SOUTH AFRICAN POULTRY ASSOCIATION

Founded 1904

Poultry Housing and Equipment

in Southern Africa

Compiled by Alan Saunders

Foreword

Over the past six decades poultry farming in South Africa has developed from small scale farming under extensive conditions of free range and basic shelters which kept birds out of the rain and poor weather conditions, to very large modern complexes housing hundreds of thousands of birds under intensive conditions.

The conditions in which birds are kept should be maintained within a narrow band of temperature and other environmental constraints. If not, production performance will not match the high genetic potential that modern breeds offer to the producer.

The higher stocking density possible with intensive systems makes it more difficult to ensure optimum environmental conditions throughout the building. Due to the economy of scale, modern poultry buildings are large, housing tens of thousands of birds. In cage and other intensive systems, cognisance of the fact that the vertical height of the building is utilised should be taken into account.

The contents of this book is intended to serve as a guide in establishing optimum environmental and housing conditions for poultry in Southern Africa and how equipment and systems are utilised in attaining these conditions.

Poultry farming in the 1950's

Modern poultry production

This book is an attempt to share my experiences and knowledge of poultry housing and equipment under Southern African conditions with those who are interested in this very vast and complicated subject of poultry production. It forms part of a series of books on poultry management which is available from the address below. Although many text books are available for reference, very few deal with local conditions in Southern Africa. These books are aimed to serve as guides to methods of commercial poultry production under local conditions. It contains written text as well as photographic illustration of housing and equipment. I am indebted to many equipment supply companies who serve the local poultry industry as well as producers who have assisted in supplying material 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 error. Neither is any liability assumed for damages resulting from the use of information contained herein.

Developed and compiled by:

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1 Environment

In rearing of chickens and housing of adult layers and breeders the control of the environment within poultry buildings is a difficult aspect to manage. Unlike feeding and watering of poultry stock, which usually requires occasional management attention, the control of the environment requires constant attention and adjustment due to outside environmental changes and requirement within the building changing rapidly within a short period of time.

The basic consideration in poultry housing is to create an environment in which the poultry stock will perform to the optimum genetic potential. In buildings with limited control and systems it is much more difficult to cater for extreme outside environmental conditions. With more sophisticated systems, the internal building conditions may be controlled within very narrow limits close to the ideal conditions suited for the stock.

A firm understanding of the properties and dynamics of air is required in order to understand the principles of creating the ideal environment for different poultry stock. This section deals with the optimum environment for poultry and climatic conditions of the main poultry production areas in South Africa.

1.1 Optimum Environment Conditions

Environment may be defined as the aggregate of all external conditions affecting the existence, growth and welfare of the organism.

In intensive poultry systems, these conditions include: -

- Temperature
- Air composition and
- Illumination

Optimum environmental conditions have to be maintained within the poultry shed if maximum production performance is to be expected. These conditions differ depending on the type of stock being kept such as rearing of broilers or pullets or the keeping of adult layers or breeders.

1.1.1 Temperature

The specific temperature requirement for different breeds and types of birds would be available from suppliers of such stock. Table 2.1 is general recommendation for various birds and ages.

Table 1.1: Normal Temperature Zones for Poultry

Type of Stock	Temperature Range
Broilers	Day old 32 to 34°C Reduce to 23 to 25°C by 3 to 4 weeks
Growing Pullets and Breeders	Day old 32 to 34°C Reduce to 23 to 25°C by 4 weeks
Adult Layers	20 to 25°C
Adult Breeders	20 to 25°C

These temperature requirements are normally referred to as the thermo neutral zone or temperature comfort zone. At temperatures within these norms, birds are able to maintain body temperature without having to apply increased heat loss or body heat production as would be the case should ambient temperature be above or below these norms. Ambient temperature both above and below these ranges would not only affect the technical performance of the stock but also the economic performance.

Ambient temperature below the ideal will result in an increase in feed consumption without any compensation in performance and higher temperature will result in a decline in feed intake which, unless compensated for by using a denser and hence more costly feed, will result in reduced technical performance.

Heat within the building originates from:-

- Heat generated by the birds
- Heat entering the building through the roof and walls

During conditions where environmental temperature exceeds the comfort zone of the birds, the heat generated in the building should be removed to ensure that house temperature remains within the limits suggested. During conditions where environmental temperature is low, heat produced by the birds should be preserved and used to maintain house temperature within these limits. Where birds are young (chicks) and the heat generated by the stock is insufficient to maintain house temperature, artificial heating is used to ensure that temperature remains within the accepted limits.

1.1.1.1 Heat generated by the birds

Poultry are warm-blooded animals and heat is produced within the body as a result of metabolic processes and muscle activity. This heat must be removed from the body so as to ensure that the body temperature is kept within very narrow limits which in the case of adult birds is 40.6°C to 41.7°C.

Factors affecting the body heat and heat production of poultry include:-

- **Type of bird** - a leghorn layer has a higher body temperature than larger breeds (broiler breeder), but the total body heat produced by a leghorn layer is lower due to differences in body mass.
- **Sex of the bird** - males have a higher temperature than females, but the metabolic process involved in egg production results in females producing more body heat per kilogram live mass than males.
- **Age of the bird** - body heat production is directly related to body mass and older pullets or broilers will therefore produce more heat than younger stock. Day old chicks have a lower body temperature than adults (39.5 to 40°C). However younger birds produce more heat per unit of body mass compared to older birds due to the relatively higher unit gain in body weight.
- **Source of energy in the feed** - digestion and absorption of energy originating from fat instead of protein or carbohydrates results in less heat production.
- **Ingestion of Feed** - body temperature and body heat production will increase soon after feed has been ingested.
- **Ambient temperatures** - at higher temperatures, the body temperature may increase slightly but the heat production reduces as temperatures increase due to slowing down of metabolic processes.
- **Light intensity** - high light intensity will result in increased bird activity, increased feed consumption and therefore increased body temperature and heat production.
- **Activity of the birds** - increased activity will result in an increase in body temperature and body heat production.

The metabolic heat produced by warm blooded animals is removed from the body in various ways.

- **Sensible heat loss** occurs when the loss in body heat causes the temperature of the surroundings (air or physical medium) to rise. Heat loss through **radiation, conduction** and **convection**, is considered to be sensible heat loss. To increase sensible heat loss birds will lift their wings and feathers so as to expose more skin area to the air. Increased blood circulation to wattles and comb furthermore assists in increasing sensible heat loss.

- **Radiation** occurs when the bird's surface temperature is higher than that of the surrounding air temperature and heat is transferred from the body to surfaces in the environment that are at lower temperatures than that of the skin. The opposite applies when the temperature of the surroundings is higher than that of the skin.

The feather covering of the body reduces the heat lost in this manner but areas such as face, wattles and combs loose heat through radiation.

- **Conduction** occurs when the bird's surface comes into contact with a colder object (in this case it is air which is a poor conductor of heat) and heat is lost through conduction from one object (surface of the bird) to the other (air). Heat loss through conduction is relatively low due to the low thermal conductivity of air.
- **Convection** occurs when cooler air which is in contact with the skin warms, becomes less dense, rises and is replaced by cooler and denser air. The heat lost through convection can be increased by increasing the movement of air (air speed) over the surface of the skin. Heat loss through convection occurs especially from bare surfaces such as the face, comb and wattles.
- **Birds also loose heat during respiration** through evaporative and non-evaporative heat loss. The former is called **latent heat loss** and it is the heat lost when moisture is being evaporated from the epithelial tissue of the lungs and air sacks. This form of heat loss increases the moisture content of the air but it has no effect on the actual air temperature. The energy is used to vaporize the moisture from the epithelial tissue, thereby leaving a cooler epithelial tissue. In poultry latent heat loss increases through the process of panting and is a condition of increasing the rate of respiration and it starts at around 28°C. Panting in itself will produce heat but provided the vaporization of moisture is high, the heat loss through panting will maintain body temperature at temperatures below 42°C. Heat lost in this manner is the means by which a larger proportion of body heat will be lost at high level of environmental temperature. Panting in itself increases body heat production but the amount of heat loss through evaporation of the moisture exceeds this by far.
- **Non-evaporative Respiratory Heat Loss** is a combination of heat lost through convection and conduction in the upper respiratory track when the colder air inhaled comes into contact with warmer body tissue. Heat from the respiratory system is removed by the warming of the air through convection and conduction as it enters the nasal passage and the rest of the respiratory systems.

At temperatures below 21°C the sensible heat loss is about 75% of the heat output of the body processes. As the ambient temperature increases above this point, latent heat loss becomes more important.

1.1.1.2 Heat entering the building through the roof and walls

Apart from heat generated by the stock a second source of heat load in poultry sheds (or heat loss from the shed if the outside temperature is lower than inside) is heat entering the building through the walls and roof. This heat load will depend on the size of the building, type of construction (insulation) and orientation in respect of the sun.

The building should preferably be orientated east/west to ensure that the side walls are shaded during summer conditions, especially if the roof overhang is large so as to increase the shaded area. This reduces the heat load through the side walls.

Insulating Poultry Buildings

The primary purpose of insulating poultry buildings is to assist in maintaining ideal conditions within the building under extreme outside environmental conditions. This is achieved by reducing heat loss generated by the stock (as well as any form of artificial heat provided by brooders) from the inside to the outside of the building, under conditions where outside temperature is colder than the required temperature inside the building. Secondly, excess environmental heat load through the walls and roof should be avoided in conditions where outside temperature is higher than the required inside temperature of the building.

By insulating poultry sheds the inside temperature fluctuation can be minimized compared to that of outside temperatures. Excessive heat loss requires additional heating of the building and this increases the cost of heating when stock is being reared and artificial heating is being applied.

Insulation assists in conserving metabolic heat produced by the birds in cold environmental conditions (winter). This in turn assists in maintaining higher temperatures in the building which will otherwise cause feed consumption to increase and result in poor rates of feed conversion.

Maintaining desired temperature conditions during winter will also result in dry litter as warm air absorbs moisture from the litter more readily than cold air.

Insulation reduces additional heat load from entering the building in hot environmental conditions (summer), which will result in high inside temperatures causing reduced feed intake and poor performance.

In very cold climates the insulation of the roof (ceiling) is as important as insulating the walls. The walls have a large surface area and insulating the walls (or ensuring that the walls have a high thermal resistance) in cold climates, low temperature will have limited effect on conditions inside the building. In areas where snow frequently builds up against the walls and on the roofs, this is of special importance.

In moderate and hot climates such as South Africa, the insulation of walls becomes less important, especially if the building is orientated in such a manner that the sidewalls are shaded during most of the day. In such climates the insulation of the roof remains important so as to reduce the heat load caused by radiation of the sun on the very large roof area.

The roof of a building would contribute 70 to 90 % of the total heat transferred into the building and the walls, 10 to 30 %, depending on the materials used and the heat resistance of the surfaces. This is the reason why insulation of the roof would receive more attention in moderate climates experienced in South Africa.

Thermal Resistance of Materials

The thermal resistance of materials is known as the R-value. The higher the R-value the more resistant the material will be in allowing heat to pass through. Heat transfer from one side to the other is mediated by convection, radiation or conduction, or all three. Thereafter the heat moves through the material by means of conduction.

On the other side of the material convection, radiation and conduction again transfer heat to the surroundings.

Calculations for heat transfer across a single layer of material can be done by using the following formula

Q = k / [L*A*Dt]

Where Q = Rate of heat transfer (Watt)
L = Thickness of the material (m)
A = Surface area of the material (m^2)
Dt = $t_1 - t_2$; temperature difference between the two sides of the material (°C)
k = Thermal conductivity of material (Watt/m°C)

The thermal conductivity values of various materials commonly used in the construction of poultry buildings are presented in the Table 1.2 below.

This formula can be used to explain that a 1 x 1 m steel sheet which is 2 mm thick and subjected to 0°C on one side and 30°C on the other will transfer more heat compared to a 20 mm polyurethane board:

Steel Sheet
L=0.002m (2 mm thick)
A = 1 x 1 m
Δt= 30°C
k = 50 watt/m°C (from table below)
Q = 50/(.002x1x1x30) or
833 watt/hour

Polyurethane Board
L= .02 (20 mm thick)
A=1 x 1 m
Δt= 30°C
k = 0.023 watt/m°C
Q = .023/(.02x1x1x30) or
0.038 watt/hour

Heat transfer across materials

Buildings are however normally constructed of combinations of materials and not single materials. The following equation may be used to calculate the rate of heat transfer across a surface constructed of various materials

Q = U * A * Dt

Where U = Overall heat transfer coefficient = 1 / R
A = Surface area
Dt = Temperature difference
and where
R = thermal resistance
= R-outside + R1 + R2 + …….. + Rx + R-inside
= 1/h0 + L1/k1 + L2/k2 + …………Lx/kx + 1/hi
where hi and h0 = Surface coefficients ($W/m^2\ {}^0C$)

Table 1.2: Thermal Conductivity of Some Common Materials

Structural material	**k** **W/m^0C**		**Insulating material**	**k** **W/m^0C**
Aluminium	160,0		Fibre cement insulating board (ceiling)	0,12
Fibre cement sheet	0,4		Corkbord	0,04
Brickwork	0,84		Fibre insulating board (bitumen bonded)	0,06
Cast concrete	1,4		Glass fibre quilt/wool	0,04
Chipboard	0,15		Insulating block (celcon)	0,184
Concrete block	1,0		Polystyrene board (expanded)	0,034
Lightweight concrete	0,35		Polystyrene board (extruded)	0,029
Glass	1,05		Polyurethane board	0,023
Hardboard	0,1		Polyurethane spray foam	0,023
Hardwood	0,15		Rockwool/mineral wool blankets	0,04
Plasterboard	0,16			
Plaster (gypsum)	0,38			
Plywood	0,14			
Roof tiles	0,85			
Sand/cement render	0,52			
Sandstone	1,30			
Steel	50,0			
Wood	0,14			
Limestone	1,53			
Slate	1,87			
Granite	2,88			

Table 1.3: Surface Coefficients

Position of surface	Surface coefficient (h_i & h_0) W/m^{0}C	
	Dull surface	**Bright surface**
Internal surfaces:		
Wall	8,1	3,3
Ceilings and floors	6,7	1,8
External surfaces:		
Wall	18	15
Roof	22	19

Example2.1: The example explains the importance of insulating the roof to combat heat load in summer

A building with an inside length of 100m and width of 12m has roof constructed of 2mm thick IBR corrugated iron sheets. An insulation layer of 75-mm glass fibre wool is put on a 4mm thick asbestos cement ceiling of dull gray colour.

Calculate the difference in heat transfer across the roof of the building with outside temperature 34 ^{0}C and inside temperature 21 ^{0}C with and without the ceiling and glass fibre wool.

First, determine the values of the thermal conductivity of the different roof elements from the appropriate tables.

$k_{IBR\text{-}sheets}$ = 50 W/m^{0}C
$k_{Glass\ wool}$ = 0,04 W/m^{0}C
$k_{asbestos\ ceiling}$ = 0,12 W/m^{0}C
h_0 = 19 W/m$^{2\ 0}$C
h_i = 6,7 W/m$^{2\ 0}$C

Calculate the overall thermal resistance (R) of the construction

R = R outside + R IBR + R glass wool + R asbestos ceiling + R inside
R outside = 1/19 = 0.05 (from table)
R IBR = 0.002/50 = 0.00004 (2 mm = 0.002 m)
R glass wool = .075/.04 = 1.875 (75 mm = 0.075 m)
R Asbestos ceiling = .004/0.12 = 0.033 (4 mm = 0.004 m)
R Inside = 1/6.7 = 0.149
R = 2.11 (0.05+0.00004+1.875+0.033+0.149)

Then determine the overall transfer coefficient, U = 1/R

= .47 Watt/m°C

Now calculate the heat transfer:

Q = A * U * Δt
= (100*12) * 0.47 * (34-21°C) (house is 100 x 12 m and temperature difference between inside and outside = 13°C)
= 7332 Watt or
= 7.332 kW per hour

Without insulation (no asbestos ceiling and fibre glass wool) the R value of the roof construction changes to .19904 (0.05+0.00004+0.149) and the heat transfer coefficient to 1/(.199) = 5.0241 W/m°C.

The amount of heat transferred through this roof construction will be:

Q = 100*12*5.0241*13 or
= 78375 Watt per hour or 10 times more than when insulated ceiling is installed.

Example 2.2: Importance of insulating walls to combat heat loss in winter

A building with a length of 100m and width of 12m has walls constructed 12 cm brick (2 m at eve and 4 m at pitch of roof). What will the reduction in heat loss be if the inside of the wall is lined with 2 cm polystyrene board during winter when outside temperature is 0°C and required brooding temperature is 30°C?

First, determine the values of the thermal conductivity of the different wall materials from the appropriate tables.

K_{brick}	=	0.84 W/m^{0}C
$K_{polystyrene}$	=	0,034 W/m^{0}C
h_0	=	18 W/m$^{2\ 0}$C
h_i	=	8.1 W/m$^{2\ 0}$C

Calculate the overall thermal resistance (R) of the walls

R = R outside + R wall+ R inside
R outside = 1/18 = 0.055 (from table)
R wall = 0.12/.84 = 0.142 (12 cm = 0.12 m)
R Inside = 1/8.1 = 0.123
R = 0.297 (.055+.119+.123)

Then determine the overall transfer coefficient, U = 1/R

= 3.36 Watt/m°C

Now calculate the heat transfer:

Q = A * U * Δt
A = 100 *2*2 for the two side walls
And 12*3*2 for the two gable end walls
= 472 m2
So Q = 472*3.36*30
= 47577 watt or
= 47.577 kW per hour

If wall is insulated with the polystyrene board:

Add the R value of the board which is .022/.034 = .647
R then = .944 and U = 1.059 Watt/m°C
Q then drops to 472*1.059*30
= 14995 watt or
= 14.995 kW/hour

The heat loss with the insulation is therefore a third compared to no insulation!

Amount of Insulation

The amount of insulation required would depend on the following:

- Under most conditions at least the roof area would be insulated as this is the area through which most of the heat transfer occurs into or from the building.
- Ever increasing cost of energy will result in houses in which chickens are to be brooded to require better insulation compared to what has been the norm in the past.
- The roof is generally insulated more than the wall areas. This is especially important in hot climates where heat load through radiation from the sun is high.
- In cold conditions or where ambient temperature remains low for long periods, the wall areas also become more important.
- With ever increasing feed cost the insulation of buildings is becoming an important factor to conserve body heat and thereby improve feed efficiency of broilers as well as adult stock.

The extent of insulation would depend on the building cost involved which is to be weighed up against the cost of heating, effect of possible low temperatures on feed consumption and utilisation as well as the effect of excessive heat load on production performance. This is not a simple calculation and each circumstance has to be treated on merit. Overall a heat transfer coefficient (U-value) of around 0.3 to .4 watt/°C (R= 2.5 to 3.3) is normally recommended for the ceiling of poultry houses where chicks are being brooded. For adult birds this value could be higher but the heat load into the building during hot days or heat loss during cold nights will increase. For walls the value could also be higher but heating cost in brooding houses and feed conversion in adult houses will increase with poor wall insulation.

Around most of the world, R-values are given in SI units, typically square-meter Kelvin per watt or $m^2 \cdot K/W$ (or equivalently to $m^2 \cdot °C/W$) as has been used in the illustration above. In the United States units are customary given in units of $ft^2 \cdot °F \cdot h/Btu$. It is easy to confuse SI and US R-values, because R-values both in the US and elsewhere are often cited without their units, e.g. *R-3.5*. Usually, however, the correct units can be inferred from the context and from the magnitudes of the values. United States R-values are approximately six times SI R-values

1.1.2 Air composition

The important aspects to be considered in the composition of air in poultry buildings will include the moisture content of the air as well as the concentration of certain gasses. Broilers and breeders may be reared on litter systems while layers and commercial layer pullets are generally kept in cage systems. Whatever system is being used, conditions within the building, included the air composition should be maintained as close as possible to the ideal.

1.1.2.1 Moisture content of the air

Control of the moisture content of the air within buildings is important in poultry production because it affects litter quality and overall conditions within the poultry shed and the wellbeing of the stock.

Moisture Production of Poultry

Moisture production in the poultry shed is influenced by factors such as:

- **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 the 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
- **Birds kept in cages** have the tendency to increase water consumption and produce faeces with higher moisture content
- **High environmental temperature** increases water consumption and hence leads to faeces with higher water content

- **Feed restriction** applied in managing broiler breeders' result in birds tending to consume more water and hence produce wetter litter condition

Effect of Temperature on Moisture Production

Although temperatures below 15°C do not greatly affect the amount of water consumed and hence the water loss through respiration and faecal discharge, temperature above this point has a marked effect on feed and water production.

Temperature also has a marked effect on the ratio between water lost through faeces as compared through respiration. At high temperatures there is a dramatic increase in water lost through respiration as birds use the vaporization of moisture from the respiratory track as a method to dispose of body heat).

Importance of Insulation of the Building and the Psychrometrics of Air

It is important to understand the concepts of psychrometric science to get to grips with the concepts of controlling the moisture content conditions of the environment and the effect that this might have on poultry.

At a first glance, even a simple psychrometric chart appears complex. However, separating the various lines and scales on the chart simplifies understanding their location, meaning and use.

Air temperature

Air temperature is a measure of the heat content of air. Three different temperature measurements are used on the psychrometric chart:

Dry bulb temperature

It is the air temperature determined by an ordinary thermometer. The dry bulb temperature scale is located on the base of the chart. Vertical lines on the psychometric chart indicate constant dry bulb temperature.

Wet bulb temperature

It reflects the cooling effect of evaporating water. 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. The wet bulb temperature scale is located along the curved upper left portion of the chart. The sloping lines from the upper left-hand side to the bottom and the right hand side of the chart indicate equal wet bulb temperatures.

Dew point temperature

Moisture will condense out of air below this temperature. Air that is holding as much water vapour as possible is saturated or at its dew point. Water will condense on a surface, such as a building wall, that is at or below the dew point temperature of the air. The dew point temperature scale is located along the same curved portion of the chart as the wet bulb temperature scale. Horizontal lines indicate equal dew point temperatures.

Relative humidity

As the name implies, relative humidity is a measure of how much moisture is present compared to how much moisture the air could hold at that temperature. Relative humidity, which is expressed as a percentage (%) value, is given in weather reports. 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 and dew point temperature scale line. The line for zero percent relative humidity falls along the dry bulb temperature scale line.

Specific humidity

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

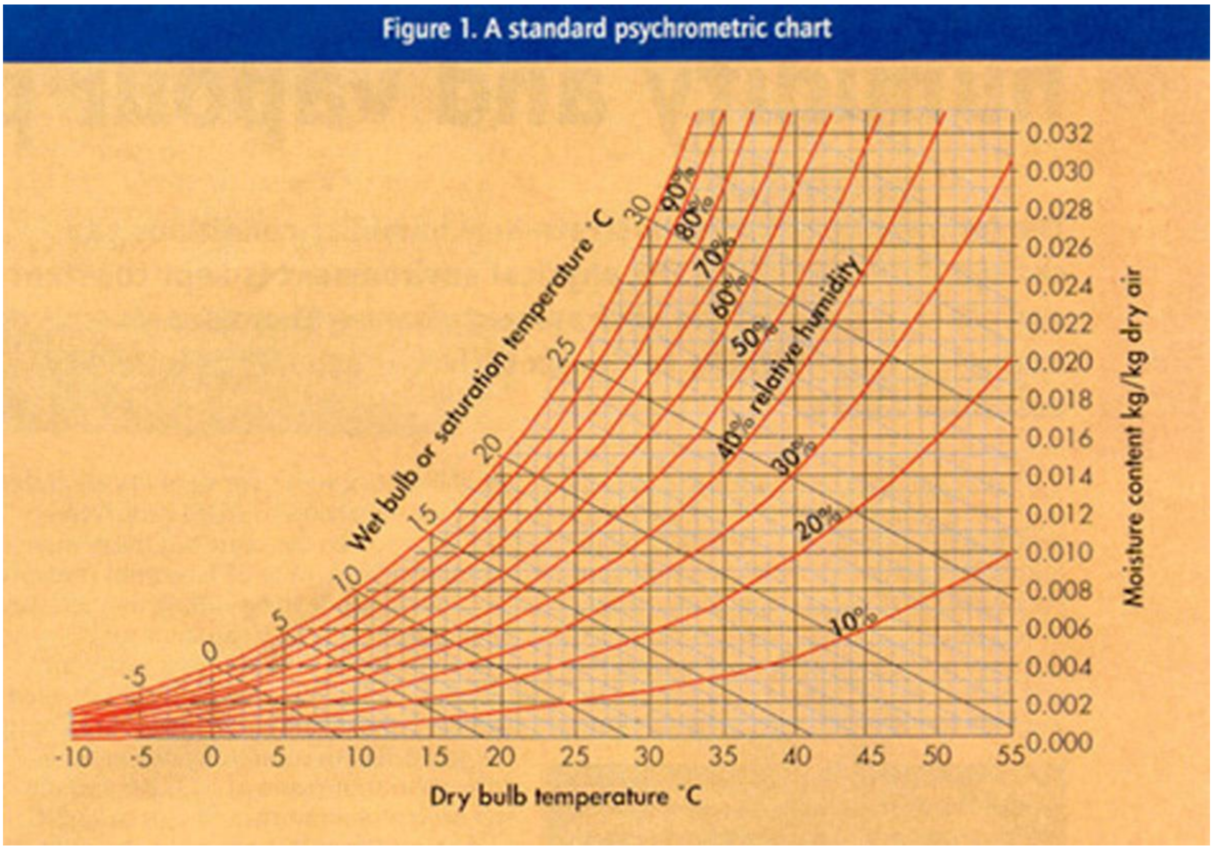


Figure 1.1: Standard psychrometric chart

The Psychrometric Chart and Practical Poultry Production

The psychrometric chart can be used to explain various concepts in practical poultry production. Given any two properties of air, the remaining properties can be determined graphically.

Condensation on Walls

Example 2.3: *The air in a poultry house has a dry bulb temperature of 27^{0}C and is at 60% relative humidity. How warm do the walls have to be to prevent condensation?*

Solution:

We need to know the dew point temperature. On the psychrometric chart, locate the intersection of the 27 ^{0}C dry bulb temperature line and the 60 % relative humidity line. Proceed horizontally to the left until the dew point temperature scale (same as the wet bulb temperature scale) is intersected. This gives the dew point temperature as approximately 19 °C. Thus, the temperature of the wall surface must be warmer than this to prevent condensation.

House Temperature and Removal of Moisture

The psychrometric chart can also be used to explain that warm air will remove more moisture from the building compared to cold air. At a temperature of say 18°C and 60% RH the air in the poultry building will contain 8 g of water per kg of air. Should the air temperature be increased to say 27°C the amount of water vapour (g of moisture per unit of air) does not change, and hence the %RH reduces to below 35% (read on the some horizontal line where it crosses the vertical line at 27°C). To get back to 60% RH at 27°C the amount of water in the air has to move from 8 gram per kg of air to 14 gram per kg of air. This warm air can therefore pick up the moisture from the building/litter and thereby create warm and drier conditions.

Warm air therefore has the ability to create a dry environment within the poultry shed. The heating of the shed can be obtained by artificial heating or making use of the heat produced by the birds. By reducing the rate of ventilation on a cold winter day (less heat removal from the building, especially if it is well insulated) the condition within the shed can be improved from a cold wet environment to a warm yet dry one. Insulating poultry buildings, together with good control on the ventilation, will assist in maintaining warm dry conditions during winter.

Adiabatic Cooling

Wet bulb temperatures tell us to what extent air can be cooled by evaporative cooling through the use of evaporation of water into the air (adiabatic cooling). On the psychrometric chart the wet bulb line running through the intersection of the 40°C dry bulb and 30% RH is the 25°C wet bulb line. If air at 30% RH and 40°C dry bulb were passed through a wet cooling pad, it would evaporate water from the pad, increasing its water content (latent heat) and reducing its dry bulb temperature (sensible heat). If the speed of air passing over the wet pad is sufficiently slow for the air to become saturated the dry bulb air temperature can be reduced to 25°C. A good wet pad system will reduce dry bulb temperature to within 85% of wet bulb temperature. The difference between wet bulb temperature and dry bulb temperature is therefore an indication to what extent cooling systems by means of adiabatic cooling can be achieved and a good system should reduce the air temperature immediately after the pad down to 85% of this difference or in the case above down to 28°C (40-25 = 15 x 85% = 12°C hence 40 – 12 = 28°C).

In areas of high humidity, adiabatic cooling of poultry sheds is not effective due to the small differences between wet and dry bulb temperatures. The ability to cool a poultry shed in an environment at 35°C and humidity of 75% is limited as the wet bulb temperature will be around 32°C and 85 % cooling ability of this difference of 3°C is less than 2°C. The shed can therefore be cooled to a very limited extent only and in addition the house will be warm at high humidity and therefore limiting the ability of birds to maintain body temperature through latent heat loss (panting).

On the other hand in dry climates adiabatic cooling is an inexpensive yet effective way to reduce temperatures. If the humidity in the above example was 20% (dry climate) the wet bulb temperature would have been 22°C with a difference between wet and dry bulb temperatures of 18°C. Effectively the dry bulb temperature could therefore be reduced by 15°C with an efficient evaporative cooling system

1.1.2.2 Concentration of certain gasses

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 as well as insufficient supply of oxygen. Most gases are easily measurable by means of Geiger kits. This is an instrument, which pumps a fixed amount of air through a tube containing a chemical, which measures the amount of gas being measured. Electronic devices with probes are also available.

Of the toxic gases commonly found in poultry sheds, ammonia is the most common gas found at high concentrations as this gas is more prevalent when litter is wet. 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.

Ammonia is especially bad for broilers as it causes the cilia of the respiratory tract (fine hair like microscopic protrusions) to stop their "sweeping" movement and will exacerbate any respiratory problem. High concentration ammonia for longer periods also leads to blindness.

Levels of ammonia should be less that 10 parts per million (ppm) by volume. Levels of 15 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 15 ppm production efficiency will be affected, especially when birds are subjected to such concentrations for extended periods of time.

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 litter conditions through the removal of sufficient amount of moisture from the building. Further control of ammonia levels rests with the ability to keep the manure as dry as possible through elimination of water spillage.

Minimum and maximum tolerated of the more important gasses of air which is generally accepted is illustrated in Table 1.4

Table 1.4: Minimum and Maximum tolerated levels of Gasses in the Air

Gas	Inside Air
O_2 (Oxygen)	**Min 19 %**
CO_2 (Carbon Dioxide)	**Max 0.03% or 3000 ppm**
CO (Carbon Monoxide)	**Max 0.001% or 10 ppm**
NH_3 (Ammonia)	**Max 0.0015% or 15 ppm**

Anaerobic decomposition of litter

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 litter is compact and wet and should be avoided in poultry buildings.

Aerobic decomposition of litter

This form of litter decomposition supports the growth of bacteria. 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 litter is relatively dry and well aerated.

Minimum ventilation of poultry

Under low environmental temperature conditions when the desired house temperature is above the ambient temperature, a minimum rate of ventilation is required irrespective of the house temperature. This minimum ventilation is required to remove moisture, carbon dioxide, ammonia, etc. and introduce sufficient oxygen into the building. The minimum rate of ventilation required is found in the following calculation proposed by the Agriculture Development and Advisory Service (ADAS) in the United Kingdom:

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

ALW = average live weight in kg

By using this formula the minimum ventilation requirement for adult birds may be calculated as being:

- Commercial layers weighing 2.0 kg the minimum would be 0.48 m^3/hr/kg or 0.97 m^3/hr/bird
- Broiler breeders weighing 3.5 kg the minimum would be 0.42 m^3/hr/kg or 1.47 m^3/hr/bird

The same formula can be used for calculation the minimum ventilation rate required for broilers and growing pullets 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 pullets or broiler chicks from day old to point of lay or slaughter at any given age. 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. This is logical as the relative gain in weight during the initial stages (hence metabolic processes) is higher compared to towards the end.

An example of calculating the minimum ventilation requirement for broilers by using the ADAS equation above is illustrated in Table 1.5.

Table 1.5: Calculation of Minimum Ventilation for Broilers

Age	Live Mass (g)	Min Ventilation (m^3/kg/hour)
1	50	1.22
2	61	1.16
3	76	1.10
4	93	1.04
5	112	1.00
6	135	0.95
7	160	0.91
8	186	0.87
9	219	0.84
10	253	0.81
11	290	0.78
12	330	0.76
13	373	0.74
14	419	0.72
15	468	0.70
16	519	0.68
17	574	0.66
18	631	0.65
19	691	0.63
20	753	0.62
21	818	0.61
22	885	0.59
23	955	0.58
24	1027	0.57
25	1102	0.56
26	1178	0.55
27	1256	0.54
28	1336	0.54
29	1418	0.53
30	1501	0.52
31	1584	0.51
32	1571	0.51
33	1757	0.50
34	1845	0.49
35	1933	0.49

Broilers grow rapidly and it is therefore essential that the adjustments to minimum ventilation rates are made regularly (daily). In pullet rearing these adjustments to the minimum ventilation setting could be done weekly. For broilers the minimum ventilation rate required should therefore be calculated for each day and set up on control charts in the poultry shed. For growing pullets the calculation and adjustment is normally done on a weekly basis.

In a fan ventilated building this minimum ventilation rate is then set in accordance with the number of birds in the shed by operating variable speed vans at a lower rate or operating single speed fans intermittently by means of a timer. In this manner the minimum rates of ventilation are achieved irrespective of house temperature.

1.1.3 Illumination

Light is radiation which is seen as packages of energy that is being sent from the light source.

The biological responses associated with egg production in laying stock to light intensity, the length of the daily light period and the pattern of daily change has been well documented in research papers and most of the research on the effect of light on poultry has been summarised in Poultry Lighting the Theory and Practice written by P Lewis and T Morris.

The response of chickens to light is due to the effect of light on the activity of the anterior lobe of the pituitary gland, located at the base of the brain and the consequent production of hormones that in turn affect the development and production of hormones in the reproductive system of the bird.

1.1.3.1 Effect of Photoperiod

Photoreceptors in the hypothalamus convert electromagnetic signals received from the eye via the optic nerve 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 gland. The pituitary gland responds to this stimulation by producing Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH). These hormones are secreted into the circulatory system and they in turn activate the ovaries in the female to produce hormones androgen, oestrogen and progesterone while in the male they stimulate the testes to produce the hormones androgen and testosterone.

There is also the view that chickens have light sensitive receptors in their brain, right under the skull, which are also responsible for activation of the hormonal system that is involved in reproductive performance. This means that the light wavelength passes through the skull to these receptors, rather than via the optic nerve.

Photoperiod and sexual maturity

Light programmes are used to control the age of sexual maturity of poultry stock and are important tools in breeder and layer stock. In principle decreasing the photoperiod during rearing will delay the age at sexual maturity (birds mature at a later age) and increasing the photoperiod during rearing will enhance the age at sexual maturity (birds mature at an earlier age).

The age at sexual maturity can therefore be 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 and within a genotype lighter birds will be delayed in maturity.

Much research has been conducted on the effects of various light programs on poultry especially so for commercial layer pullets. 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

There is a negative correlation between age at first egg and constant hours light followed during rearing if the photoperiod is less than 10 hours. Commercial layer 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 less than 10 hours.

Above a constant photoperiod of 10 hours the correlation is positive but weak of about one day delay for every 3 hours.

Consequently the earliest maturity for a constant program is achieved on a 10 hour photoperiod.

In practice this would mean that if age at first egg is 136 days at a constant photoperiod of 8 hours for a particular breed, age at first egg could be expected to be 140 days at if reared at 6 hours constant photoperiod, 132 days at 10 hours photoperiod and 133 days at 13 hour photoperiod.

Decreasing photoperiod during rearing

A declining photoperiod during the first part of rearing will delay maturity and a gradual decline in photoperiod during this period has a more pronounced affect (delay) compared to a single decline. Therefore the more gradual the decline over time the more delay in sexual maturity will be achieved.

In practice this would mean that with a constant rearing photoperiod of 10 or 8 hours a more gradual decline in photoperiod to the 10 or 8 hours photoperiod during the initial stages of grow out (0 to 10 weeks) will delay sexual maturity more compared to when the decline is more rapid and the 10 or 8 hour constant photoperiod is reached by for instance 3 weeks of age.

Increasing photoperiod during rearing

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 advancement 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 advance maturity further.

Increasing the photoperiod from a lower base also has a larger impact than increasing from a higher base level. An increase of 5 hours in photoperiod from 8 to 13 hours is more pronounced compared to a 5 hour increase from 13 to 18 hours.

Increasing the photoperiod prior to 6 weeks of age has very little effect on maturity. Between 6 and 12 weeks there is a progressive increase in the number of birds susceptible to a change in photoperiod. Pullets are most responsive to increased photoperiod between the age of 12 weeks and the natural maturity age (18 to 20 weeks in most layer strains), but the response is reduced as the age at which the increase is given approaches age at which the breed of bird would mature naturally.

Effect of Sexual Maturity on Egg Production

Early sexual maturity may result in increased egg numbers per hen housed but initial egg size will be small and if mature body mass is not achieved at onset of production, 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 corrected but hen housed production will suffer as a result of production time being lost.

Specific programs are developed for particular circumstances and most modern rearing houses for rearing of commercial pullets and breeder birds 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 be developed for use in such houses which will result in natural seasonal changes in photoperiod having limited effect on the sexual maturity.

Effect of Sexual Maturity on Egg Weight

The photoperiod applied during rearing may be used to change the age of sexual maturity. It should however be noted that feed restriction also affects age at sexual maturity. When sexual maturity is delayed by photoperiod, egg weight for age will be increased and this increase in egg weight for age will remain throughout the life of the flock.

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).

The extent to which maturity is to be delayed would depend on particular circumstances and aspects such as relative egg prices in relation to size would influence this. It is advisable to consult with chick suppliers and breeders for detailed instructions on the specific light program and ideal age at sexual maturity.

Ovulation and photoperiod

It is not because the photoperiod lies between 10 and 15 hours after starting of the light that there has to be continuous light for layers. Birds experience the hours after the morning light as their "subjective day". Short periods of dark after the light-start will not affect this. As long as there is a light flash in the photoperiod, the photosensitive reaction will occur. The short dark periods will not be experienced as night and the birds will not sleep.

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 eggs during these hours.

The time from ovulation to the egg being laid takes just more than 24 hours. 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.

Photorefractoriness in broiler breeders

Photorefractoriness is the inability of broiler breeders to respond to an otherwise stimulatory day length. Broiler breeders should preferably be reared in closed (dark) houses. Where this is not possible most breeders are currently recommending that when rearing broiler breeders in open sided buildings, natural day light should be applied during rearing. Research at the University of Natal questions the correctness of applying a constant “long day” to broiler breeders when they would otherwise be exposed to a natural increasing day length. Sexual maturity is markedly delayed when broiler breeders are maintained on day lengths that are longer than 11 hours during the rearing period.

1.1.3.2 The Effect of Light Intensity

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

Different stock requires different light intensity and in rearing of birds, a higher intensity is applied during the initial stages of brooding.

Light Intensity in Open Sided Houses

Birds should not be exposed to the very high light intensity such as direct sunlight. Other than it being 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 as well as poor carcass quality in broilers. Open side houses especially should therefore have sufficient overhang on the side walls to eliminate direct sunlight from entering the building. Open sided buildings should also not face east/west but north/south to ensure that morning and afternoon sun light is eliminated from the building.

Light Intensity in Pullet rearing Houses

Light intensity has very little effect on sexual maturity of pullets.

When chicks are placed, the light intensity should be increased to levels of around 20 lux for the first week to ensure that chicks find drinker and feed systems with ease. Thereafter the intensity is reduced to around 5 lux so as reduce bird activity. The low light intensity in pullet rearing houses will improve feed efficiency through reduced locomotive activity and will also reduce flightiness. For this reason, houses in which pullets are to be reared (layers or breeders) are to be equipped with dimmers.

With multi-tier rearing 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 and feed troughs also create shadows and it is of special importance to note that such shadows do not fall on the drinker nipples when placing chicks at day old. These shadows could cause chicks not finding the drinker nipples at placement. In multi-tier rearing cages it would be advisable to suspend the lights at a height that will allow the light to shine into the cage as in most systems the drinker nipples are normally situated towards the back of the cage.

1-1 Example of a light meter

Once chicks are past the critical stage of learning where the drinker system is the light intensity in cage systems should be measured at the feed trough, at a point furthest away from the light source. In a very high cage configuration, the lights may be suspended at different heights down the cage rows to even out the differences in intensity at the various levels. However cages close to the light source will always be at a higher intensity compared to cages further away from the light source.

Light Intensity in Broiler Rearing Houses

Broiler chicks require high levels of light intensity during the start of the growing period (20 to 30 lux) to ensure that chicks find feed and drinker equipment as soon as possible. This intensity is measured at a point furthest way from the light bulbs at floor level and normally at the drinkers.

Thereafter the intensity is reduced (5 to 10 lux in closed broiler houses) to eliminate vices (pecking) and keep the flock calm and so avoiding bruising and scratching. Reduced activity also improves feed efficiency.

Dimmers in closed broiler houses are therefore essential.

In open sided broiler houses, the artificial light supplied at night should also be dimmed, but not as low as in closed houses. A high level of intensity is required during brooding which should be lowered during rearing to around 10 lux.

Light Intensity in Commercial Layer Houses

Work done as early as 1967 by 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 and layer breeders in open housing 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. Dust accumulating on the light source will also reduce the effective intensity.

In multi-tier cage systems it is impossible to achieve an even light intensity at all levels as the 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 and feed troughs also create shadows. Light intensity in cage systems should be measured at the feed trough, at a point furthest away from the light source. In very high cage configuration, the lights may be suspended at different heights to even out the differences in intensity at the various levels.

Light Intensity in Broiler Breeder Houses

There is evidence that a 10:1 ratio is required for broiler breeder hens to distinguish day from night and consequently to initiate a maximal photoperiodic response in open houses, broiler-breeding stock should be subjected to levels above 50 lux.

In completely closed (dark) houses where natural day light has no influence, a light intensity of 30 lux for broiler breeders will be sufficient to maintain satisfactory levels of production.

In completed closed breeder or layer houses (dark) the artificial light intensity could therefore be lower than what would be supplied in open houses where birds are subjected to natural daylight.

Light Intensity in Dark Houses

Dark houses are used in pullet rearing (including broiler breeder rearing) to control the sexual maturity of stock more effectively. In these houses the photoperiod used is shorter than the natural day length. Light trapping of fans and air inlets is then used to eliminate outside light from the building.

This light trapping should provide for intensity within such sheds at a level below 0.2 lux, measured within one meter of the air inlet or fan area.

The same principle would apply in dark houses used for egg production (commercial layers and breeders) where the total hours of light supplied is less than the longest seasonal day length.

1.2 Climates in South Africa's Production Areas

Poultry production in South Africa is concentrated mainly in the central inland areas where maize, the main ingredient in poultry feeds, is grown. Being at high altitude (1400 to 2000 meters above sea level), this area is generally referred to as the Highveld Region. Poultry production also occurs close to other major industrialized areas of Western Cape, Eastern Cape and Natal.

1.2.1 Highveld Region

This region is known for its cold winter early mornings (around 0°C) with daytime temperatures rising to above 20°C within a relatively short period of 6 hours. The high altitude of this region (lack of oxygen) together with the cold winter conditions gives rise to ascites problems in broilers, especially under conditions of poor ventilation. Coupled to the low night temperatures, these aspects must be given consideration when designing minimum ventilation systems for broilers in this region. In fan ventilated as well as open sided houses, the ventilation systems must cater for and be able to cope with the rapid changing circumstances in the 24-hour cycle of the day.

Insulation of especially the roof needs consideration and to some extent the insulation of the walls in rearing houses should be considered as well. This is of special importance in the colder parts of the Eastern Highveld.

Cooling of poultry sheds in this region is not essential for bird survival but production efficiencies will be improved if cooling is provided during summer, especially with high stocking densities. The cost thereof should be weighed up against the improved performance.

1.2.2 Free State Region

This region is very similar to the Highveld Region and the principles suggested above would apply to this region as well.

The insulation of walls could however be of special importance in the colder parts of the Eastern Free State where winter snow could occur.

1.2.3 Western Cape Region

This winter rainfall region is known to have cold, wet winter conditions in which daytime temperatures remain cold (<15°C) but seldom down to freezing except in the mountainous areas. During summer the day temperatures may rise to above 40°C and this high temperature is normally associated with conditions that are relatively dry (Berg winds).

Poultry housing in this region should therefore be able to cope with long periods of low temperatures (minimum ventilation requirement) during which relative humidity is also high.

Buildings should be well insulated, to ensure that house temperatures will remain at a level that enhances dry litter condition during these cold and high humidity conditions.

The very hot dry summer calls for cooling as temperatures will reach the point where not only the performance will be affected but high losses due to heat stress will occur as well. Evaporative cooling systems work very well in this dry hot climate during summer.

1.2.4 Natal and Eastern Lowveld Region

The Natal Coastal and Lowveld regions are considered to be sub-tropical and the significance of this is to consider high levels of humidity during hot summer conditions. These conditions make adiabatic cooling of poultry sheds less efficient and in fact impossible when farms are established close to the coastal area. This becomes less of a problem further away from the coast where temperatures during summer can also become high, requiring cooling if maximum production efficiencies are to be achieved.

Increased fan capacities to increase sensible heat loss through wind chill factor will assist in reducing the sensible heat of poultry at high relative humidity conditions.

Seasonal fluctuation in temperature as well as the temperature fluctuation within a 24 hour cycle is less in this region compared to the Highveld and Western Cape regions.

1.2.5 Eastern Cape Region

In this region high summer temperature (>35°C) could prevail but winter conditions are less severe compared to that of Western Cape and Highveld Regions.

The hot dry summer calls for cooling as temperatures will reach the point where not only the performance will be affected but high losses due to heat stress will occur as well. Evaporative cooling systems work very well in this climate during summer but care should be taken that close to the coast, relative humidity could be high during summer. This would call for increased fan capacities to enhance sensible heat loss.

With winter conditions being reasonably mild, normal minimum ventilation requirements would apply in this region.

2 Ventilation and Cooling

There are a few basic reasons why poultry houses need to be adequately ventilated and include:

- Removal of heat produced by the birds
- Removal of heat entering the building through the walls and roof.
- Removal of excess moisture produced by the birds
- Minimize dust
- Limit the build-up of harmful gases such as ammonia and carbon dioxide
- Provide oxygen and fresh air to the birds for respiration

During warm summer months heat build-up is the major concern. Air within the building is heated by heat produced by the birds as well as solar heat entering the house and warming the structure. The warmed air has to be exchange with colder outside air by fans or side windows and inlets in the structure. Thus for summer (hot conditions) ventilation design has to be based on maximum summer ventilation requirement.

Under conditions when outside temperatures are lower than the temperature required within the building, a minimum amount of ventilation has to be provided so as to ensure sufficient supply of oxygen and removal of carbon dioxide and other gases as well as moisture from the building. For winter ventilation the design has to be based on minimum ventilation requirement.

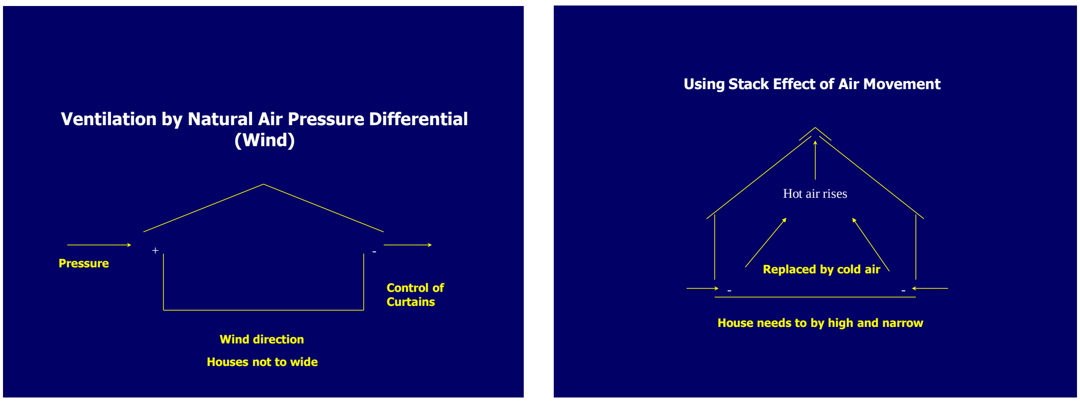
2.1 Natural ventilated Houses

Natural ventilated houses are houses 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

2.1.1 Air Pressure Effect of Air Movement

When wind blows against the building, a positive air pressure is created on the wind side of the building and a negative air pressure on the opposite side. Should ventilators be placed on the sidewalls, air will move into the building on the positive pressure side and out of the building on the negative pressure side.



2-1 Illustration of how air moves with natural ventilation

Greater wind speed increases the airflow through the building. Wind speed and the effect on air movement is illustrated in table 3.1. The amount of airflow through the building may be controlled by opening and closing the side inlet and outlet areas in relation to wind speed and the amount of ventilation required. Under conditions of no wind, very little ventilation is achieved.

Table 2.1: Wind speed and the effect on air movement

Description of Wind	Wind Speed (km/hour)	Air flow through a 1x1 meter opening (m^3/min)
Light breeze	3	50
Reasonable breeze	15	250
Strong breeze	30	500
Light wind	40	660
Strong wind	50	830
Very strong wind	70	1160

From: Commercial Chicken Production Manual, Fourth Edition, North and Bell

2.1.2 Stack Effect of Air Movement

The stack effect of air movement in the building (also often referred to as the chimney effect) is as a result of warm air that rises and colder air moving in through inlets. Outlets are placed in the roof and inlets as low as possible on the sidewalls to make use of this effect of air movement.

The approximate expected airflow as a result of the stack effect of air movement is presented in the Table 2.2.

2-2 Illustration of high rise house which will have some stack effect due to height

Table 2.2: Air speed through ventilator of 1 m² as a result of stack effect if difference in height is 2 m

Temperature Difference	Airspeed
3°C 5°C 10°C	1.7 m^2/min 2.0 m^2/min 3.0 m^2/min

From: Commercial Chicken Production Manual, Fourth Edition, North and Bell

The possible amount of ventilation through the use of the stack effect is relatively small and a large temperature difference is required before air will move as a result thereof. Its importance in ventilation of naturally ventilated poultry buildings is therefore limited and used only in creating minimum ventilation in these houses under cold winter condition.

2.1.3 Width of Natural Ventilated Houses

Natural ventilated houses up to 10 meter wide with a flat mono-pitch roof can be ventilated satisfactorily by natural air pressure effect. These houses have limited stack effect, as they are generally very low in their construction.

2.3: Typical natural ventilated buildings with buildings on the right having ridge opening

Wider natural ventilated houses should have central ridge ventilation and if sidewalls are constructed reasonably high, effective utilization can be made of the stack effect, especially for minimum ventilation.

Natural ventilated buildings should not be wider than 13 meter. Under low air pressure conditions, wider buildings will not be adequately ventilated. This could be overcome by the installation of fans that move air within the building and thereby increasing the sensible heat loss of the birds.

2.4: Use of air circulating fans in floor and cage systems

2.1.4 Advantages and Disadvantages of Natural Ventilation

Advantages would include:

They are easier to construct and less expensive to establish (cost per unit area)
They are simple to operate
No emergency power is required
Operating cost is low due to lower electricity used and lower maintenance cost

Disadvantages of Natural Ventilated Houses:

It is more difficult to ensure correct environmental conditions within the building, especially for young growing birds
Stocking density is limited
High light intensity causing increased activity, scratching and pecking.

2.2 Mechanical Ventilated Houses

2.2.1 Amount of Ventilation

The amount of ventilation required in mechanically ventilated houses has three considerations.

- Minimum ventilation
- Maximum ventilation
- Intermediate ventilation

2.2.1.1 Minimum Ventilation

There is a minimum amount of ventilation required, irrespective of air temperature. This amount of ventilation is required to ensure adequate levels of Oxygen being introduced and adequate levels of Carbon Dioxide being removed. This ventilation should also be sufficient to remove moisture from the building and by so doing, insuring low levels of Ammonia.

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

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

ALW = average live weight in kg

By using this formula the minimum ventilation requirement may be calculated as being:

Commercial layers weighing 2.0 kg the minimum would be 0.48 m^3/hr/kg or 0.97 m^3/hr/bird

Broiler breeders weighing 3.5 kg the minimum would be 0.42 m^3/hr/kg or 1.47 m^3/hr/bird

For broilers, and pullets during rearing the minimum ventilation required would depend on the age and the particular breed. The body weight at a specific age for a specific breed needs to be used to calculate the minimum requirement at the specific age. Illustrations 2.5 and 2.6 below are two examples in which the body weight for age has been used to calculate the minimum ventilation rate required for pullets and broilers (m^3/kg live mass) with the application of the formula ADAS.

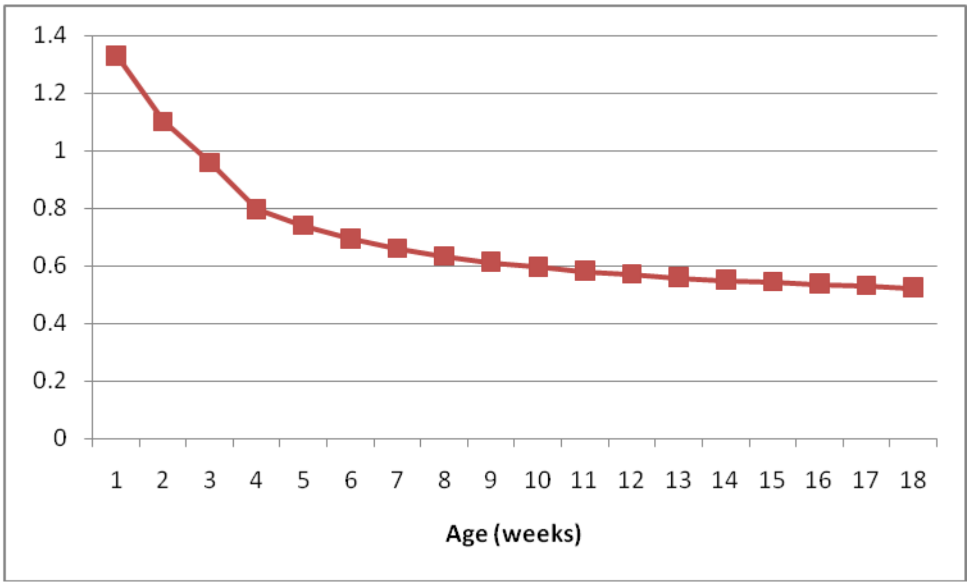


Figure 2-5: Illustration of the minimum ventilation for pullets in rear (m^3/kg live mass)

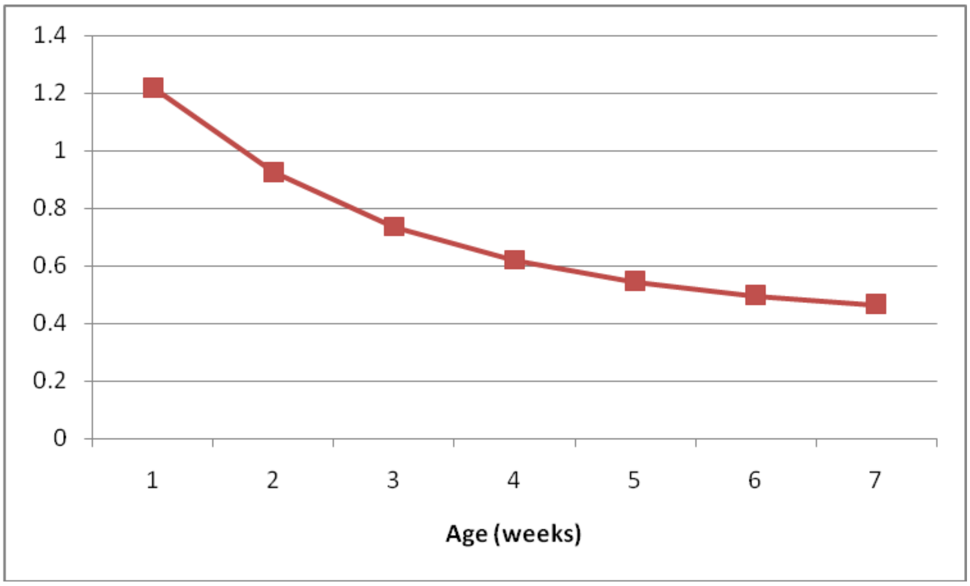


Figure 2-6: Illustration of the minimum ventilation requirment of broilers (m^3/kg live mass)

Minimum Ventilation under High Humidity Conditions

At high levels of humidity, especially when ambient temperature is close to the required norm within the building, note should be taken that insufficient level of moisture produced by the birds will be removed when using the ADAS formula. This will be influence by the temperature and humidity level of the incoming air and this may be calculated by using the following formula (assuming inside RH of 75%):

$$\textbf{V min. (m}^3\textbf{/hr/bird) = X/(Xi-Xo)}$$

X = water vapour production of the birds (g/hr)

Xi = water vapour content of air inside the building at 75% RH

Xo = water vapour content of air outside the building

Xi and Xo may be obtained from the psychrometric chart

Using this formula it can be calculated that at environmental temperatures close to the desired house temperature (20 to 25°C) and at high levels of relative humidity outside, the minimum ventilation should be increased above the levels suggested by ADAS to dispose of sufficient levels of moisture.

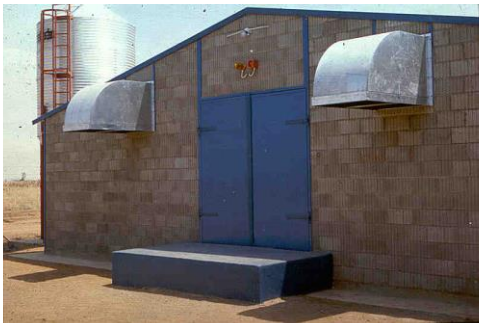
Supplying minimum ventilation

Minimum ventilation is supplied under conditions where temperatures are low and also this system would operate more often when birds are young (chicks). The minimum ventilation should therefore be introduced over the entire building as evenly as possible and directed away from the birds so as to avoid wind chill.

When using conventional side inlets together with negative pressure fans, the inlets should be adjusted to such an extent that a negative pressure in the order of 30 to 40 Pascal is maintained to ensure that air speed at the inlets is in the region of 250 to 350 m/min. These inlets should be small and evenly distributed throughout the building, directing air away from the birds.


Figure 2-7: Example of small inlet opening under minimum ventilation

A plastic tube with holes (commonly referred to as a fan jet) with a fan and air intake system from outside is often used to distribute fresh air as well as circulate and mix air within the building when fresh air intake is closed. These are very good minimum ventilation supply systems but have the negative of being difficult to clean. They also collect dust during the production cycle. It is important to ensure the correct number of holes to be punched into the tube for correct air pressure and the tubes are not to be longer than 70 meters. With longer houses the tubes are then installed at both gable ends. They are however not all that popular in modern buildings due to difficulty to clean, especially so in floor rearing houses.

2-8 Example of a fan jet with inlet on outside

2.2.1.2 Maximum Ventilation

Once house temperature exceed the required temperature (set point) within the building, increasing amount of ventilation needs to be applied to remove the heat build up in the building. Since the amount of heat produce would depend on the type of stock in the building as well as amount of insulation installed, the maximum ventilation required would depend on:

Heat produced by the birds which is mainly dependant on body weight, and

Heat entering from outside (when outside temperature is higher than inside) or lost to outside (when outside temperature is lower than inside) the building and this is dependent on amount of insulation and size of building

As a rule a practical formula to use under conditions of reasonably well insulated buildings is to multiply the minimum rate of ventilation proposed by the Agriculture Development and Advisory Service (ADAS) in the United Kingdom by a factor of 10..

The maximum ventilation for **commercial layers** weighing 2.0 kg would be 4.8 m^3/hr/kg or 9.7 m^3/hr/bird from the minimum rate calculated above.

Broiler breeders weighing 3.5 kg the maximum would be 4.2 m^3/hr/kg or 14.7 m^3/hr/bird

For a **commercial pullet** rearing shed the maximum ventilation would be required at the age of 18 weeks of age. Should the body weight at 18 weeks be in the order of 1.4 kg then the maximum ventilation required would be in the order of 5.3 m^3/hr/kg or 4.2 m^3/hr/bird

For **broiler** sheds the maximum ventilation required would be at processing age. Should the processing body weight be 2.0 kg then the maximum ventilation required would be in the order of 4.8 m^3/hr/kg or 9.7 m^3/hr/bird.

In very hot climates, ADAS recommends the following formula:

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

ALW = average live weight in kg

Using this formula the maximum ventilation required for South African conditions where summer temperatures often exceed 30°C would be higher compared to the calculation above.:

For **commercial layers** weighing 2.0 kg it would be 6.0 m^3/hr/kg or 12.0 m^3/hr/bird.

For broiler breeders weighing 3.5 kg it would be 5.2 m^3/hr/kg or 18.2 m^3/hr/bird

For a **commercial pullet** at 18 weeks weighing 1.45 kg the maximum ventilation required would be in the order of 6.5 m^3/hr/kg or 9.4 m^3/hr/bird, and for

Broilers weighing 2.0 kg the maximum ventilation required would be in the order of 6.0 m^3/hr/kg or 12.0 m^3/hr/bird.

2.2.1.3 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 as well the age (body weight) of birds.

The amount of intermediate ventilation (i.e. ventilation required between maximum and minimum) is then obtained by means of a step control system or variable speed fans.

By step control the fans will be controlled by a thermostat, which will operate increasing numbers of fans from the minimum rate, in steps, until all fans are operating at maximum ventilation. This method of control is used when use is made of 3 phase electrically driven fans with no speed control. The temperature differential between steps is generally in the order of 0.5 to 1.0 °C and this would depend on the particular controller and steps available.

Generally the maximum rate of ventilation would be reached at a point around 5 to 6°C above the set point. So if set point is 20°C the maximum ventilation would be reached at 25/26°C and if the controller had 10 steps or phases then the temperature differential between phases would be 0.5/0.6°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

2.2.2 Wind Chill

Under conditions of high environmental temperature it is advantageous to use the wind chill factor of air moving over the birds to assists 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 3.3. Note that this is the air speed within the building over the stock and not the air speed at the air inlet.

Table 2.3: Effect of Airspeed on Sensible Heat of Poultry 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

The age of the stock and temperature conditions should therefore be considered in the ventilation of stock and air movement over birds. Younger birds are more susceptible to wind chill compared to adult birds.

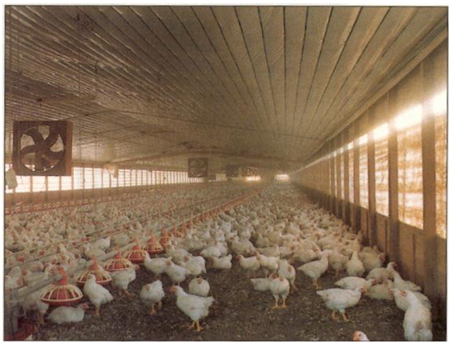
For **chicks** the air speed should be minimal (<0.25m/sec) as they are easily chilled.

Under normal temperature conditions more **mature stock** the air speed should be (between 0.5 and 1 m/sec)

For **adult stock** and especially under high temperature conditions, the wind chill effect can be used very effectively to make birds "feel" more comfortable. At a house temperature of 30°C adult birds will "feel" 4.4 °C cooler if the air speed over the birds was 1.5 m/sec. They would therefore sense a temperature of around 25 to 26 °C and not 30°C.

The effect of wind chill is used very effectively in tunnel type ventilation systems because in a tunnel configuration the air speed down the length of the building would be higher compared to when the same volume of air is ventilated across the building in a cross ventilation configuration. Obviously as the air temperature approaches body temperature the wind chill effect will reduce. At low environmental temperature the wind chill effect would be much larger compared to what is presented in table 3.3.

In open sided buildings fans could be installed down the building so as to blow air over the birds down the length of the building. Depending on the size and design of the fan the distance between fans would be in the order of 20 to 30 meters. Fans could also be installed down the one side wall to blow air at an angel across the building. .



2-9 Example of using air circulating fans to increase wind chill in open sided buildings

2.2.3 Advantages and Disadvantages of Fan Ventilation

Advantages of mechanical ventilated houses

Stocking density can be increased compared to open sided houses
It is possible to ensure optimum environmental conditions within the building, provided the building is properly designed and the system is operated accordingly
Heating cost in rearing stock is reduced due to better insulation of walls and control of the environment in the building
Light intensity can be controlled

Disadvantages of mechanical ventilated

The houses are more costly per unit floor area compared to open sided houses
Fan ventilated houses require emergency power supply
Such houses have higher operating due to electrical supply and more mechanical equipment that needs to be maintained.

2.2.4 Ventilating Fans in Mechanical Ventilated Houses

2.2.4.1 Positive and Negative Pressure Houses

The required air may be introduced into the building by creating a negative air pressure by use of fans and allowing outside air to enter the building via air inlets. A second but less popular way is to force the air into the building by using positive pressure fans and allowing air to escape from the building via air outlets. The air velocity at the delivery side of the fan is extremely high and has to be diverted away from birds. For this reason with positive pressure systems, air is preferably to be introduced into buildings via air ducting. The ducts have to be designed in such a manner that air is distributed into building as evenly as possible without creating excessive draughts. The ducts are costly and also difficult to clean and hence the lower popularity of this system in poultry buildings.

2.2.4.2 Calculating the Number of Fans required

By calculating the expected biomass in the building and assuming that the building is to be reasonably well insulated the number of fans required for a particular circumstance can be calculated.

In this example the number of fans to be installed for sufficient maximum ventilation under conditions exceeding 30°C for 40000 broilers, which may reach a body mass of 2.0 kg is to be calculated. The design capacity of the fans is given as being 35000 m^3/hour at a negative pressure of 25 Pascal.

Calculation

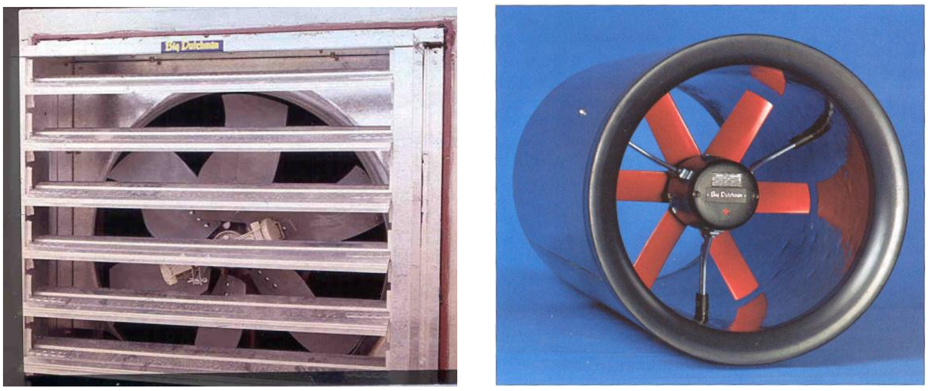
40000 broilers with 2.0 kg live mass will result in total biomass of 40000 x 2.0 or 80000 kg and require
80000 x 6.0 (this being the maximum required ventilation as per 2.2,1.2 above)
= 480000 cub meter of air to be ventilated per hour

If fan capacity is rated as being = 35000 m^3/hour
Then the number of fans required = 480000/35000
= 13.7 or then 14 fans

2.2.4.3 Factors that Effect Fan Capacity

It is always advisable to check the rating of the fans. Most fan ratings are given as free flow and allowance must be made for the fact that fans will be operating at a negative pressure as well as against light baffles, louvers, etc. The effective fan capacity when working against a negative pressure is affected by various factors and include:

In regions such as the South African Highveld, cognisance should be taken of the fact that high altitude affects the effective capacity of fans. A factor of at least 10% should be allowed for this.



2-2 Belt driven fan with shutter on left and axial fan on the right

The fan rating should take into account the fact that the fan will operate at a negative pressure. The fan capacity decreases with increased pressure against it.

Some form of shutter will be installed to close off the fan when not operating. These shutters also reduce the effective capacity of the fan.

Fans may be installed close to one another, reducing the effective capacity. When installing fans in a fan room close to one another, it should be considered not to install fans closer than 1.5 x the diameter of the fans to one another.

2.2.4.4 Measuring Fan Capacity

The effective fan capacity may be measured by a Vane Anemometer. The anemometer converts revolutions into air velocity. Some makes of instrument measure temperature and humidity at the same time. If the air velocity (m/sec, m/min, etc.) is measured over a given area (m^2), then multiplying the air velocity by the area measured provides the average volume of air within the period (m^3/sec, m^3/min, etc.).

2-11 Example of an Anemometer

The air velocity at the fan is however extremely variable. Under practical conditions, the air speed is more stable at the air inlets of the building and effective fan capacity should be measured at the intakes, with fans operating at normal static pressure (negative pressure or air inlet opening). The total air velocity over all inlets is therefore multiplied by the total effective inlet area and this total air volume is then divided by the number of fans to arrive at the effective capacity per fan.

There is a relationship between air velocity and static pressure and other instruments measure the static pressure and convert this into inlet air velocity. Again, by determining the total effective inlet area and multiplying this with the inlet air velocity, the total air volume may be calculated and by dividing this by the number of fans, the capacity per fan may be determined.

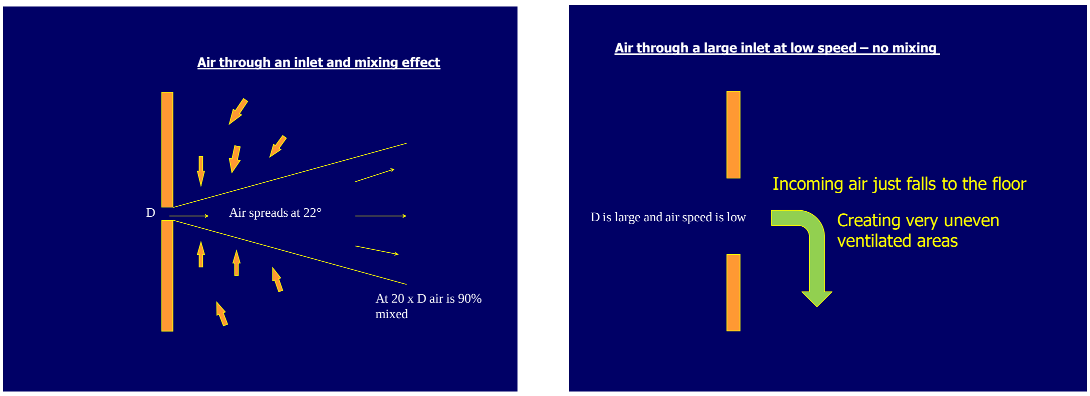
2.2.5 Air Inlets in Mechanical Ventilated Houses

The manner in which the ventilated air moves through the building to ensure proper "mixing" of air and elimination of "dead spots" as well as over ventilated areas (creating of draughts) needs to be considered. In negative ventilated buildings this is determined mainly by the way in which the air enters the building and not so much by where the fans are situated.

2.2.5.1 Airflow through an Inlet

Figure 3.10 illustrates how air flows through an inlet if the air speed at the inlet is in the order of 300 m/min compared to when the inlet airspeed is low. If the air speed is relatively high (300 m/min) the incoming air spreads at an angle of 22 degrees. As a result of turbulence, the incoming air draws in air from the side into the venturi, thereby causing fresh incoming air to be mixed with air in the building. At a distance of 20 x diameter of the opening, the air speed has reduced to 20% of the incoming airspeed and the incoming air at this distance from the inlet would be 90 % mixed with inside air.

If the air speed is low then the incoming air, which would normally be colder the the air inside the building simply “drops” to the floor.



2-10 The manner in which air flows through an inlet

When air is moved through larger openings it will then have to be moved over a greater distance before proper mixing occurs. This is the reason why with negative pressure buildings the air inlets should be as small as is practically possible and spread throughout the building as much as possible to create good mixing of incoming air with air inside the building. If not, the building will tend to develop poorly ventilated and over ventilated spots. A negative pressure in the order of 25 to 40 Pascal will ensure good air movement and mixing effect.

2.2.5.2 Air Inlet Airspeed

Birds should not be subjected to high air speeds during cold conditions, while under warm conditions and especially when birds are older, the air speed may be increased so as to use the wind chill factor in creating a more comfortable condition.

In a negative pressure building the incoming air speed will be determined by the negative pressure. The higher the negative pressure the higher the inlet air speed and the lower the pressure, the lower the inlet air speed.

As a rule of thumb air speed of incoming air under different conditions should be as close as possible to the following:

Chicks 200 to 250 m/min maximum

Young stock under cold environmental conditions 200 to 250 m/min maximum

Growing pullets and broilers as well as adult layers and breeders under normal temperature conditions 300 to 350 m/min

The above will be achieved with negative pressure in the order of 25 to 40 Pascal. Higher negative pressure increases the air speed and lower negative pressure decreases the air speed.

2.2.5.3 Air Inlet Size

The total air inlet area should be calculated to suite the fan capacities and the incoming air speed. This is done by calculating the maximum air inlet required for the desired air inlet speed and making the air inlet area adjustable to suite conditions of intermediate rates of ventilation.

The air inlet size for 14 fans rated at 35000 m^3/hour (490000 m^3/hour in total) with a desired air inlet speed of 350 m/min would be 490000/60/350 = 23 m^2. Should size of individual inlets be 1.4 m^2 then a total of 23/1.4 or 16 inlets would be required for this amount of ventilation.

The inlet area should be adjustable to match the amount of ventilation being applied during stages of intermediate ventilation when only a portion of the total ventilation capacity is being applied. This is also to adjust the air movement over the birds to increase or decrease the wind chill factor and ensuring adequate negative pressure for even distribution of incoming air.

2-3 Inlets adjusted to amount of ventilation, closed, partially open and fully open

2.2.6 Positioning of Fans and Air Inlets

In negative pressure houses the position of fans is of less importance that the placement and distribution of the air inlets. Especially during cold environmental conditions and with young stock, inlet air should be distributed as evenly as possible throughout the building and away from the birds. When cooling air through the use of wet pad systems, the inlet air is concentrated in one or two areas of pad area. Various configurations could be applied successfully.

The important fact to note is that with a negative pressure building it is important to maintain a negative pressure of at least in the order of 20 to 40 Pascal to ensure good air movement, mixing of incoming air with air inside the building. If the negative air pressure is too low, the incoming air will not move in the form of a venturi as explained above and due to the consequent low air speed at the inlet incoming air will merely fall towards the floor. This in turn will lead to cold and warm areas within the building as explained above.

2.2.6.1 Fans in Fan Rooms

Fans may be installed in fan rooms situated on one or both side walls of the house. By installing fans in fan rooms they are less costly to install and the fan area is more easily light trapped for dark houses. The light trapping is achieved by a light-breaking barrier (wall or sheet metal painted black to reduce reflection) being installed in the fan room. Outgoing air is however concentrated into the area of the fan rooms. In this configuration, inlets would normally be distributed evenly on the side walls.

2-4 Example of fans placed in a fan room

2.2.6.2 Fans Mounted in the Roof

Fans mounted in the roof are costly to install and it is more difficult to design shutters and light trapping on the fans. Smaller and less efficient fans are used compared to large belt driven fans which are more energy saving and cost effective when mounted at ground level. The advantage of this method of installation of fans is that the fans move stale air in the direction of the natural stack effect and away from the birds. This method is particularly popular in cold environments.

With this configuration, inlets are installed along the side walls.

2-5 Example of fans placed in the roof

2.2.6.3 Fans on Side Walls

Fans may be evenly distributed along one or both sidewalls and in so doing make use of cross ventilating the building. This is however more costly method of installation as compared to installing fans in banks and each fan has to be individually light trapped if light control is desired. The outgoing stale air is however not concentrated into particular areas as is the case when fans are installed in fan rooms.

With this system inlets would normally be installed evenly along one or both the side walls and the system is commonly referred to as cross ventilation.

2-6 Example of fans placed along the side wall

2.2.6.4 Fans on Gable end Walls

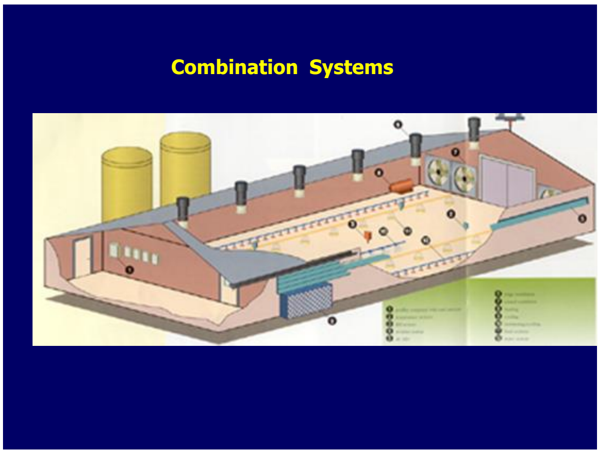
Fans may be installed in one gable end of the building with the inlets in the opposite end and this is commonly referred to as tunnel ventilation. This configuration works well in summer ventilation when associated with pad cooling but in conditions of intermediate ventilation the system will not be effective unless side inlets are installed as well to ensure even distribution of colder incoming air. With tunnel ventilation there will always to be a temperature differential from one end of the building to the other (inlet side compared to exhaust side).

2-7 Example of fans placed in gable end

2.2.6.5 Combination Systems

Combination systems are used to make use of the advantages of various configurations. For example, roof fans and side inlets could be installed for use during stages when birds are young or environmental conditions are cold and when a limited amount of ventilation and good mixing of air with low air velocity throughout the building is required. At stages when increased ventilation is required to remove heat and also when cooling is required, the system of tunnel ventilation is used. With the high velocity of air down the length of the building the chill effect of air movement is then used to assist with increasing sensible heat loss due to convection.

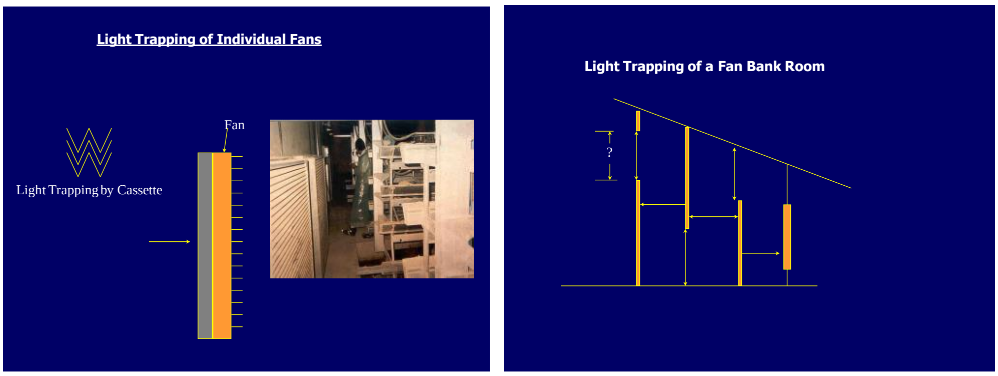
Although these systems utilise the best of what is available, they are costly.



2-8 Sketch of a Combi system suggested by Big Dutchman

2.2.7 Light Trapping of Fans and Air Inlets

In the rearing of pullets (commercial pullets as well as broiler and layer breeders) the use of mechanically ventilated houses are considered as being essential. This is due to the fact that these birds should preferably be reared under conditions in which the total photoperiod provided is less than natural day length in order to control sexual maturity. These houses are referred to as dark houses in which the natural light has been blocked from entering the building. This is achieved by use of light baffles on fans and inlets or by the use of fan rooms which eliminate light from entering the building direct.



2-9 Example of a light trapping cassette mounted to the fan and a fan room

Whatever light trapping is considered the light intensity in dark houses should be less than 0.2 lux measured within 2 meter of the inlet or fan.

2.3 Cooling

Wet bulb temperature could be used as an indication of the extent that the air can be cooled by the use of evaporation of water into the air (adiabatic cooling). When water evaporates, energy is required to convert the water into vapour, resulting in cooling of the air. On the psychrometric chart (Figure 1.2) the wet bulb line running through the intersection of the 35°C dry bulb and 40% RH is the 24°C line. This means that the relative humidity of the air is 40% at a dry bulb temperature of 35°C and a wet bulb temperature of 24°C.

If air at 40% RH and 35°C dry bulb were passed through a wet cooling pad, it would evaporate water from the pad, increasing the water content (latent heat) of the air and reducing the dry bulb temperature (sensible heat). If the speed of air passing over the wet pad is sufficiently slow for the air to become saturated (or almost so under practical conditions) the dry bulb air temperature would be reduced to nearly 24°C (that is close to the wet bulb temperature or point of saturation). A good wet pad system will reduce dry bulb temperature to within 85% of wet bulb temperature. The difference between wet bulb temperature and dry bulb temperature is therefore an indication to what extent cooling systems by means of adiabatic cooling would be able to reduce the dry bulb temperature of the incoming air.

In areas of high humidity, adiabatic cooling of poultry sheds is not effective or difficult to achieve due to the small differences between wet and dry bulb temperatures. The ability to cool poultry sheds in an environment at 35°C and humidity of 75% is limited as the wet bulb temperature will be 33°C at this level of RH. The cooling ability of 85 % of this difference of 2°C is less than 1°C. The shed can therefore be cooled to a very limited extent only and in addition the temperature will remain high at an even higher relative humidity.

In dry climates adiabatic cooling is an inexpensive yet effective way to reduce temperatures. If the humidity in the above example were 20% (dry climate) the wet bulb temperature would have been 18°C with a difference between wet and dry bulb temperatures of 17°C. Effectively the dry bulb temperature could therefore be reduced by 14°C (85% of 17°C) with an efficient evaporative cooling system.

Various systems are available in which evaporation of water is used to reduce temperatures in poultry sheds.

2.3.1 Wet Pad Cooling System

Wet pad cooling systems are systems where air is drawn over wet perforated pads and allowed to evaporate. This system is generally used in negative pressure ventilated sheds. Air is drawn through a wet perforated fibrous pad mounted between two water troughs. Water is pumped into the upper trough and through holes allowed to run down over and wet the pad. Any surplus water runs into the water trough below and is re-circulated through the pump system. The water that has been evaporated from the pad is then replenished by fresh water into the sump. As the air passes through the pad, it is cooled through the process of evaporation of water from the fibrous pad (sensible heat is converted to latent heat).

2-10 Example of cool pad installations

The airspeed required in negative pressure pad cooling is much less than the normal inlet speed that is required to create sufficient negative pressure in the building and hence adequate mixing of incoming air. The general rule is to achieve an air speed of 80 to 100 meter per minute in order to maximize water pickup by the air over the pad. At higher airspeeds the air will not take up sufficient moisture to ensure adequate cooling. This is the reason why the air first passes through louvered openings to create the desired airspeed (negative pressure) into the building where after the air then passes over the cool pads which have a greater area than the inlets.

To achieve an air speed of 80 to 100 m/minute, the pad area should be 0.15 to 0.2 m^2/1000 m^3/hour

2.3.2 High Pressure Spray

High pressure mist systems in which water is turned into a fine mist 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). The use of high pressure pumps and spray nozzles to convert water into a fine mist which is able to absorb heat (convert sensible heat into latent heat) is an effective way of reducing the dry bulb temperature (sensible heat). These systems are very popular in open sided (natural ventilated) houses as the fine mist is sprayed directly into the building and in so doing, cools the air within the building. Care should however be taken that the air is not blown out of the building before the air that is in contact with the birds is cooled. The water pressure should be high (+ 3 bar) and water quality is of extreme importance to ensure that spray nozzles do not get blocked through dirt or mineral deposits.

2-11 Example of high pressure spray

The equipment would consist of water filters and chemical treatment, high pressure pump water lines and spray nozzles. A booster pump to ensure sufficient water supply to the system may also be required. These systems are generally found in open sided houses but fan ventilated buildings could also incorporate high pressure spray systems.

2.3.3 Wetting of Roof Area

Spraying of water on roofs and environment adjacent to the poultry sheds will also help, in that the water then evaporates into the environment thereby cooling the air. Much water is however used and cooling is not all that effective.

3 Equipment

Various types of equipment are used to ensure that birds receive adequate feed and water, that the building is heated to desired temperature levels, that the building is adequately ventilated and that the correct amount of light is supplied. Such equipment may be incorporated into very sophisticated and automated production systems used in modern day poultry production.

Poultry equipment is manufactured and supplied by a number of specialized and reputable companies and much research is conducted to ensure maximum efficiency for what the equipment is intended for. The aim of most of the research is to improve on production efficiency, to improve bird welfare and to reduce labour cost.

3.1 Feeder Equipment

Feed remains to single most costly item in poultry production and whatever production system is applied, the equipment must ensure sufficient supply of feed without wastage. Various makes and types of feeders exist and the choice of feeder would largely depend on the type of birds being fed (broilers, breeders, layers, etc.) as well as the application (floor or cage systems). In broiler breeder rearing and broiler hatching egg production, the fact that some form of feed control and that males and females will be fed separately needs to be taken into account.

3.1.1 Feed Space Requirement

No fixed rules apply when recommendations are to be made on the correct feed space for various types of stock. Feed space requirement of poultry stock will however vary in accordance with various aspects which should be taken into consideration and they include:-

Age of the birds - Young chicks are confined to small areas commonly referred to as brooder areas in which feed space is concentrated to ensure that small chicks find the feeders easily. The older the bird the larger the feed space required per bird.
Type of bird - Heavier birds require larger feed areas. Broiler breeders will therefore require more feed space per bird compared to layer breeders due to the size of hens. Broilers will also be provided with larger feed space compared to pullets being reared for egg production due to higher rates of feed consumption.
Stocking density - Although the space per bird required may not increase with increased stocking density, the increased numbers of birds in the poultry shed increases the amount of feeders required in the shed.
Feeder type - Since 20% more birds are able to feed from a circular trough at the same time (shape of bird fitting circular feeder), space for round feeders is less compared to trough feeders. Less feed space is required as measured at the trough in the case of pan feeders compared to through feeders.
Application - When feed restriction is applied as is the case with broiler breeders, more feed space will be provided per bird compared to ad lib feeding to ensure that all birds feed simultaneously. This will improve uniformity of the flock.

As a guide the following recommendations detailed in Table 3.1 may be used.

Table 3.1: General Feed Space Requirement

Application	Unit	Space
Broiler Breeders		
Chick feeders (φ35 cm)	Chicks/feeder	100 – 150
Day old to 6 weeks (φ 35 cm)	Birds/feeder	20 – 22
Day old to 6 weeks (Trough)	cm/bird	7 - 8
7 to 20 weeks (φ 35 cm)	Birds/feeder	10 – 13
7 to 20 weeks (Trough)	cm/bird	13 - 15
Laying period (φ 35 cm)	Birds/feeder	14 – 16
Laying period (Trough)	cm/bird	14 – 16
Male feeders (φ 40 cm)	Males/feeder	10 – 12
Broilers		
Chick feeders (φ 35 cm)	Chicks/feeder	100 – 150
Day old to slaughter (φ 35 cm)	Birds/feeder	60 – 65
Day old the slaughter (Trough)	Birds/meter	80 – 85
Layer Breeders and Pullet Rearing on Floor		
Chick feeders (φ35 cm)	Chicks/feeder	100 – 150
Day old to 6 weeks (φ 35 cm)	Birds/feeder	50 – 60
Day old to 6 weeks (Trough)	cm/bird	5 - 6
7 to 20 weeks (φ 35 cm)	Birds/feeder	30 – 40
7 to 20 weeks (Trough)	cm/bird	9 - 11
Laying period (φ 35 cm)	Birds/feeder	20 – 30
Laying period (Trough)	cm/bird	10 – 12
Commercial Layers in Cages		
Chicks feeders	Chicks/feeder	100 – 150
Pullets during rearing	cm/bird	5 – 8
Layers	cm/bird	8 - 10

3.1.2 Feeder Equipment for Floor Systems

3.1.2.1 Chick Feeders

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

3-1: Example of using chick feeder trays. Note paper under drinker line

3.1.2.2 Manual Feeders

In floor 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.

3-2 Example of tube feeder in a floor system

3.1.2.3 Automated Feeders

Automated feed systems for floor operations consist of a pan or trough from which the birds feed and some form of mechanism which transfers feed from a central hopper to the feeder pans or troughs. The feeder types can be categorised into two main types:-

Chain feeders which consist of a continuous open trough around the poultry shed fitted with a flat chain, which drags feed from a central hopper acting 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, which enables automated and controlled setting on the amount of feedings required. Single, double, three track as well as four track feeders are available so as to allow for increased feed space as required. Slow and high-speed feeders allow for various conditions such as feeding young chicks or birds being subjected to a controlled rate of feeding. The entire system can be suspended from the building by cables and a wincing system if crossbeams are able to carry the weight. The troughs can also be fitted to carrier legs, which allows for height adjustment. The height of the feeder must be adjustable to suite the height of the birds so as to eliminate feed wastage.

3-3 Example of chain feeder being used in rearing Broiler Breeders

Pan type feeders consist of single or looped tube in which an auger conveys feed from the feed hopper. Openings made at the bottom of the tube allow feed to drop from the tube to a pan fitted to the tube. Most pan feeder systems would have an adjustment mechanism by which the feed height in the feeder pan can be set. 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, which 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.

3-4 Example of a pan feeder

3.1.3 Feeder Equipment for Broiler Breeders

These feeding systems are very much the same as described for floor systems. For the application to heavy broiler breeders, special feeders exist whereby the males cannot gain access to the feed fed to the females. This provides the opportunity to feed separate feeds as well as different levels of feed to the males and females. The male feeders are set at a height whereby the females cannot gain access whilst female feeders are equipped with a grid mechanism prohibiting access by the males as a result of their larger head and comb. The grid size should be in the order of 45 mm x 55 mm to exclude males from the female feeders. These feeders should also ensure that feed is distributed within a period of 5 minutes to all birds under conditions of feed restriction. The male feeders should be large enough to ensure all males have free access to feed.

3-5 Example of grills used on chain feeder for females on the left with male feeder on right

3.1.4 Feeder Equipment on Cage Systems

Feeders on cage systems would normally consist of troughs at the front of the cage system, which are filled either manually or by means of a mechanical system.

3.1.4.1 Manual Feeding on Cage Systems

Manual feeding equipment for birds in cages will consist of a feed cart into which feed is placed. The feed cart is then pushed down the cage rows and feed is then transferred by means of a scoop into the feed trough. The feed cart may be motor driven and a feed auger then conveys feed from the feed cart into the feed trough as the feed cart is moved down the row of cages.

3-6 Example of feeding with a scoop and feeding with a cart for layer cages

3.1.4.2 Automated Feeders on Cage Systems

Chain feeder systems on cages consist of a continuous open trough around the cage row fitted with a flat chain. The system could be filled by corner hoppers situated on each trough which are filled by the cross auger from the bulk tank, or from a column hopper which is a larger bin situated at the end of the cage row, or at the centre of the cage system.

The chain is dragged through the feed hopper and in so doing it is filled with feed. A slide mechanism adjusts the amount of feed which is picked up by the chain. 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 timer through which the amount of feedings during a period of 24 hours can be controlled.

3-7 Example of chain feeder on left and feed gantry feeder on right

Travelling feed hopper or gantry feeders on cage systems consist of a motorised feed hopper (container) which runs down the cage row on some form of rail mechanism. The feed hopper is filled by cross auger from the bulk feed bin and moves on rails down the length of the cage row depositing feed into the trough. The motorised hopper is 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 being motor driven.

Limit switches at the auger allow for all of the hoppers to be position before the auger is activated to fill the hoppers. A limit switch at the last hopper switches off the auger, once the system has been filled.

3.1.5 Bulk Feed Bins and Auger Systems

It is advisable to have feed storage space for at least one week's feed, depending on the reliability of feed supply. Bulk bins in various sizes are available and are constructed mainly from rounded corrugated sheeting.

With large sheds, two bulk bins per poultry shed is often preferred compared to one very large bin. This allows for more accurate checks on feed stocks as well as periodic cleaning of the bins in long cycles (layers).

3-8 Bulk feed bins

Cross augers, which convey feed into the building could be either flex augers or ridged augers with 90° bends.

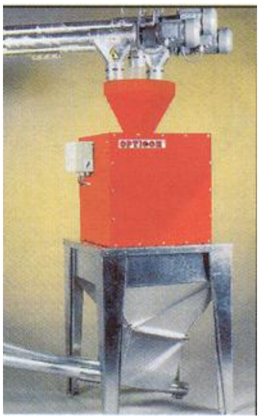
3.1.6 Feed Weighing

Feed is the single most costly item in poultry production and it is essential to gather accurate records on the daily feed intake of birds. With bulk systems this is difficult to judge unless scales are used to weigh feed accurately. Several makes of automated scale systems of available and consist mainly of two types:

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

Load cells are placed under the bulk feed bin for accurate and continuous 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.

These systems also supply checks on feed delivered by the feed supply company.



3-9 Example of a dump scale on the left and load cells on the right

3.2 Water Supply Equipment

Water supply equipment has developed from open troughs which become dirty and contaminated and more difficult to keep clean. Small automated cup drinkers have also been developed but they too become dirty as a result of them being open. 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.

3.2.1 Drinker Space Requirement

Water space requirement will depend on the type of drinker as well as the application and type of stock. Drinker space requirement would therefore depend on: -

Type of drinker - due to more space available around a round drinker the linear space per bird for Bell shaped drinkers would be less compared to trough drinkers.
Type of bird - heavier birds are normally provided with more drinker space than smaller birds.
Age of the bird - older birds are provided with more space per bird than young (smaller) birds.
Hot environmental conditions would require drinker space to be increased.
In layer cages two supply points (nipples or cups) should be provided per cage so that birds have access to two nipples. Per bird the nipple drinkers allowed might therefore be excessive but it is accepted practice to allow for two drinker points per cage in case of one being faulty.

No fixed rules apply when recommendations are to be made on the drinker space for various types of stock. Manufacturer recommendation as well as the application needs to be considered. As a guide the recommendations set out in Table 4.2 may be used:

Table 3.2: General Drinker Space Requirement

Application	Unit	Space
Broiler Breeders		
Chick drinker (fonts)	Chicks/drinker	100 – 150
Day old to 6 weeks (φ 35 cm)	Birds/drinker	150 – 200
7 to 20 weeks (φ 35 cm)	Birds/drinker	150 – 200
Laying period (φ 35 cm)	Birds/drinker	150 – 200
Nipple drinker		
Rearing	Birds/nipple	8 – 12
Laying	Birds/nipple	6 – 10
Broilers		
Chick drinker (fonts)	Chicks/drinker	100 – 150
Day old to slaughter (φ 35 cm)	Birds/drinker	120 – 130
Nipple drinkers	Birds/nipple	11 – 15
Layer Breeders and Pullet Rearing on Floor		
Chick drinkers (fonts)	Chicks/drinker	100 – 150
Day old to 6 weeks (φ 35 cm)	Birds/drinker	150 – 200
7 to 20 weeks (φ 35 cm)	Birds/drinker	150 – 200
Laying period (φ 35 cm)	Birds/drinker	150 – 200
Nipple drinker		
Rearing	Birds/nipple	6 – 8
Layers	Birds/nipple	4 - 6
Cage Systems		
Chick fonts	Drinkers/cage	1
Nipples in rearing cages	Birds/nipple	8 – 12
Cups in layer cages	Birds/cup	4 – 6
Nipples in layer cages	Birds/nipple	4 - 6

3.2.2 Types of Drinker Equipment

Drinkers are designed for either young (day old chicks) and growing birds or adult stock.

3.2.2.1 Drinker Equipment for Chicks

Chicks should be started off with equipment specially designed to ensure that water intake is not limited during the initial stages of growth. This is of special importance for broiler chicks, where any limitation in water consumption will result in poor weight gains during the first week.

Chick Fonts are manually filled pan and jar drinkers and are popular manual drinkers for young chicks. Water is placed in the jar which when turned will feed water into the trough. These drinkers are suited for floor systems as well as cage systems, provided the height of the jar is such that it fits into the cage.

3-10 Example of chick fonts, float cups and low pressure nipples being used for chicks

Low-pressure nipples suitable for starting chicks which are suspended on drinker lines are becoming 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. These nipples could also be used in cage rearing systems. Some types of nipples are equipped with drip cups to eliminate dripping onto litter while others operate without drip cups.

Low-pressure float cups are often used in brooder cages of cage rearing systems together with nipples to assist in starting day old chicks and replace manually operated chick founts. The float cups are removed when chicks are accustomed to the nipple systems or they could be used throughout the growing period. These systems have also been adapted to floor rearing systems

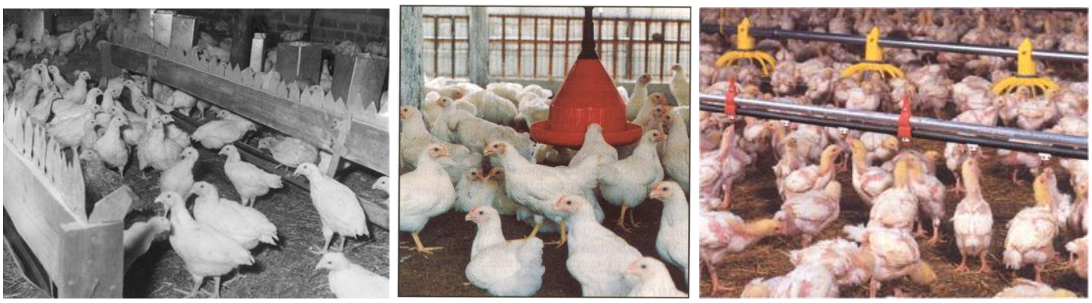
3.2.2.2 Drinker Equipment for Older Birds

Open troughs are automatically filled with some sort of valve mechanism to control the flow of water (they could also be filled manually). Such systems may be found in small scale operation but due to them being labour intensive and often causing water spillage, they have lost popularity in large scale poultry production. .

Hanging Bell-shaped drinkers are plastic drinkers and are suspended from the ceiling on adjustable nylon cables to suite bird height. They have been very popular in floor systems for many years. The drinker is equipped with a valve and spring mechanism, 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 filled with water), which reduces swinging and water spillage.

Cup drinkers are small drinker cups equipped with a spring valve and trigger mechanism or trigger, plunger and small pressure valve. Cup drinkers were 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. Cup drinkers on cage systems also tend to become dirty and soiled.

Nipple drinkers are very popular in modern cage as well as 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.



3-11 Example of trough, bell drinker and nipple drinkers used in floor systems

3-12 Example of nipple and cup drinkers on cage systems

3.3 Heating Equipment

Day old chicks require an environmental temperature in excess of 30°C. Their total heat output is insufficient to maintain the building at this temperature and the environment therefore has to be heated by artificial means to ensure correct temperature. The amount of heating required will depend on the extent of insulation used and whether the building is naturally ventilated or closed and ventilated by artificial means.

3.3.1 Brooding Methods

The methods used in brooding the chicks will to a large extent determine the type of heating equipment. The brooding method applied would also depend on the type of building (ventilation and degree of insulation).

Spot brooding is referred to as the method where a small area to which the chicks are confined is heated and the temperature in the area being heating is more important than the temperature within the building. This method is commonly used in open type buildings and in buildings with poor insulation.

Whole house brooding is the method where the entire house is heated by distributing heated air into the entire building or brooding area. Although chicks may still be confined to demarcated brooding enclosures, the temperature in the building becomes more important.

Partial house brooding is where a portion of the building is cordoned off for the young chicks and only this section is then heated, either by spot heating or again heating the entire section of the building so cordoned off. This is usually applied in floor brooding operations to save on fuel as chicks require a smaller floor area compared to older stock.

3.3.2 Fuels

The energy source required to heat poultry sheds consist of a variety of fuels. The choice of fuel would depend on the application, the relative cost of fuel in a particular area in comparison to cost of the equipment as well as the availability of the fuel.

Gas - could consist of natural gas, liquid petroleum gas or methane gas. The gas may be used to fire individual brooders or a central heating system
Kerosene - could also be used to fire individual stoves or a central heating system
Coal - can be used as fuel to heat water flowing through a heat exchanger trough which air is passed before being blown into the poultry shed.
Oil - this fuel may be used in oil fired burners in the same way as coal fired burners explained above
Electricity - heat exchanger using electricity as source of energy are available. In some small operations infrared lamps may also be used.

3.3.3 Heating Equipment

Hover brooders - are older type of gas or kerosene burners placed under a large metal canopy. Chicks are confined close to the brooder and this system is popular for spot heating in open type poultry sheds

3-13 Examples of a hover brooder, infrared gas brooder and a pancake brooder

Canopy brooders - are similar to hover brooders but have a small top (±1 meter diameter) under which usually a gas-fired heater is situated. 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.

Infrared gas brooders - use a special burner under a tile reflector that produces infrared rays when heated. The chicks are confined to a specific area with this type of brooder and the infrared rays heat the floor area. With these heaters the temperature of the object being heated (chicks and floor) is more important that the temperature of the surrounding air, although the latter will eventually be heated through convection from the heated objects.

Infrared electric lamps - are used in a similar fashion as infrared gas heaters and would be popular for heating small numbers of chicks in an enclosed area.

Heat exchangers - could use gas, electricity or hot water as source of heat and are generally used to heat an entire building or part of the building. Air is passed through the heat exchanger before being blown into the poultry shed. These systems are usually employed in whole house or partial house brooding. The heated air is often blown into a plastic sock (fan jet) with holes down the length so as to distribute the heated air evenly throughout the brooding area. This fan jet is then coupled to the minimum ventilation system so as to distribute the minimum air required as evenly as possible.

3-14 Various types of heat exchangers are available

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

Open flame heaters are gas or oil fired burners which heat the air as it passes over the open flame and the heated air is then blown into the brooding area.

3.4 Lighting Equipment

The light equipment in a poultry shed would consist of the lights themselves, a time clock as well as a dimmer in rearing houses.

3.4.1 Incandescent Light

Incandescent lamps have been used for a number of years in poultry sheds. This light source is dimmable, fairly robust and will withstand washing, they have been relatively cheap top buy and the colour spectrum closely approximates the frequencies of sunlight. They are however inefficient in converting electrical energy into visible light as a large portion of the energy is converted into heat. The output of incandescent lamps is in the order of 10 to15 lumen per watt compared to 45 to 70 lumen per watt for fluorescent tubes.

The cost of electricity is exerting pressure on poultry framers to find alternate light sources to be used in poultry housing.

3-15 Mercury lamps on the left and fluorescent tubes on the right

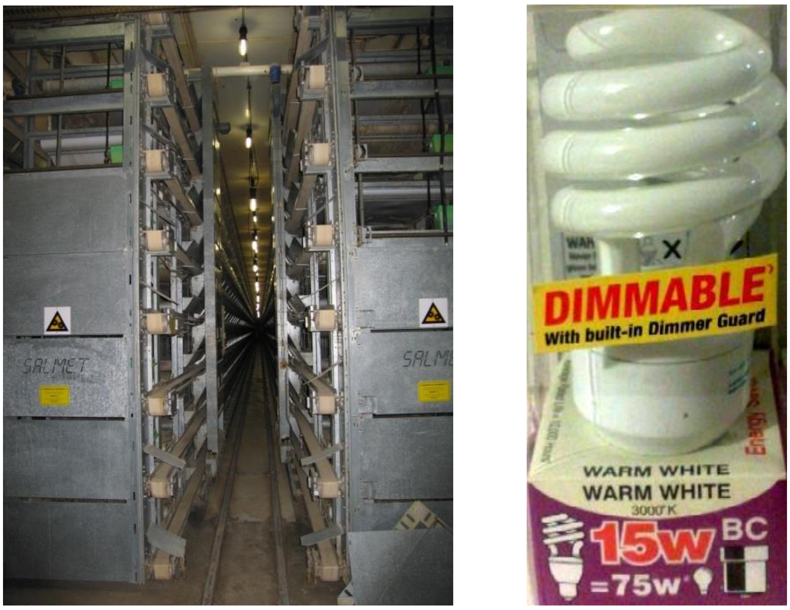
3.4.2 Fluorescent Light

Standard Fluorescent Tubes supply a broad spectrum light, has less than 5 seconds warm up period and supplies an output of 45 to 70 lumens per watt. Life expectancy may be rated as being in excess of 10000 hours. Standard fluorescent tubes are used in installations such as commercial layer houses where dimming of light is not required.

Compact Fluorescent Lights (CFL) are smaller fluorescent tubes that fit into conventional incandescent light fittings. They have been more expensive than conventional incandescent light bulbs but have a higher output (40 to 70 lumen per watt compared to 10 to 20 lumen per watt for incandescent bulbs) but are generally referred to as energy saving light bulbs. They also have a 5 second warm up time and life expectancy is in the order of 10000 hours. These lamps cannot dim and but are used very successfully in houses intended for the housing of adult birds where dimming is not required. Warm White and Cool White lights are available and due to the colour of the Warm White light's closer approximating that of natural sunlight (longer wavelength) these lamps are preferable in poultry housing. Where lower light intensity is required (rearing systems) two CFL globes of varying size could be fitted into the same lamp and by circuit switching it is possible to achieve three levels of intensity.

Cold Cathode Fluorescent Lamps (CCFLs) are usually also called cold cathodes. These are an emerging lighting source as they give great output for a small amount of energy. The can be dimmed down to around 20% if fitted with the required electronics but the robustness to withstand the harsh conditions in poultry houses is still questioned.

High Pressure Sodium Lamps have a long warm up time (up to 5 minutes) high output (50 to 100 lumen per watt and a long life expectancy (>20000 hours). These lights cannot be dimmed and take time to light up but are often used in brooding sections to increase light intensity by replacing normal light bulbs during brooding.



3-16 CFL lamps on the left and dimmable CCFL lamp on the right

3.4.3 Light Distribution

The manner in which lights are installed has a bearing on the efficiency and the intensity must be as uniform as possible. The further the object is from the light source, the lower the light intensity on the object and fluorescent light supplies more light per watt compared to incandescent lamps. The effective light intensity of the light source will be increased if ceilings are white and when lights are placed under a reflector. Light intensity required would depend on the application and details are found in the section dealing with the environmental requirement of poultry.

The general rule applied is that 1 bulb watt for every 0.37 m^2 of floor area will provide for 10 lux (1 foot candle) of light when incandescent lights are used. In the case of using fluorescent light, 1 bulb watt for every 1.11 m^2 of floor will supply the equivalent 10 lux (three times more efficient).

In floor operations a good rule of thumb is ensure that the distance between the bulbs is 1.5 times the distance from the bulb to bird level and to install the light source 2 to 2.5 meters above the floor. If more than two rows of lights are required, then the bulbs between the rows should be staggered. The distance between the wall and outermost row of bulbs should be half the distance between bulbs.

In cage operations with multi deck systems it is more difficult to obtain uniform light distribution and often lights are then set at different levels in the passage between cage rows. The intensity inside the cage is also obscured by the cage equipment and often with chick brooding systems care should be taken to ensure that sufficient light intensity is achieved at the chick drinkers normally situated inside the cage. In layer cages, the intensity is measured at the feed trough.

3-17 In multiple tier cage systems lights should preferably by at varying height

The light requirement for a poultry building 100 meter long by 13 meter wide and lights suspended 2.1 meter above floor level and where a maximum of 20 lux is required using incandescent light is calculated as follows:

For incandescent lights 1 bulb watt/0.37 m^2 provides 1 ft candle (10 lux). To supply 20 lux 1 bulb watt over 0.37/2 = 0.185 m^2 will be required

The house is 100 x 13 = 1300 m^2. Therefore 1300/0.185 = 7027 total watt must be provided
If 60 watt globes are used, total number of globes required = 7027/60 = 117
If over 2 rows, 117/2 = 58 lamps per row
If over 3 rows, 117/3 = 39 lamps per row
If over 4 rows, 117/4 = 29 lamps per row
29 globes per row fit the best as they will be 100/29 = 3.4 m apart within the rows, and this spacing is 1.6 times the distance of the globes to floor level, and the light rows will be 3.25 meter apart, the two wall rows being 1.625 from the wall. The lights are then distributed evenly between rows as well as within rows.
Note that if larger wattage globes are selected, the distance between globes increases and light distribution would be uneven.

3.4.4 Measuring Light Intensity

Light intensity may be measured by a light meter. When measuring light intensity the following should be noted:

Hold the light meter at a distance equal to light sources at bird level
Ensure that light meter is not being shaded
Ensure that lights are clean
For open houses, measure intensity during the night
In cage operations light intensity should be measured at the feed trough.

3.5 Ventilation and Cooling Equipment

The principles of using ventilation and cooling to control the environment within poultry sheds is dealt with in the section Ventilation and Cooling. In mechanical ventilated buildings, the equipment would consist of various components such as the controller, the fans, the inlets and possible cooling system.

3.5.1 Ventilation Controller

Various types and makes of controllers are available and the basic principle upon which most controllers operate is to use temperature sensors to activate whatever ventilation is required.

Below the adjustable set point, ventilation would operate a minimum amount to ensure sufficient minimum air supply operated by speed control of the fans or by activating fans by time control.

Above the set point the controller will activate the fans at increased capacity through increasing the fan speed with variable speed fans or be switching on more fans when single speed fans are used (step control).

In rearing houses where artificial heating is applied, the controller is then also used to activate the heating equipment when temperature drops below set point. Likewise, the controller is also used to activate any cooling system that may be installed.

3.5.2 Fans and Inlets

Various types and makes of controllers are available and the basic principle upon which most controllers operate is to use temperature sensors to activate whatever ventilation is required.

Below the adjustable set point, ventilation would operate a minimum amount to ensure sufficient minimum air supply operated by speed control of the fans or by activating fans by time control.

Above the set point the controller will activate the fans at increased capacity through increasing the fan speed with variable speed fans or be switching on more fans when single speed fans are used (step control).

In rearing houses where artificial heating is applied, the controller is then also used to activate the heating equipment when temperature drops below set point. Likewise, the controller is also used to activate any cooling system that may be installed.

3.5.3 Cooling System

The equipment in which water vaporization is used to cool poultry buildings comprise either wet pad systems or high pressure fogging systems.

Wet Pad Systems utilise the principle of drawing air over a perforated fibrous pad which is wet and by vaporization of water from the pad, the air passing through the pad is cooled. These systems are popular in negative pressure buildings, and especially where tunnel ventilation is applied. The equipment would consist of a sump and pump, a water trough above the wet pad with holes that allow water to run onto the pads, a water trough below the pads to catch any runoff water and return such water to the sump.

The sump is supplied with fresh water with a high and low switch mechanism.

It is imperative that the water in the sump can be pumped out from time to time and replenished with clean water.

High Pressure Fogging of air utilise the vaporization of the fine mist into the air and thereby converting sensible heat into latent heat. High pressure fogging systems are popular in open sided (natural ventilated) buildings. The use of high pressure pumps and spray nozzles to convert water into a fine mist which is able to absorb heat (convert sensible heat into latent heat) is an effective way of reducing the dry bulb temperature (sensible heat). These systems are very popular in open sided (natural ventilated) houses as the fine mist is sprayed directly into the building and in so doing, cools the air within the building. Care should however be taken that the air is not blown out of the building before the air is cooled. The water pressure should be high (+ 3 bar) and water quality is of extreme importance to ensure that spray nozzles do not get blocked through dirt or mineral deposits.

The equipment would consist of water filters and chemical treatment, high pressure pump water lines and spray nozzles. A booster pump to ensure sufficient water supply to the system may also be required.

4 Management Systems

Poultry management systems comprise floor systems for the production of hatching eggs, floor systems for growing broiler and other rearing stock, cage systems for the rearing of commercial egg laying pullets and the production of table eggs as well as alternate systems to cages for the production of table eggs. These systems are continuously being improved on from the point of reducing labour and increasing production efficiencies. In recent years research on these systems has also concentrated on the well being of the stock.

Welfare considerations may not be so topical in South Africa compared to other countries, especially Europe, but welfare issues in Europe and other first world countries and the effect thereof on production systems will no doubt in the long run impact on the industry in South Africa as well.

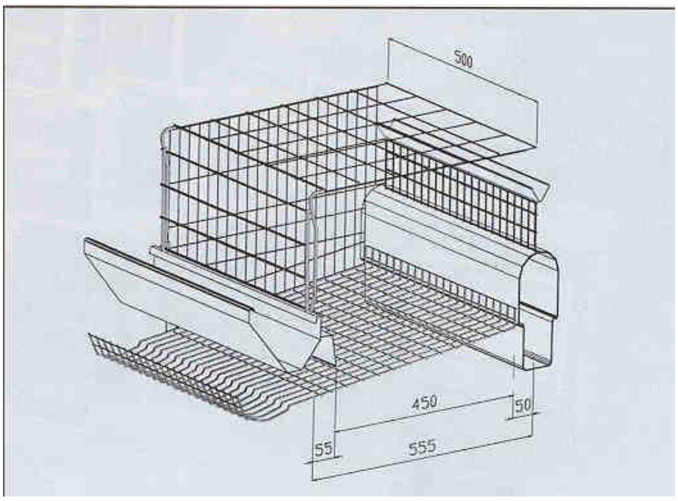
This section describes the various systems used in the production of hatching eggs, growing of broilers and other stock on the floor, as well as cage and alternate systems for the production of table eggs. More detail on particular equipment is to found in the equipment section of this book.

4.1 Layer Cages for Commercial Egg Production

Layer cages have become more intensive over the years, developing from single 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.

4.1.1 Basic Cage Design

Various cage design and configurations exist housing from 5 birds per cage to as high as 8 birds per cage. The main criteria are that the floor area provided per bird should be in the order of 450 cm^2 per bird and feed space of around 10 cm per bird. This stocking density has been generally accepted as the minimum density but some countries are suggesting more cage area per bird.



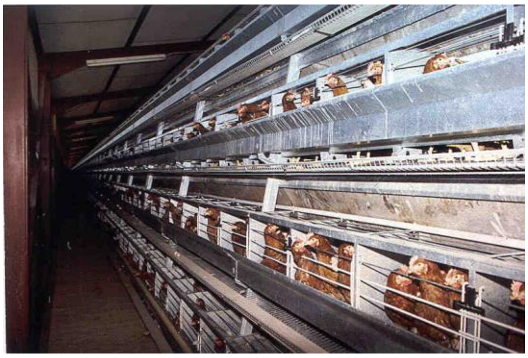
The accepted code for South African is taken up in the **South African Poultry Association Code of Conduct.**

In the A-framed configuration the cages are placed on top of one another in the configuration of an A. The back of the A-framed cage is 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. This is done to reduce the width of cage stack.

The A-frame configuration has become less popular in many countries due to the fact the cage height at the back of the cage is such that the entire floor area is considered not suited. In some countries the area of the cage under the sloped top is excluded as being part of the cage area as this area is not in agreement with the minimum cage height specification. In many regulations fewer birds will be allowed in these cages. There is also a limitation in height of the cage stack in this configuration as the top tier in a 4-tier A-framed cage is difficult to manage.

In the stacked configuration the cages are directly above one another with some form of mechanical manure removal system (scrapers or belt) between the cage tiers.

Due to a narrow stack being possible the building space is saved with stack cages in multiple tiered cages as compared to A-framed cages. Compared to A-frame configuration these cages are more costly due to the manure removal systems that are required between decks of cages. They do however allow for bird density in a building to be higher due to the stack configuration of the cages (width of the stack is less). The entire cage area is utilisable as cage floor space as the back part is not sloped or cut away.



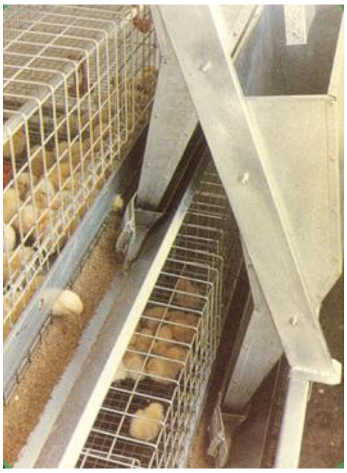
4.1.2 Feed Systems on Cages

Feeder system on battery cages could comprise **Manual Feeding** or an **Automated Chain** or **Feed Hopper (Gantry) System.**

Manual feeder systems are less costly but more labour intensive. If not managed properly, feed wastage could be excessive due to overfilling of troughs and poor control when transferring feed from the feed cart to the feed trough. Manual feeding equipment for birds in cages will consist of a feed cart into which feed is placed. The feed cart is pushed down the cage rows and feed is transferred by means of a scoop into the feed trough. The feed cart may be motor driven (motor driven feed cart) and a feed auger conveys feed from the feed cart into the feed trough as the feed cart is moved down the row of cages.

Chain feeders are very easy to manage but use more power (electricity) compared to gantry systems. For example a four tier cage stack equipped with chain feeding will require four 1 kw motors compared to one 0.75 kw motor required to drive a gantry on the same stack of cages. This feeder consists of a continuous open trough around the cage row fitted with a flat chain. The system could be filled by corner hoppers situated on each trough which are filled by the cross auger from the bulk tank, or from a column hopper which is a larger bin situated at the end of the cage row, or at the centre of the cage system.

The chain is dragged through the feed hopper and in so doing it is filled with feed. A slide mechanism adjusts the amount of feed which is picked up by the chain. 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 timer through which the amount of feedings during a period of 24 hours can be controlled.




Travelling feed hopper or gantry feeders consist of a motorised feed hopper (container) which is filled by cross auger from the bulk feed bin and moves on rails down the length of the cage row depositing feed into the trough. The motorised hopper is 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 being motor driven.

Limit switches at the auger allow for all of the hoppers to be position before the auger is activated to fill the hoppers. A limit switch at the last hopper switches off the auger, once the system has been filled.

4.1.3 Drinker Systems on Cages

Drinker systems for cages consist of either open drinker cups or closed nipple systems, normally installed within the partition between two cages. Birds in each cage therefore have access to two water supply points.

Cup drinkers are small drinker cups equipped with a spring valve and trigger mechanism or trigger, plunger and pressure valve. Cup drinkers used to be popular in cage operations and replaced open troughs but have now largely been replaced by nipple drinkers due to high level of maintenance required on cups and the cups being pecked through.


Nipple drinkers have become very popular in cage systems as the system is closed, require very little maintenance and if installed and managed correctly, result in very little water spillage and wet litter. The older type of nipple drinkers required a drip cup to eliminate spillage and hence wet litter but more modern nipples exist which are used without drip cups. A pressure control mechanism is required and this is done by equipping the system with small header tank (water reservoirs) at the ends of the cage stack at each tier of cages or by means of pressure regulator valves at each cage tier. Water pressure adjusters are also installed where water lines are long and the cage is loped to one side of the building.

4.1.4 Egg Collection Systems on Cages

Egg collection from layer cages could comprise either manually or by mechanical means. 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 failing which good first quality eggs may be broken or become dirty on the collection and conveying system, resulting in large financial loss.

4.1.4.1 Manual Egg Collection

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

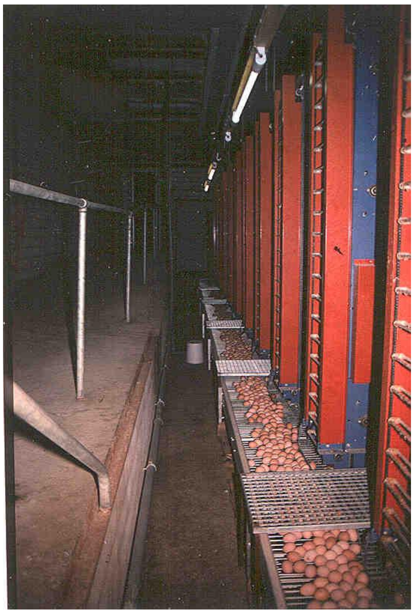
4.1.4.2 Automated Egg Collection

In automated egg collection belts and transfer systems are used to collect eggs from the cage rows and convey such eggs into egg packing and grading machines. A fully automated systems will consist of the belts on the cages onto which the eggs will roll from the cages, the transfer system which transfers the eggs from the belts to a cross conveyor, the cross conveyor which transfers the eggs from the poultry sheds to the egg packing room and lastly the egg packing system.

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

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.



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 place above head height or below floor level to enable the passageways to be clear for movement of traffic.

Lift Systems can be described as a flexible cross conveyor, which moves 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 conveyor) 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.

Incline conveyer systems consists of small 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.

In semi automated systems the transfer system could deposit the eggs onto a table situated at the cage row end from where eggs are manually placed onto egg fillers. In fully automated systems a cross conveyor receives eggs from the transfer system and transports the eggs to a central collection point, normally a farm packer situated in a central egg room serving a number of poultry sheds. 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 packers transfer the eggs from the cross conveyor 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.

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.

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 on the cross conveyor, which then provides for records on a house basis.

4.1.5 Manure Removal Systems

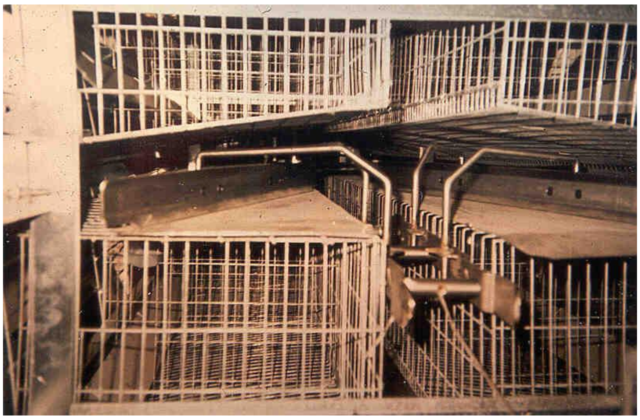
In cage systems the removal of manure requires the removal of manure from the cages as well as removal of manure from the building.

4.1.5.1 Manure Removal from the Cages

With A-framed caged configuration the manure drops from upper cage decks down to the manure pit or area below the cages from where it is removed by mechanical means or manually by means of wheel barrow and spade in smaller operations.

The older type of A-framed cage was wide and the cage configuration was such that manure dropped freely from the upper rows of cages past the cages below. In order to save building space with the A-frame configuration, equipment suppliers started installing manure deflector plates (normally plastic sheeting) behind the cage. This required for the back portion of the cage to be slanted, which in turn reduced the cage height at the back section of the cage. As a result of cage height specifications being required by welfare regulations, the effective floor area in these A-frame cages was drastically reduced and hence the cages lost popularity.

Example of an A-frame cage system with manure dropping into a pit below in a high rise building (left) manure belt cages (below left) and manure scraper cages (below right)



In some stack cage configurations, scrapers operating on manure plates between cage decks are used to scrape the manure from the upper decks. The manure then falls down between the cage rows into the manure pit below or onto a manure belt conveyor below.

Manure belts have become popular in modern intensive cage systems. This system consists of plastic belts 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 is linked to a manure drying tube situated in the cage deck so as to assist in drying the manure. These systems could even be linked to a heat exchange system, which uses the heat produced by the birds to heat incoming air which is then blown into these tubes and then onto the belt, so as to assist in drying the manure on the belts.

4.1.5.2 Manure Removal from the Building

Manual manure removal from layer cages is very labour intensive and various mechanical removal systems have been devolved to remove manure from layer cage operations.

Scraper systems consist of scraper blades under the cages which are drawn by stainless steel cable. The scraper could also be attached to a small tractor which moves down between the cage rows.

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 (2 to 3 times per week) and therefore produces relatively wet manure.

Step manure scrapers 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 metre) and then forward to the end of the building. Since manure can be allowed to build, 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. The scrapers could also drop the manure onto a cross conveyor belt system which will transfer the manure onto a vehicle outside the building for transporting manure away from the premises.

Buildings commonly referred to as High Rise Houses have also been developed for ease of manure removal. In these double storey buildings the cages are situated on the top deck and the bottom deck is used as a manure pit. The cages could then be either "A-framed" or equipped with a scraper system on the cage decks which push the manure into the pit. The lower deck then serves as a manure store and is removed by tractor or bobcat and front end loader less often, usually at the end of a cycle.

4.1.6 Cage Welfare

Due to welfare pressure, cage systems have become unpopular European Union Regulations prohibit the use of conventional cage systems as from 2012. Some changes to conventional cages have been suggested to overcome the negative welfare issues of cages and include:-

The use of **abrasive strips** on the plates below the feed trough which continuously shortens toe length and hence eliminates scratching
The inclusion of **perches** in a higher cage
The use of **shallow cages** (wider but narrower) to increase feed space
Increased **floor space** from the current accepted 450 cm^2 per bird
Use of **solid partitions** instead of wire mesh to improve feather condition
Change of **cage doors** from vertical to horizontal bars or wire which reduces abrasion on neck feathers
Having the entire front of the cage to serve as **door opening** so as to reduce damage to birds when being placed or removed from the cage.
A major challenge facing cage design is to satisfy the welfare pressure to supply a **nest** for the bird in which to lay eggs.

4.2 Alternative Commercial Egg Production Systems

Pressure from poultry welfare activists and retail markets 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 while others are of opinion that the cage in any form will be banned in the long term and have moved away from cages

Large group housing have replaced cage systems in Europe but still face the problems of cannibalism and feather pecking in flocks that have not been beak trimmed. Increased levels of dust for the stock and people working with the stock, parasites (internal and external) and bumble foot and keel bone deformation, which were not reported as being problems in cage systems are now being seen. Production results in alternate floor systems are much more variable compared to results in cage systems. While egg production may be similar, variable mortality due to pecking and cannibalism impacts negatively on hen housed performance. Research has shown that genotype/environmental interaction is apparent and breeders in Europe are in process of developing specific genotypes for large group housing systems. Free Range Systems allow the stock access to outside pasture and results are even less predictable due to added disease challenges and internal and external parasites which are seldom seen in cage systems. The increased risk to food safety in free range systems (salmonella) and the extent to which the consumer is aware of this risk may also be questioned. In addition the continuous threat of Avian Influenza in free range operations poses additional risk especially in countries were AI is a natural disease risk.

4.2.1 Modified 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 is mainly aimed at finding the correct size of nest, position of nest and dust bath and reducing the number of second grade eggs in these cages. Other aspects which still require research includes improving egg quality (cracks), nest design and placement thereof, litter distribution in the dust bath, material used and disposal thereof, group structure and the reduction of investment cost. 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.

These cages are being installed by some producers in European Union countries.

4.2.2 Deep Litter Systems

With deep litter systems (Barn Systems) commercial egg layers are kept in very much the same way as conventional breeder hens. Birds move around freely in the building of which the entire floor area is covered with litter. The low stocking density possible with these systems, prohibit them from being economical in EU countries but in South Africa these systems are used as alternate to cage systems..

4.2.3 Slatted Floor Systems

Slatted floor 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. Litter is then placed in the remaining floor area for dust bathing and in breeder houses it is the area where mating would normally occur. In EU countries initial capital cost per bird capacity is reduced as a result of the increased stocking density allowed, despite the increased capital required for the slatted floor area. Perches have been added to these systems to satisfy European Union Regulations for the production of table eggs. The main cost disadvantage with slatted floor systems is that because birds cannot move in the vertical plane, usable floor area and hence overall stocking density for the shed is limited.

4.2.4 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 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

4.2.5 Free Range Systems

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. This is due to the added problems with external and internal parasites, diseases, vermin, predators and weather conditions encountered when allowing birds access to outside range.

4.2.6 SAPA Code

To date no regulations have been promulgated in South Africa. The South African Poultry Association (SAPA) Code of Practice is accepted as being the industry norm. This document is updated regularly and is available from the offices of SAPA.

4.3 Breeder Systems

Breeders are generally kept in **Conventional all litter floor systems** or **Slatted Floor Systems.**

Breeders in caged systems are not common although some pedigree breeding is done in cages using artificial insemination. Colony breeder cages are available from some European cage manufacturers and light breeders are kept successfully in these systems.

Feeders used in breeder systems are described in the Equipment Section

Drinkers used in breeder systems are described in the Equipment Section

Nests used in Breeder Systems may be classified into individual or communal nests. With individual nests 1 nest per 4 breeder hens is supplied. Where communal nests are used the required nesting space is in the order of 120 birds per m² of nesting area but manufacturer specifications should be applied.

Nests should preferably be closed during the night so as to eliminate birds sleeping in the nests. The perch in front of manual nests serves for this purpose.

Mechanical egg removal nests are becoming popular in larger operations. Nests are placed down the centre of the building and the eggs collected in the room situated at the end of the building.

4.4 Commercial Pullet Rearing Systems

4.4.1 All Litter Floor Systems

Pullets destined for egg production could be reared on all litter floor systems in which the entire floor area is covered with wood shaving or other moisture absorbing material. If managed properly, good quality pullets may be reared in such systems but birds would have greater difficulty in adapting to cage systems when placed in cages prior to onset of production.

A stocking density of 10 to 12 birds per m² is normally applied depending on ventilation and insulation. Pullet rearing houses should be light controlled (dark) in order to control onset of production.

4.4.2 Cage Systems

4.4.2.1 Flat deck Cage Systems

Single tiered rearing cages were popular in the early 70's. The single deck of cages made it easy to manage birds. They are however no longer popular as the space available in the building is not utilized effectively.

The cages are usually in the order of 1.0 x 1.2 meter in size housing 40 to 43 birds with the feed (chain system) trough running through the middle of the cages and two cage rows being installed back to back. Stocking density is therefore in the order of 300 cm^2 per bird.

The drinker system is mounted on water lines of which the height may be adjusted to suite bird age.

4.4.2.2 A Frame Cage Systems

In the **A-frame cage configuration**, the manure will drop onto deflector sheets and then into a pit (manure scraper system) or manure pit in a high-rise type of building. The A-framed systems have less mechanical parts (manure removal system in stack cage configuration) but use up more building space. In systems higher than 3 tiers it is also more difficult to manage the top tiers in the A-frame configuration as it is difficult to reach to top tiers.

Chicks will normally be brooded in the centre cages and moved out to the upper and lower cages at 3 to 4 weeks of age. These brooding cages would then have special feeder and drinker systems fitted to ensure that day old chicks as well as larger birds are catered for.

Various cage sizes exist but most are in the order of 1 meter width x 0.5 meter deep housing 16 to 17 birds at point of lay resulting in stocking density of 294 to 310 cm^2 per bird.

Feeder systems may consist of chain or travelling feed hopper.

The drinker system is mounted on water lines of which the height may be adjusted to suite bird age.

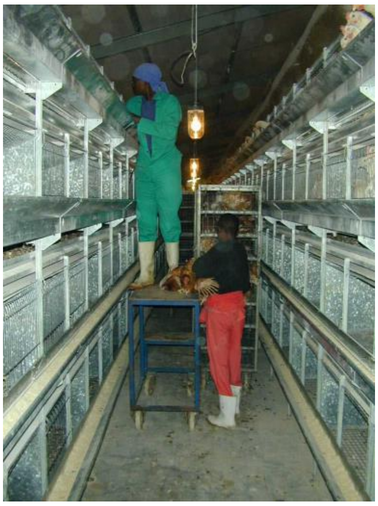
4.4.2.3 Stack Cage Systems

In **stacked cage systems** the manure will drop onto a belt or scraper system situated between every deck of cages.   Multiple tiered rearing cages are limited to four tiers high as the top most row of cages are already difficult to manage because of the height. With four tiered rearing the day old chicks are usually placed in the middle two tiers for brooding and moved to the upper and lower decks at 4 to 6 weeks of age. The brooding cages are equipped with a smaller mesh on the floors in order to eliminated the feet of chicks getting stuck in the mesh and the feed and drinker equipment caters for day old as well as older birds.

Various cage sizes exist but most are in the order of 1 meter width x 0.5 meter deep housing 16 to 17 birds at point of lay resulting in stocking density of 294 to 310 cm^2 per bird.

Feeder systems may consist of chain or travelling feed hopper.

The drinker system is mounted on water lines of which the height may be adjusted to suite bird age.



4.5 Broiler Rearing Systems

Broiler rearing is generally done in all litter houses in which the floor area is covered with some type of absorbent material such as wood shavings or cut wheat straw. In the brooding stages the chicks are confined to a limited area of the building to conserve heat and chick drinker and feeder systems are then concentrated in this area as well. This brooding area is enlarged as the birds grow until the entire floor area is occupied at 2 to 3 weeks of age. Depending on the type of building stocking density of broilers will range from 15 birds per m² for open type houses to 22 birds per m² for well designed mechanically ventilated houses provided with cooling systems.

Open type houses have the advantage of being less costly to install but on the other hand are more difficult to manage and stocking densities is limiting. The environment within an open sided building is more difficult to maintain (temperatures and ventilation) and requires a high level of management and stockmanship. The light intensity in open sided houses cannot be reduced and this leads to more downgraded birds due to pecking and scratching. The birds also tend to be more flighty and active in the high light intensity resulting in poorer feed conversion ratios.

Feeder, drinker and heating equipment suited for floor rearing is used and described in the Equipment Section.