5.2 Oiling of Eggs

Oiling of eggs consists of spraying the eggs with a light film of tasteless mineral oil. When eggs have been washed this is done immediately after drying. The oil seals the shell pores which are exposed after washing and prevents weight loss as well the escape of carbon dioxide from the egg. By retaining the carbon dioxide in the egg, the increase in pH is slowed down and this preserves the egg quality (Haugh Units) and air cell size.

Oiling of non-washed eggs will also assist in preserving internal egg quality. Such eggs will however be difficult to shell after boiling as the membranes are then difficult to separate from the shell as a result of the lower pH.

5.6 *Egg Storage*

As soon as the egg is laid it cools down from body temperature causing the internal contents to contract. The shell is porous and exchanges of carbon dioxide in the air causes chemical reaction in the egg, resulting in an increase in pH and the deterioration in albumin quality. Direct loss of moisture through the porous shell results in weight loss.

This process may be slowed down under cool conditions. Although the market chain of eggs in South Africa is not cooled, cooling of eggs during storage on the farm, especially if such eggs are not marketed within a day or two, will assist in delaying deterioration in egg weight and quality. Farm egg cool rooms will generally be held at 24 to 25°C and a relative humidity of 70 to 75%. A high relative humidity assists in slowing down the moisture loss. Very high humidity levels (>80%) are conducive to mould growth.

6 Flock Health and Hygiene

The manifestation of a disease depends on the aggravating (assist in bringing about the disease) and mitigating (assist the bird to combat the disease) factors. The disease causing agent such as particular viruses, bacteria, protozoa or toxins must be present for the disease to manifest itself. Without them, the disease will not occur.

Various factors such as stress, low feed intake, malnourished and underweight birds and poor environmental conditions are examples of aggravating factors caused by poor management.

A well nourished bird, with a high level of immunity (well vaccinated) are examples of mitigating factors brought about by good flock management.

Poor control on the biosecurity measures increases the risk of disease causing agents to spread onto the farm and consequently the risk of the disease to manifest itself.

In managing a layer flock, it is essential to know and understand the difference in appearance between healthy and sick birds.

Table 4.1 Difference between Healthy and diseased birds

	Healthy Bird	Sick Bird
Stance	Erect, tail held up	Tail and wings droop, head held close to the body, twisted back or between legs
Head	Clean pinkish red comb and wattles, bright and alert eyes and clean nostrils. Eyes more round	Discoloured shrunken comb and wattles, eyes dull and watery, nostrils caked, face swollen, eyelids closed and swollen. Eyes more oval shaped
Legs and feet	Clean waxy scales, smooth joints cool to the touch	Dehydrated with prominent tendons, enlarged joints warm to the touch and feet swollen and cracked
Feathers	Smooth and neat	Ruffled and stained on the vent
Thirst and appetite	Eat and drink often	Loss of appetite and birds often more thirsty in beginning
Droppings	Grey/brown with white caps, definite form. Ceacal droppings may be frothy	Discoloured, watery or sticky, excess odour and could contain blood
Breathing	Silent, beak closed under normal temperature	Stressful, coughing, snickering and obvious panting movements

6.1 Biosecurity on Layer Farms

Due to the economy of scale in building larger units, most layer sites are large. Unless the unit form part of a larger operation, these units are not depopulated and re-stocked on an all-in, all-out replacement basis. Most commercial layer production units in South Africa would therefore have flocks of varying ages on the same site.

This does not mean that strict biosecurity measures need not be applied on layer farms. In fact the mere size of some layer operations would suggest that most strict security measures should be in place to ensure that the birds will remain disease free and have the ability to express their full genetic potential. Once a disease manifests itself in a multi age site, it is very difficult to rid such sites of the disease, irrespective of the size thereof.

Diseases may be transmitted to a site either by vertical or horizontal means.

6.1.1 Vertical Transmission of Diseases

Certain avian pathogens (micro-organisms) are transmitted vertically from the parent flock via the hatchery to the day old chick progeny and then eventually via the point of lay pullet onto the layer farm. Some diseases may enter the chain by horizontal transmission at any stage and then be transmitted vertically

To prevent vertical transmission of diseases it is advisable that pullets are sourced from a reputable supplier of which the disease status known.

It is also not advisable to mix pullets from different sources as the status of one source may impact negatively on the performance of others.

6.1.2 Horizontal Transmission of Diseases

Pathogens may also be transmitted horizontally between farms, sites and poultry sheds. Important factors to be considered in horizontal transmission of disease include:

- An all-in, all-out replacement cycle should be followed, if not by farm or site then at least by shed
- Good separation between farms, sites and sheds is essential
- Control of access of staff and visitors to the site through showering and wearing of clean clothes and foot wear is advisable
- Access of service vehicles such as feed trucks should be controlled
- Feed should be purchased form feed companies who practice Salmonella control monitoring
- Vermin must be controlled

6.2 Pillars of Biosecurity

The pillars on which a sound biosecurity program is developed are flock separation, control of visitors, people and traffic, sanitation and cleaning and ensuring a good immune status.

6.2.1 Flock Separation

Poultry sheds should be operated on the basis of single age groups per shed allowing for an all-in, all-out replacement cycle by shed. This is not only to enable depopulation and cleaning of the building to break any possible disease but in this period proper maintenance can be carried out and the building prepared for the next batch of birds. The light, feed and vaccination programs designed for the particular flock can then be followed.

The layer premises should be well separated from other poultry farms. The distance of such separation should be such that direct contact through staff, vehicles and other means are not made and prevailing winds would also be taken into consideration.

The premises should furthermore be fenced off to assist in defining demarcated areas into which movement is controlled.

The layer buildings should be bird proof and no other birds or water fowl should be kept on the premises. As far as possible, open water and dams that attract water fowl should be avoided.

6.2.2 Control of Traffic

Movement of staff and other traffic must be controlled and although showering onto layer sites it not often practised, it is a good measure to at least remove clothes and wear site clothing and foot wear when entering the layer farm.

Of particular importance is the control of traffic such as feed trucks which may have contact with other poultry operations. Such vehicles should be clean and the vehicle sprayed down and disinfected when entering the premises.

Buyers of end of lay hens often have direct contact with other poultry farms and should not be allowed entrance to the layer farm. When disposing of end of lay hens, the birds should be removed from the farm by vehicles and crates which are known to be clean and the birds transferred to the vehicle of the end of lay bird trader in a neutral point. Such crates should then be washed and disinfected before re-entering the layer farm.

Visitors to the premises should be strictly controlled and should wear farm clothing when entering the premises.

6.2.3 Sanitation and Cleaning

It is essential to ensure that the environment and premises does not carry over any pathogenic micro-organisms which could affect the health, welfare and performance of the subsequent flock. Although point of lay pullets have been immunized against most of the common diseases, such immunity will not be adequate to face severe disease challenges.

A good cleaning program will consist of insect control, removal and correct disposal of all manure, washing with high pressure water containing a detergent, cleaning and de-scaling the water, cleaning the feed system and disinfecting the premises prior to receiving the next batch of birds.

It would be advisable to such a sanitation and cleaning program developed by a competent veterinarian for a particular operation.

6.2.3.1 Insect Control

Insects such as litter beetles not only carry pathogenic micro-organisms but could also destroy building materials such as woodwork and roof insulation materials. Immediately after birds have been removed and while the building is still warm the walls, manure and equipment should be sprayed with an insecticide. The insects will start to migrate to the warmer ceiling as soon as the building starts to cool down after removal of the birds and surfaces over which the insects migrate should be covered before this occurs.

Should the infestation be high a second treatment may be required. Warming the building will occur once the building is re-stocked and this will again attract insects into the building from the areas to where they migrated after removal of the birds.

The efficiency of the product being used should be monitored and changes made following consultation with specialists in this field.

6.2.3.2 Removal of Manure

Prior to removal of manure, all ventilation and electrical systems should be switched off and the building and equipment dusted down to ensure that such dust lands up on the floor. In open sided houses the curtains should be closed. This will assist in reducing the dispersing of possible micro-organisms through dust into the surrounding area.

The aim should be to carry out a proper dry cleaning of the equipment and building prior to removal of the manure.

The manure is then removed either manually or by mechanical means and as far as possible, spillage of litter onto surrounding areas must be avoided.

Manure should not remain or be stored on site but should be disposed of as soon as possible and as far away as possible from the poultry farm.

6.2.3.3 Washing and Cleaning

The washing down of caged layer operations with high pressure spray, especially in the case of automated systems where a great deal of electrical and other equipment is present, should be carried out with care. Some automated farms would in fact only carry out a thorough dry cleaning, followed by disinfecting using formaldehyde fumigation.

The washing process should consist of washing down the building, equipment and surrounding areas, using a high pressure water pump with a detergent added to the water. Prior to this process, all electrical equipment that could be damaged by water should be covered. The detergent is added to assist in removing dirt and greasy substances.

The process consists of washing down the building, top to bottom and eventually removing all water into drains outside the building. The surrounding areas including control rooms and ablution facilities are then cleaned, paying special attention to any residue material lying around. Avoid excessive spray of water onto moving and greased areas such as egg conveyors.

Once this process is complete, there should be no dirt, dust debris, litter or feathers visible in the building as well as surrounding areas.

Prior to placement of the next flock, the building should be disinfected.

6.2.3.4 Cleaning the water and feed systems

Drinker system:

- All pipes and tanks should be drained and any possible sediment removed
- All pipes, tanks, lids, covers, taps, etc., should be washed with a detergent
- The drinker system should then be flushed out to remove any build up of sediments. This is of special importance with nipple drinker system and should be done in accordance with manufacturer recommendation. For alkaline water, vinegar or citric acid solution will remove mineral build up and for acid base water, household ammonia may be used.
- The system should be flushed out with clean water and made ready for the next crop.

Feed system:

- All feed should be removed from the feed tank and feed system and disposed of
- The feed auger system should be removed from the feed tank
- Of special importance is to note any caking of feed onto the sides of the bin. Should this have occurred, the caked and mouldy feed should be removed and possible water leaking into the bin from outside should be repaired.
- The bulk feed bin should be clean out with detergent.
- The system is then re-assembled and disinfected.

6.2.3.5 Disinfecting the Premises

Once all equipment has been repaired and attended to for receiving of the next flock, the building should be finally disinfected. This is done by fumigation or by spraying the disinfectant. It is best to seek professional advice on appropriate products to be applied.

The external areas should also be kept cleaned. The areas where major activity such as loading of birds, parking of feed trucks, etc., should preferable by paved or concreted for proper cleaning. The areas between buildings should be free of vegetation, well drained and if grassed, such grass should be kept short. This will eliminate interference with ventilation and any problems with rodent infestation will be easily noticeable.

6.2.4 Immune Status

The objective of vaccination is to ensure that there is controlled exposure to the disease organism (antigen carried in the vaccine) which will ensure a good response to the immunological response of the bird which will actively protect the bird from subsequent natural field challenges. Although common diseases such as Newcastle and Infectious Bronchitis are routinely vaccinated against, vaccination places additional stress on the birds and the vaccination requirement and programs will vary according to circumstances. They should be devised and developed through veterinary assistance taking into consideration disease challenges in the area.

Two basic types of vaccines are used. Live vaccines or killed vaccines each of which has specific use and advantages in commercial egg production.

6.2.4.1 Live Vaccines

Live vaccines are most commonly used in commercial egg production to ensure a sustained high level of immunity. In caged operations they are normally administered by spray vaccination.

These vaccines carry the living organism (virus) that creates the disease. Because the virus has been attenuated (modified) the vaccine will cause multiplication of the virus within the bird without creating the disease itself. Vaccine reaction may however be noticed and the severity and consequences of the reaction will depend on the level of management (environmental control). Poor environmental control could cause vaccine reactions to develop into severe secondary reaction of the respiratory tract, especially if such vaccines are administered via spray method and if other pathogens such as mycoplasma are present.

The most common live vaccines used in commercial egg production include Infection Bronchitis (IB) and Newcastle (NCD). Normally the live vaccines contain only one antigen but combinations of IB and NCD are available.

Most live vaccines need to be administered (consumed) within a period of between one to one and half hours after preparation. If shorter, vaccine may not be well distributed between all birds and if too long, the vaccine will be destroyed.

Vaccines may be administered via the drinking water. Some key points with water vaccination include:

- The water intake of the flock at the time of administration should be known. The hourly rate of consumption is then calculated and the amount of water to which the vaccine is be added and consumed in the stated period is then calculated. Note that when water is withheld for an hour or two, intake will increase and this must be compensated for.
- The vaccine should be added to water containing no trace of chlorine as this will inactivate the live virus. If such water is not available then skimmed milk powder may be added to the water (1 g per litre of water) and the recommendations of the vaccine supplier followed.
- By process of trial and error and building information data, the best procedure for particular circumstances and bird age will be found.
- Even distribution is necessary and this is achieved by manually distributing the water into the open dry drinkers after water has been withheld. Header tanks may also be used and it is essential to ensure that the drinker system is clean, free of chlorine residue and that water reaches all drinkers in the building within the given period of time.
- Live vaccines are best administered by using a dosing applicator.

- Dye tablets available that assist in checking the distribution of water containing the vaccine. The dye will also mark the tongues of the birds and this may then also be used to check the percentage of birds that have in fact consumed the water to which the vaccine has been added.

Vaccines may be administered by spray method using various types of applicators available in the market. Some key point with spray vaccination includes:

- Use applicator for vaccine application only and thoroughly clean the applicator after use. Avoid using soaps, detergents or disinfectants as residues may destroy vaccines. Rinse the equipment thoroughly with water.
- In floor operations, herd birds into a smaller area (half the normal space) to ensure higher density and better cover. Portioning with low wire mesh frames will assist to keep birds controlled
- Reduce ventilation to the minimum. In open houses, close curtains.
- Reduce lights and in open houses it will be beneficial to spray vaccinate at night or late evening when birds may be kept calm through reduced light intensity
- Move slowly through the flock spraying with a "fanning" motion at birds not more than 3 meters away.
- In caged operations, move down a single row of cages at a time.
- Keep the vaccine at the required temperature (2 to 6 °C) until reconstituting and only mix sufficient vaccine that could be administered within one hour.
- The amount of water would depend on the applicator being used and this must be established through trial and error using guides supplied by the manufacturer. The vaccine must be administered within the period of one hour.

6.2.4.2 Killed Vaccines

Killed vaccines are composed of the inactivated organism (killed virus called the antigen) which is carried in an oil emulsion or aluminium hydroxide solution. This helps to increase the uptake of the antigen by the bloodstream over a period of time and these vaccines are administered by injection.

They are commonly used in pullet rearing to ensure a high level of immune status prior to point of lay. The reaction time is slower compared to live vaccines but the immune status will be maintained for a longer period, compared to immunity induced by live vaccines.

6.3 Vermin Control

The control of rats and mice in poultry sheds is very important, because they not only cause severe damage to electrical wires, plastic piping, wet pads and insulation material but are also carriers of numerous diseases. Rats have huge appetites and consume poultry feed at a rate of 6 kg feed per day for every 100 rats. They are intelligent animals and are quick to become bait shy and even resistant to poisons and presentation, location and types of poison should be regularly rotated. Live stock is present in the poultry shed and care must be taken not to contaminate feed or water with poison.

6.3.1 Essentials in Rodent Control

Essentials of rodent control include: -

- When the shed has been depopulated and feed removed, rodent control should be stepped up
- Old and dirty poisons will not be consumed. Rather place smaller volumes in a number of bait stations on a more regular basis. Rats are territorial and aggressively protect their territory from intruders. Unless adequate bait distribution is provided, only those rats having access to bait in specific areas will die
- If poison intake does not occur at a specific site, then move the bait station to another location. Always try to identify the routes of the rodents. Rodent restaurants can even be tied onto cables or structural beams. Baits should be placed in the normal line of travel, and under cover so that they will feel secure when they feed. Rodents usually avoid open spaces. Grease marks are good indicators of rat traffic.
- Chicken sheds usually have an abundance of feed, making liquid poisons very effective if managed well. Liquid bait stations also have the indirect benefit of dissuading rats from chewing through the water drinker pipes in search of water. The addition of sweet wine or cheap sherry creates another alternative to increase intake. Mice do not need drinking water.
- Poisoned grain wrapped in newspaper can be stuffed into any holes used by rodents.
- Cement or seal any unnecessary holes in the building.
- Well-managed mechanical rattraps are a good investment.
- Remove spilled feed, especially under the feed silos and feed hoppers and eliminate feed wastage
- Check for signs of rodents at night using a flashlight and especially for rodent tracks and faeces on the feed in the hoppers during the early morning. Most rat activity, including feeding, occurs at night. If rats are seen during the day then the rat population is very high
- Keep grass very short or remove it around the sheds. Be on the lookout for rat holes in areas adjacent to the poultry buildings
- Where a rat infestation persists in houses i.e. where baiting is not able to intercept rats use of a gel painted onto the pipes, cables, bricks or posts which rats use to move around in the house can be used. The gel is picked up by the rat on its feet and fur and this is ingested when the rat grooms itself. A gel can be prepared by mixing 10 ml of liquid concentrate poison with 1 kg of a carrier such as Vaseline white petroleum jelly.
- Tracking powder poisons can be used in a similar way as gels.
- Sugar, vegetable oils and non-rancid animal fats increase the acceptance of cereal baits
- Keep water tanks completely closed.
- Limit the handling of bait with your bare hands. Rodents have very good smell and may reject the bait. It is advisable to handle the bait with a plastic bag.

- Do not scatter bait where it will be accessible to domestic animals or other non target species.
- Dead rats and mice found should immediately be placed in a mortality pit. Ensure that mortality pits are always sealed.
- Shed curtains (if they fold up) should be lowered and lifted completely at least once per week to discourage the formation of fixed paths and nesting sites for the rodents.
- Concerted efforts are needed during the winter. During this period more rodents move to the sheds from the veld in search of food and shelter.

6.3.2 Edible Poisons

Edible poisons are divided into two main groups:

Multiple-dose anticoagulant baits must be consumed for several days to be lethal and are therefore safe for non-target animals. The effects are cumulative, therefore, it is imperative that enough bait be available for the rodents to eat for several days.

Single-dose anticoagulant baits only require a single meal with sufficient dosage to kill a rodent. These products can be lethal for non-target animals such as owls that consume the rodent.

6.4 Fly Control

Not only can flies pose a significant health risk to poultry by enhancing the spread of diseases between birds, they are also a major nuisance factor for the poultry, humans working with the birds as well as neighbours.

The common housefly (Musca domesticus) and the lesser housefly (Fannia canicularis) are normally associated with poultry farming. Adult flies will feed on a wide range of materials and in poultry sheds such materials include spilled feed, broken and cracked eggs and manure.

The life cycle of the fly consists of the adult fly, eggs, larvae, pupae and back to the adult fly. Housefly larvae are the typical white maggots seen while that of the lesser housefly are brown, flattened, spiny organisms. Lesser housefly infestation would generally peak in early spring, while the common housefly infestation would be later and during summer.

Essentials of fly control: -

- Pre-empt the seasons (spring) build up of the fly population where it is most effective - avoid and/or treat potential breeding sites. These areas include spillage at the basis of feed bins, wet grass bales and heaps, water drainage areas, litter spillage areas, manure heaps
- The period immediately after placement is an extremely vulnerable period as manure is wet and the natural population of predators of fly larvae normally found in dry manure has not been established
- Keep manure as dry as possible and remove any areas where water wastage has occurred

- It is helpful to encourage and maintain the natural predators of fly larvae. Consider leaving some manure from the previous cycle under the cages, should this fit into the biosecurity program
- When manure is removed from the sheds, do not allow it to remain outside but dispose of it as soon as possible. Better to load manure direct onto transport system. Should there be no alternative, then at least keep the manure in a steep heap. This will result in high temperatures within the heap of manure and rain water will run from the heap.
- Products such as Larvadex are available but are expensive. They could be used selectively
- Methods of using insecticides are adulticides (baits, surface sprays, misting) and larvicides (spraying poultry sheds and using feed additives). Insecticide formulations used are emulsifiable concentrates or wetable powders
- Baits consist of an insecticide mixed with some attractive substance such as brown sugar or molasses. Baits should be placed in pans or protected locations where flies are frequent. Flytraps containing baits (e.g. rotten flesh) can also be very effective but require regular replenishment.
- Rotate fly control products (insecticides) at least on a six monthly basis so as to reduce the development of resistance. Try to rotate between the main groups of products i.e. organophosphates, chlorinated hydrocarbons and pyrethroids.
- Treatment directed against adult flies should be applied to the surfaces of the buildings with a coarse spray to minimize drift. The structures where adult flies are observed to rest should be targeted. Those are usually partitions and upper parts of the structure where flies rest for long periods at night. Spotting of the surfaces by regurgitation and faeces from flies indicates fly resting areas. Insecticide application should thoroughly wet the surfaces but not to the point that runoff occurs.
- Selective treatment of obvious breeding sites can be accomplished by spraying or spreading a larvicide.

6.5 Litter Beetles

Litter beetles are carriers of many diseases such as Mareks and Gumboro. Products used to combat litter beetles should be rotated regularly, preferably on a six monthly basis, so as to reduce the risk of resistance developing. Products may not be used in combination with any other cleaning, disinfecting or insecticidal agent unless prescribed. Litter beetles are specially targeted when the building has been depopulated and the building is cold. Beetles will then migrate to areas such as the ceiling where they can cause extensive damage to insulating material.

All cracks, crevices and hiding places where the beetle may seek shelter must receive special attention. Every treatment should include a band spray, 0.5 to 1 m wide and at least 0.5 m above the ground. All supporting posts must be treated with the band spray, including roof-supporting struts. Cracks in the wall and floor should also be sprayed. This is achieved with a knapsack spray. The knapsack sprayer should be fitted with a hollow cone nozzle, producing a spray angle of at least 30 degrees.

Thermal foggers may be used to disperse insecticide in an empty shed if the number of litter beetle builds up to unacceptable numbers.

6.6 Ectoparasites

Ectoparasites in modern poultry keeping consist of mite and lice. Normal biosecurity measures are as important with mite infections as with any other contagious disease.

- Ensure that pullets arrive free of external parasites.
- Birds should be inspected regularly for mite and note that for Red Mite, such checks should be done at night or looking into crevices and cracks close to the birds
- Mites are occasionally seen on eggs and this is an indication of severe infestation.
- All treatments must consist of two poison applications, 10 to 14 days apart. This will ensure that the mite and lice eggs that hatch after the first application will also be killed, thereby leading to a much longer treatment interval.
- Treatment of the whole site will increase the treatment interval.
- Rotate Arthropod control products at least on a six monthly basis so as to reduce the development of resistance. Rotate between the main groups of products i.e. organophosphates, carbamates and pyrethroids.
- Additional poison treatments should only be given after discussion with the veterinarian.
- In modern cage operations it is difficult to adequately spray the birds and care should be taken to ensure that eggs and feed are not contaminated. Spray after egg collection and for Northern Fowl Mite, ensure that vent area is properly wet.

6.6.1 Northern Fowl Mite

The life cycle of the Northern Fowl Mite is completed in less than one week on the birds. Eggs are laid on the feathers and hatch in one day. Unlike the Red Mite, the Northern Fowl Mite can be found on the birds throughout the day and night. The Northern Fowl Mite can survive for up to 3 to 4 weeks away from the host. It is an active bloodsucker and causes decreased egg production, feather pecking, loss of body mass, poor feed conversion and even death due to loss of blood during heavy infestation.

Other wild birds, rats and even humans carry the mites.

On fowls the mites tend to cluster in the soft, fluffy feathers around the vent but infested patches may also occur on other parts of the host. Generally a grey or black discoloration of the feathers around the vent, matting of the feathers and scabbing is seen in infested fowls.

Birds should be inspected routinely (weekly) and any spraying should be followed up after 10 days.

6.6.2 Red Mite

Red Mites do not live permanently on the host but feed only at night and conceal themselves in the premises during the day. The especially in cracks and crevices. The adults are resistant to starvation and may survive up to 5 months without a blood meal.

The life cycle of Red Mite is 7 days, so follow up treatment is to be done after 10 days to kill off progeny.

Red mite will therefore not be found on the birds during the day. They are more active during summer and seldom seen during winter. Crevices and cracks should be inspected and if birds are inspected, this should be done at night. Placing cotton wool under a heavy object in strategic points will attract red mite, and if present such area will soon reveal the presence of Red Mite on the cotton wool. They appear red when filled with blood but translucent during the day when blood has not been consumed.

It is an active bloodsucker and causes decreased egg production, feather pecking, loss of body mass, poor feed conversion and even death due to loss of blood during heavy infestation.

6.6.3 Lice

Lice spend their entire life cycle on the host. Eggs are attached to the feathers, and require 4-7 days to hatch. Their normal life span is several months, but away from the birds they can remain alive for only 5 or 6 days.

Bird lice eat feather products and may consume blood by puncturing soft quills near the bases and gnawing through the covering layers of the skin itself. Lice will transfer from one bird species to another if these hosts are in close contact.

Although the effect of lice on production is mixed, heavy infestation could cause production drops.

6.7 Endo parasites

Endo parasites would normally not pose a problem in caged operations.

It does however happen that with manure belt systems the manure is poorly scraped from the belt and when birds on the lower tier peck at the manure (the belt serves as the roof of lower tiers) endo parasites such as coccidiosis could develop.

Excessive manure build up and areas in cage systems that do not allow manure to fall from the cage, which allows birds to peck at the manure will also lead to endo parasite challenges.

6.8 Common Diseases

Not all diseases found in South Africa are discussed. This text merely provides a brief description of the more common diseases of caged layers in South Africa and further detailed reading in special veterinary manuals and books is required to obtain an in depth knowledge on this topic.

6.8.1 Cage Layer fatigue

Symptoms

This condition often manifests itself in high producing birds. Birds loose control to stand on legs, lie on their sides and the bones are soft and brittle. The ribs may be beaded at the cartilage juncture. As long as birds are able to stand and get to feed and water, they will continue producing eggs with good quality.

Cause

The disease is more common in caged layers as compared to layers kept on litter systems due to lack of movement. Although not agreed on by all, the most common cause is believed to be due to inadequate levels of inorganic phosphorus. There is also indication that inadequate levels of calcium during peak production could be a precursor to this syndrome.

Treatment and Control

No general method of treating this condition is to be found. Ensure that the phosphorus levels are correct and additional levels of calcium and vitamin D during peak production may be of benefit when this condition occurs.

6.8.2 E.Coli Infection

Symptoms

Escherichia Coli are bacteria that represent one of the many coliform group of organisms that inhabit the lower part of the intestinal tract. Many of these organisms are harmful and most in fact assist with digestion. Some are however pathogenic and produce certain poultry diseases, including:

Airsacculitis, which is infection of the thoracic and abdominal air sack

Salpingitis, which is an infection of the oviduct

Synovitis, which is an infection of the leg joints and usually associated with other infections such as *mycoplasma*

and general *coli septicemia* in adult birds showing swollen livers, spleen and other internal organs.

Causes

Most *E.coli* infections start with a dirty and contaminated environment and poor environmental control. Good housekeeping, cleaning and disinfection of poultry buildings and good environmental control will reduce the risk of this infection.

Treatment and Control

The treatment of *E Coli* infection should start with its prevention through good housekeeping, creating a clean and healthy environment and good ventilation control.

Broad-spectrum antibiotics may be helpful following laboratory conformation of the infection. Many *E. coli* are however resistant to commonly used antibiotics and a sensitivity test should be conducted by the laboratory to identify the best drug for treatment.

6.8.3 Egg Drop Syndrome

Cause

This disease is caused by an adenovirus which was identified for the first time in 1976, and is thought to be spread by migrating waterfowl.

Symptoms

The symptoms are most exclusively associated with a decline in production, and the loss is primarily associated with the fact that eggs do not have shells (shell-less). Production loss can be between 40 and 50% for varying length of time, up to 10 weeks.

Very little other symptoms are seen.

Treatment and Control

There is no known treatment and the control rests with the use of inactivated vaccines administered to pullets prior to lay (14 to 16 weeks). Waterfowl should not be allowed on farms.

6.8.4 Fatty Liver Syndrome

Causes

Fatty liver is a metabolic disorder in laying hens which causes excess fat in the liver. The exact causes for this is not fully understood, but factors such as toxins, nutritional imbalances, very high energy diets and endocrine imbalances are thought to be involved. There may also be a genetic connotation. Although the condition is not induced experimentally, there is sufficient evidence that the syndrome is of nutritional origin.

Symptoms

This condition only appears in flocks with good production. Birds are in good health and sudden drops in production and increased mortality occur. Post mortem examination will reveal an enlarged liver, which is fatty, friable and tan in color. The birds will also be excessively fat. Mortality is mainly due to rupture of the liver with gross hemorrhaging.

Treatment and Control

A reduction in energy intake and correcting possible nutritional imbalances remain the only possible control measure. In some instances the addition of vitamin E, B_{12} and choline chloride has been beneficial but not in all cases.

6.8.5 Infectious Bronchitis

Causes

This highly infectious disease is caused by a virus which has a propensity towards genetic mutation and many serotypes therefore exist. Although various vaccines are available, this disease continues to pose problems within the industry, especially during colder winter period.

Symptoms

Infection and spread in adult birds, even in cages is rapid. Very little external symptoms are noticed and the disease manifests itself in adult layers by a sever drop in production. The return in production will take several weeks and egg quality is severely affected. Eggs are soft shelled, misshapen, wrinkled and chalky. With brown eggs layers many eggs with lighter shell color will appear. Production may return to normal but egg quality seldom does. It is best to have this disease confirmed by laboratory diagnosis, although this could be difficult in many instances.

Treatment and Control

There is no treatment. Good vaccination, routine serology tests to follow possible challenges and good biosecurity measures remain the best method of combating possible outbreaks.

6.8.6 Infectious Choryza

Cause

This disease is caused by the bacterium *Heamophilis paragallinarium*, and can cause severe production drops in layers. The disease spreads slowly through caged layer flocks, as it spreads from bird to bird.

Symptoms

Facial swelling together with snicking and discharge from nasal and sinus passage are common. When complicated by *Mycoplasma gallisepticum*, nasal passages and sinuses become filled with a cheesy exudate. Production drops could be severe.

Treatment and Control

Antibiotics are used to treat this condition, but success could vary. Vaccines are available to vaccinate against the disease but good biosecurity measures and hygiene control remain the main preventative measures.

6.8.7 Marek's Disease

Cause

This disease is caused by a herpesvirus and several serotypes have been identified. Birds become infected in early life and remain infected until death.

Symptoms

Lameness and paralysis is typical and the disease is often diagnosed by the presence of enlarged peripheral nerves that appear yellowish and have lost their typical cross striations. It often occurs in flocks close to or during onset of production and mortality loss could by high. Tumors of the visceral organs may or may not occur. In some cases it may be difficult to differentiate the tumors from those caused by lymphoid leucosis.

Treatment and Control

There is no treatment. The only control remains good biosecurity, cleaning and rest period of farms and adequately vaccinating the day old chicks before placement. Breaks in MD are often traced back to poor vaccination, poor vaccine handling as well as poor immune response of the chicks. It is best to involve veterinary advice with MD breaks, as the causes and control need to be traced back to the chick hatchery and pullet rearing farm.

6.8.8 Mycoplasma Gallisepticum

Cause

This disease is caused by small organism which is delicate and which has no cell wall. The organism may remain dormant and cause no disease until the bird undergoes some stress at which point the disease becomes active. Birds remain carriers of the disease and transmit the disease to other birds. MG is often seen on multiple aged layer farms and once it is introduced onto such farms through vertical (breeders to pullet chicks) or horizontal (brought onto the farm from outside) transmission, it is difficult to rid the farm of the disease, due to birds remaining to be carriers of the disease.

Symptoms

In mature layers the disease may go unnoticed. Close observation may reveal depressed and inactive birds and a slight nasal discharge and snicking may be observed. A diarrhea may be noticed and feed consumption drops with a consequent effect on production. The severity of the disease would depend on the level of stress, environmental conditions as well as the involvement of other diseases and challenges. Of particular importance is the involvement of coliform bacteria and respiratory viruses which then typically results in airsacculitis

Control and Treatment

Tylosin is an antibiotic specific for the treatment of birds infected with MG. Other drugs such as aureomycin and erythromycin may also be used effectively.

Medication and treatment of MG can only be considered to be a temporary solution and proves to be expensive. If left untreated, production losses could be high. Eradication and maintaining a MG free farm remains the best long term option and this can be achieved through vaccination, or treatment with tylosin, especially during the period that the disease manifests itself in order to reduce shedding of the organism and infecting of other birds. MG vaccination is however expensive and it is best to seek professional veterinary advice to develop an eradication and control program.

This is one disease that remains to be a problem on many multiple aged layer farms due to poor biosecurity measures and allowing buyers of end of lay hens onto such farms.

6.8.9 Mycoplasma Synoviae

Cause

This disease is caused by a small delicate organism that has no rigid cell wall. The disease is transmitted vertically via the breeder farm, through the egg to the progeny but may also be carried onto the farm through contact with other birds, either direct (wild birds) or indirect (contaminated staff, vehicles, visitors, etc.)

Symptoms

In adult stock respiratory symptoms are often not seen. There may be a loss in appetite and weight. Inflamed leg joints (hocks) cause birds to become lame. A persistent tenosynovitis may be evident and morbidity rather than mortality is a problem. MS will often go unnoticed unless routine serology is performed.

Treatment and Control

Broad spectrum antibiotics may be of some value but usually MS will not cause major losses in layer flocks, unless the hocks are particularly inflamed causing birds to become lame and unable to feed. MS negative pullets should be sourced followed by strict biosecurity to maintain a disease free farm.

6.8.10 Newcastle Disease

Cause

Newcastle disease (NCD) is caused by a virus and although only one serotype, there are three forms classified, according to their pathogenicity: Velogenic (high pathogenic), Mesogenic (medium pathogenic) and Lentogenic (mild pathogenic). The virus spreads very easily and rapidly through the air, through contact (clothing, feed trucks, equipment, etc.), between flocks, wild birds, predators, etc.

Symptoms

Symptoms will depend on the pathogenicity of the virus. This disease is commonly vaccinated for and problems on layer farms are often associated with poor vaccination or severe challenges. A mild respiratory condition may be observed coupled with a drop in production, the extent of which would depend on the challenge and level of immunity. Often nervous symptoms (twisted necks) are observed. Egg shell quality may also deteriorate, but again this will depend on the challenge and level of immunity. Serological testing is required to confirm NCD.

Treatment and Control

There is no treatment for NCD. Broad spectrum antibiotics may be used to medicate for secondary diseases which often manifest during a NCD challenge.

Routine serology to monitor the immune status and adapting the vaccination program accordingly is of importance. This is best achieved through seeking professional veterinary advice and insisting that point of lay pullets are adequately immunized.

6.8.11 Mycotoxicosis

Cause

Mycotoxicosis is caused by toxins produced by various molds. The molds grow on grains and under conditions such as high temperature and moisture, the toxins are produced. The most common mycotoxins encountered are: Aflatoxin, Orchratoxin and Fusariotoxin.

Symptoms

Morbidity as well as mortality are usual in most of the toxins.

Aflotoxin will generally cause impaired immunity, increased bruising and blood clotting time, alter the protein and fat metabolism lower the resistance to other diseases and reduce pigmentation.

Ochratoxin will reduce feed consumption, cause urate deposits throughout the body cavity and impair kidney function.

Fusariotoxin causes sores and lesions in the mouth and feet, reduces egg production and shell thickness, causes reduced feed intake and body weight and poor feathering.

Treatment and Control

The best treatment is to find and remove the source of mycotoxin. This includes feed bins.

6.8.12 Samonellosis

Causes

There are many Salmonellae that cause disease in poultry. While pullorum disease and fowl typhoid were of importance to the industry prior to their control and virtual elimination, the paratyphoid form of the disease, which is the non-chicken specific form of the disease has in recent years threatened the industry through public health concerns.

Symptoms

Most paratyphoid bacteria cause very little disease symptoms in layers. However, many of these bacteria may infect humans, especially the young and old or humans weakened through chronic or immune suppressive diseases. The bacteria is thought to penetrate the egg through the shell and S. enteritidis especially has been implicated in many cases of human infection. Other forms of contamination include fecal contamination, ovary transmission, contamination via staff as well as via the feed.

Treatment and Control

It serves very little purpose to treat a flock infected with paratyphoid, although some drugs may act indirectly by reducing the organisms in the intestinal tract and thereby decreasing the number of bacteria deposited on the egg shell. The reduction or exclusion of paratyphoid organisms is difficult as they occur in many species (including humans). Control of this bacteria is of importance and quality-assurance programs should be developed in discussion with professional veterinary advice to suite particular circumstances. These programs would include the following:

- The possible use of vaccines

- The use of competitive exclusion products which are aimed at populating the gastrointestinal tract with adequate number of normal beneficial bacteria in an effort to reduce the harmful paratyphoids
- Elimination of the use of feed ingredients which are of animal origin and purchasing feed from a reliable feed supplier
- Ensuring that water is not contaminated
- Good control on rodents
- Good cleanout and disinfection between flocks