SOUTH AFRICAN POULTRY ASSOCIATION
Founded 1904

Hatchery Management

in

Southern Africa

Compiled by Alan Saunders

Introduction

The majority of chicks produced in South Africa are hatched in modern hatcheries which need to be managed and operated at a very high level of technical skill. Modern breeds require different approaches to incubation compared to breeds which were known two to three decades ago. The ever increasing genetic pressure on both the broiler and commercial layer has not only impacted on the commercial performance of the bird. It has also resulted in changes in the approach to incubation of these breeds.

A sound knowledge of equipment, incubation systems, the functioning thereof as well as good technical knowledge of embryonic development and all interacting factors, is a prerequisite to the production of quality and disease free day old chicks.

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

The text should be read in conjunction with many manuals available for specific incubators as well as equipment manuals specific to such equipment. This book is a guide to methods of managing commercial broiler and layer chick hatcheries and contains written text as well as photographic illustration. I am indebted to many incubator supply companies as well as day old chick supply companies and breeders who serve the local egg and broiler producer and who have assisted in supplying photos for this book.

Alan Saunders

Stellenbosch

Disclaimer

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

Contents

1 Chick Hatcheries

The day old chick hatchery forms an important link between hatching egg supply farms and commercial production farms. Not only is there a large amount of contact made with egg supply and commercial farms but also as a result of the fact that the hatchery is central in the production chain, any problems that may be encountered in the hatchery could have significant consequences, be it an integrated production business or a hatchery supplying day old chicks to the industry at large.

The hatchery building and equipment used within the building are highly specialized with unique environmental and hygiene requirement. A large amount of live biological material in the form of eggs, chicks and hatchery waste is handled daily. The environmental conditions that are created in the hatchery are also conducive for the development and growth of harmful micro-organisms, which may be spread to commercial farms as well as back to the hatching egg supply farms.

The chick hatchery has to be planned with the view to the production of quality day old chicks which are healthy and disease free.

1.1 Basic Requirement of Hatcheries

The chick hatchery forms an important link between hatching egg supply farms and rearing farms. Three basic types of chick hatcheries exist:

- Broiler chick hatcheries produce large numbers of chicks destined to be reared for their meat production qualities. In some of these hatcheries chick sexing through feather sexing may be carried out and vaccination, if required, is usually confined to spray vaccination.
- Layer chick hatcheries are more labour intensive and will require chick sexing by colour or feather sexing as well as Mareks and possibly other vaccination to be performed. Unwanted male chicks and hatch debris need to be disposed of.
- In parent and breeder chick hatcheries vent and possibly feather sexing of the chicks will be required and Mareks and possibly other vaccination will be done. Unwanted male or female chicks depending on the lines being hatched as well as hatch debris will require disposal.

Each operation will have unique requirements that need to be considered in the design and sizing of the building.

1.1.1 Location

To assist in the control of disease spread, hatcheries should be well separated from egg supply farms as well as farms and customers to which the chicks are supplied. On the other hand, large distances between hatching egg supply farms and chick rearing farms, will result in high transport cost. A balance therefore needs to be found between an economical distance and the risk from a disease control point of view.

The availability and reliability of labour, water and electrical supply as well as ease of disposing of hatchery waste should also be considered.

1.1.2 Floor Plan and Construction

Control of the flow of product through the hatchery building is important in the control of spreading of pathogens within the hatchery and this needs to be considered in the basic

design and floor plan. Hatcheries should be constructed in such a way which ensures that eggs are taken in at one end, chicks out the other and that there is no back flow of product or equipment prior to such equipment being cleaned and disinfected.

Common materials used in the construction of hatcheries consist of bricked walls with very smooth plaster finish which is to be painted and sealed with a durable paint capable of withstanding large amount of high pressure washing. A second but more expensive option is to use polyurethane board covered with metal sheeting on both sides. Although more costly, the panelling is energy efficient, seals very well, is cleaned and sanitized easily and requires minimal maintenance once erected.

Movement of staff within the building is a further biosecurity consideration, especially during days when chicks are being hatched and removed from the machines.

The removal of hatchery waste, disposal thereof and the manner in which cleaned equipment and bins return back into the hatching process should also be considered in the design of the building.

Adequate controlled ventilation should be provided and the flow of air should be in the direction of product flow, which is from the clean end (egg receiving end) to the dirty end (chick dispatch and debris disposal end) of the building.

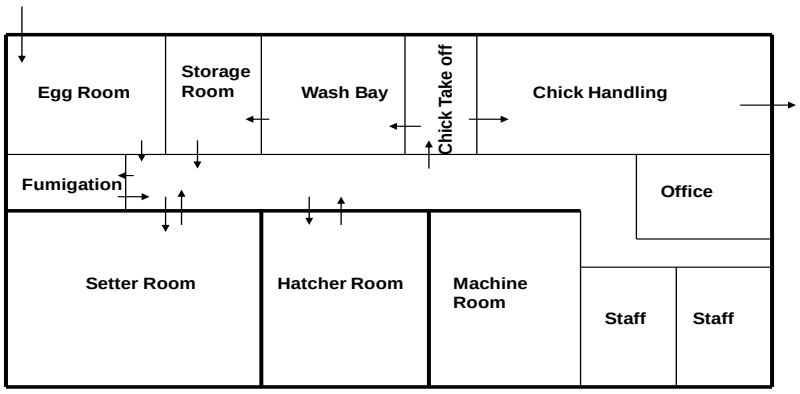
As a result of a significant volume of wash water being used in cleaning of the hatchery building and equipment, adequate drains are to be provided. Drains should remove waste water in the direction of product flow which is from the clean end to the dirty en" of the building.

Two basic designs of chick hatchery buildings are usually considered.

1.1.2.1 Rectangular Floor Plan

The rectangular design of the building as illustrated in Figure 1.1 below is a basic design which allows for good utilization of space and work flow. This basic floor plan however lends itself very poorly to future expansion.

Figure 1.1: Basic rectangular floor plan



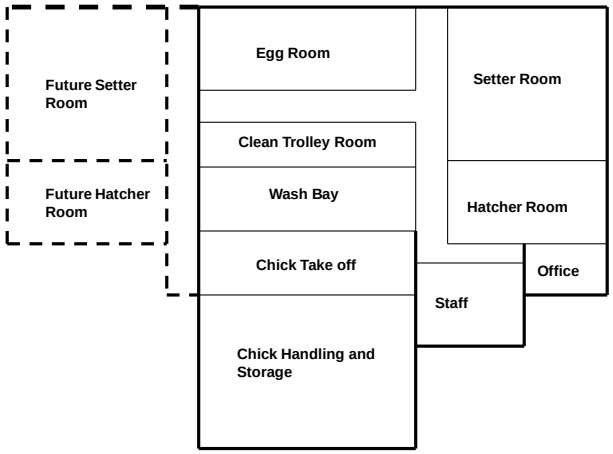
Although the rooms are orientated in a manner which allows for production flow from clean to dirty areas by means of a central passage way, this design does lack in biosecurity features, especially in terms of staff movement within the building.

This compact rectangular design of the hatchery building is commonly used in smaller hatcheries.

1.1.2.2 T-shaped Design

In this building design, the setter and hatcher rooms are located on the side of the building, with the central area accommodating the areas where egg storage, chick handling and cleaning will occur. Passage ways are created to ensure movement of equipment and staff without having to pass through demarcated areas and this improves the application of biosecurity control measures.

Figure 1.2: T-shaped design



This basic design has excellent biosecurity features but as a result of more passages separating the rooms the initial building costs will be higher.

If cognisance of possible future expansion is taken in the initial planning, this design lends itself very well to future expansion without major disruption to ongoing production.

1.1.3 Water Supply

Water is required in fairly large volumes for sanitation as well as cooling of air (evaporative cooling) and humidification of machines and machine rooms or lobbies. Cold water supply from water chillers is also required in most modern machines for cooling purposes. Adequate supply of clean water (chemical as well as bacterial) with a neutral pH is therefore essential.

1.1.3.1 Water Temperature

Most modern incubators make use of water in a closed reticulation system through copper tubes to assist in cooling. The installation of a water chiller to maintain water at around 13 to 15 °C in larger hatcheries will be justified. Water is circulated within the closed system and the system will provide for the opportunity to adjust water temperature to best satisfy the requirement of a particular circumstance. The water lines to the machines should be well insulated to prevent condensation and dripping.

Water which is used for humidification of machines and hatchery rooms or lobbies should be around normal room temperature of 25 to 26°C.

For hatchery sanitation, water at normal room temperature will be adequate but the supply of hot water (50 to 60°C) in areas where much debris accumulates and washing is done will assist in speeding up and improving the sanitation process and possible saving on chemicals used in the long run.

1.1.3.2 Water Pressure

The water pressure required for cooling coils would depend on the specific machine type but in most instances it is in the order of 2.5 to 3.0 bar.

Most machines require a slightly higher water pressure for the humidification nozzles (4.0 to 5 bar).

The water pressure for sanitation should be high and most high pressure low volume pumps used in the cleaning and disinfecting of hatchery equipment operate at a pressure of 100 to 120 bar.

1.1.3.3 Water Quality

Water with high mineral content will soon block humidification and spray nozzles. The installation of a water filtration and treatment plant may need to be considered, especially where borehole water is being used.

The use of river and open dam water for hatcheries can only be considered with great caution if a reliable water treatment and filtration plant is installed.

1.1.3.4 Volume of Water

The volume of water required will depend on the machine type and size of the hatchery and needs to be checked and verified with the supplier of the incubators.

It is advisable to size the supply lines based on simultaneous operation and combined demand of all applicable equipment and usage.

1.1.4 Staff

The staff that will be required will depend on the type of hatchery (broiler production, commercial layer chick production or parent chick production) as well as the extent of automation. Areas where most labour is required include the process of preparing eggs to be set, tray over of eggs from setter to hatcher machines as well as the process of chick take off, chick grading, sexing and boxing and cleaning of machines and equipment during this process.

It is best to consult with the suppliers of equipment in this regard as each application will have its own set of labour requirement and circumstance. The number of days that chicks will be hatched during the week will also determine labour requirement. Chicks may be hatched either four times per week, twice per week or only once per week. This results in a considerable fluctuation in the amount of labour required on a daily basis.

It is also common to have chicks removed from the machines as early as possible on the day of hatching to ensure that chicks are dispatched or transported to farms as early as possible. This will result in setting of eggs at night and removal of chicks from the hatchers during very early hours of the morning.

1.2 Hatchery Buildings

It is not possible to put forward a hatchery design that will suit all circumstances as they differ widely. Most suppliers of incubator machines have standard design plans which can be used and modified to suit requirements.

The building will consist of various major areas grouped as follows:

- Egg receiving, handling and storage
- Fumigation and preheating room
- Setter rooms
- Hatcher rooms
- Chick take-off, holding room and dispatch
- Cleaning area
- Chemical and vaccine storage
- Machine and electrical control room
- Workshop and spares
- Offices and staff area
- Connecting passages

1.2.1 Egg Receiving, Handling and Storage Rooms

No fixed rule can be applied to determine the size of the egg room but consideration should be given to the following points:

- The cold room should be large enough to provide for storage of eggs ready to be set. Sufficient space between trolleys and walls (15cm) as well as between trolleys for free air movement during storage should be allowed for
- In most instances, sufficient storage space for 5 to 7 days stock will be considered, depending on the frequency of supply from hatching egg supply farms. This could be longer for commercial layer and parent hatcheries where hatching is not as regular as for example in the case of broiler chicks hatcheries
- The storage area should be large enough to ensure easy rotation of stock (first in, first out)
- The manner in which eggs are transferred from the breeder farms and the need to grade and transfer eggs onto machine trolleys will determine the additional space required to carry out this work. In many instances, eggs are collected direct onto setter trays and trolleys on the farm which requires very little additional handling at the hatchery other than to possibly transfer the setter trays holding the eggs onto machine trolleys. Eggs may also be received in cartons and pulp trays, requiring transfer onto setter trays at the hatchery which requires additional space
- If eggs are to be sanitized rather than fumigated at the hatchery, an area for the sanitizing machine must be provided for but then the fumigation room may be omitted

Example of a hatchery egg holding room

1.2.2 Fumigation and Pre-Heating Room

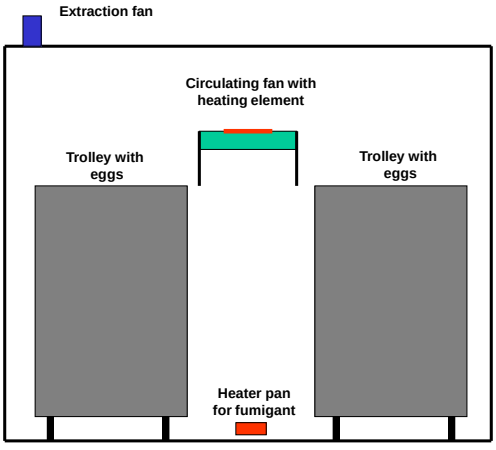
The fumigation and preheating room should be located close to the egg storage room and normally connects the egg room to the setter room or passage.

When single stage machines are used, this room may be omitted as in single stage setters preheating can be done in the machine cabinet at setting. A fumigation room may however still be required to fumigate eggs upon receipt at the hatchery.

The fumigation and preheating room should be large enough to take one full setting of trolleys and in particular, sufficient space between trolleys as well as between trolleys and the wall should be allowed (15 to 20 cm) for good circulation of air. The design of the room and positioning of circulating fans should such that air is forced through the entire setting (all trolleys) to ensure that all eggs are exposed to the warm air as well as the fumigant.

The room will be equipped with air circulating fans and heating elements, heating pan for fumigation, extraction fan and controls. An illustration of positioning of the air circulating fans, heater elements and trolleys for good air circulation is presented in Figure 1.3.

Figure 1.3: Diagram of a fumigation and pre-heating room



1.2.3 Setter Room

The sizing of the setter room will depend on the number and type of setters used. For example to hatch 120 000 broiler chicks per week over two hatches per week will require 4 multi stage setters, each with a capacity of 108 864 eggs or 24 trolleys holding 4 536 eggs each.

Calculation:

108 864 ÷ 6 settings = 18 144 eggs/machine (4 trolleys/setting) x 4 = 72 575 eggs per setting

72 575 eggs per setting twice/week = 145 152 eggs per week

@ 83% hatch = 120 476 chicks/week or 60 238 chicks/hatch

This hatchery setter room will therefore have to accommodate 4 such setters.

Some machines require access to the back of the cabinet while others may be installed with the back and sides flush against the wall. It is however important to allow for sufficient space in front of the machines (3.0 to 4.0 m between the machine and facing wall or facing row of setters). This will provide for temporary storage of trolleys and easy manhandling of the trolleys into and out of the machines. A good ceiling height above the setters should be provided as this area needs to be kept clean and from time to time maintenance work will be carried out in the area above the setters.

Example of a setter lobby

1.2.4 Hatcher Room

The sizing of the hatcher room will also depend on the number and type of machines used. In the example above for the setters hatching 120 000 broiler chicks per week over two hatches per week, 4 hatchers each with a capacity of 18 144 eggs will be required.

Calculation:

18 144 eggs/hatcher x 4 hatchers = 725 76 eggs/hatch 2 times/week = 145 152 eggs/week

The eggs will be transferred into the hatchers on for example Monday afternoon and Friday morning for hatching on Thursday morning and Monday morning respectively. At 83% hatch = 120 276 chicks/week (60 238/hatch)

Some machines require access to the back while others may be installed with the back and sides flush against the wall. The exhaust ventilation system chosen will also affect the size of the hatcher room. When a plenum chamber is to be used then allowance for this must be made at the back of the hatcher cabinets (see Ventilation below).

Only hatchers used on the same day of hatching are to be located in the same room. This will require two or more hatcher rooms so that micro-organisms released during hatching do not affect eggs of a subsequent hatch. The individual rooms are then completely cleaned and sanitized before placement of the next hatch, without disrupting other settings.

It is important to allow for sufficient space in front of the machines (3.5 to 4.0 m between the machine and facing wall or facing row of hatchers). This will provide for sufficient working area for transfer of eggs from setter trays to hatcher baskets.

Example of hatchers

1.2.5 Chick Take-off, Handling and Holding Room

The chick take off area should be separated from the chick handling and storage area. During the process of removing chicks from the hatcher baskets, a large amount of fluff and debris is produced and it is best to keep this away from the staff and chicks being processed and made ready for shipment. The chick take off room should be large enough to comfortable hold the chicks from one hatcher, providing for sufficient space between stacks of baskets as well as a large enough working area.

Placing chicks onto a chick carousel situated in an adjacent chick handling room

The size of the chick handling and holding room will depend on the type of hatchery (need for sexing, vaccination and grading) as well as the frequency with which chicks are dispatched.

The area in which boxed chicks are to be held should be large enough to allow for sufficient air movement between stacks. Allow for 20 to 30 cm between stacks of boxed chicks for good ventilation.

A hatchery chick handling room

1.2.6 Waste Disposal, Wash Bay and Trolley Storage

From the chick take off room, production flow is in three directions. Chicks will flow to the chick handling room, waste will flow to the waste disposal area and the hatcher baskets and trolleys will flow to the wash bay.

The waste disposal area, usually outside the building, is required for storage of waste bins and eventual removal and disposal thereof at the end of the chick take off process. The size of this area will depend on the number of bins required and this area should be adjacent to the wash bay to enable bins being returned to the hatchery to be cleaned before re-use.

The wash bay area should be large enough to handle hatcher baskets and trolleys of at least one hatcher plus sufficient working area, taking into account whether the washing will be done manually or by use of a tray washer.

It should also be noted that live un-hatched embryos that may have partially pipped but that are still alive should be disposed of humanely as soon as possible. This is normally done by passing all of the hatchery waste through a macerator.

The washed hatcher baskets and trolleys will be moved into a drying area/room (trolley storage room) in which they are stored before being moved back into the hatcher room, after the latter has been cleaned. The size of this holding room will depend on the working schedule and should allow for all hatcher baskets in question to be stored as long as it takes for the hatcher room and machines to be cleaned and disinfected.

1.2.7 Chemical and Vaccine Storage

Hatcheries make use of a large amount of cleaning and sanitising agents and a separate storage room of adequate size for these products must be allowed for. It is preferable to locate such storage room close to the pumps and dosing system which will be used for supplying high pressure water.

Likewise all vaccines should be stored in a special room adjacent to the chick handling room. In this regard Mareks vaccine in the case of parent and commercial layer chick hatcheries is of special importance. The room should not only allow for an area where the vaccine can be stored and properly prepared. It should also provide for cleaning and storage of equipment used in administering such vaccines.

1.2.8 Machine and Electrical Control Rooms

The electrical standby plant and switch gear, air conditioning plant, water chiller, boilers, high pressure pumps, chemical dosing system, air compressors and all other major fixed ancillary plant and equipment are usually placed in the machine control area.

This area need not necessarily be enclosed (walled) to allow for sufficient air flow, but should preferably be under roof.

1.2.9 Workshop and Spares

Due to a large amount of equipment being used in a hatchery and the need to make necessary repairs as quickly as possible, a well equipped workshop will be of great benefit.

The spares that need to be carried will depend on circumstance and backup service provided by the equipment suppliers. A high inventory of spares will be costly and should be weighed up against the risks involved in not having the particular spare part available. It is best to set up an essential spares list in consultation with equipment suppliers.

1.2.10 Offices and Staff Ablution

For biosecurity reasons, no staff members or visitors should be allowed access to a hatchery without at least covering private clothes with protective clothing and removal of shoes and wearing boots or covering shoes with plastic covers.

With disease risks in mind, it is preferable that the hatchery only be accessed after showering and wearing of clean protective clothing and footwear supplied by the hatchery. Such ablution facilities should allow for separate male and female showers, with toilet facilities as well as a common canteen for tea breaks.

1.2.11 Connecting Passages and Doors

Connecting passages allow for proper control of access to the various rooms and it is essential to ensure that all passages allow for movement of product as well as staff and equipment in a discipline fashion from "clean" to "dirty" areas within the building. The passages should furthermore provide for cleaned equipment to be moved back into use after such equipment has been cleaned, without crossing areas considered to be "dirty".

This is of special importance during hatch days when chicks are being removed from the hatchers. On such days, no movement from the chick hatching area, back into the egg rooms and setter areas should be allowed.

Doors connecting the various rooms to the connecting passages should close in a positive fashion and doors on overhead rollers are popular. The doors should also be large enough to allow for easy movement of trolleys through the door openings and this should be checked with the trolleys that will be used in the setter machines.

Impact bumper rails protecting the doors from accidental damage by trolleys should also be considered.

1.3 Hatchery Floor and Drains

The hatchery floor is of extreme importance in efficient hatchery operation. The floor should be capable of withstanding heavy traffic in the form of eggs on trolleys. Because of a large volume of water being used for proper sanitation and hygiene control, the slope of the floor and drainage is a further point to be considered. The direction in which the drainage water flows should also take into consideration product flow and must always be from clean to the dirty end of the process and hatchery building. The floor should be sloped to the drainage and generally a slope of 1 mm per meter is applied in passages, lobbies and other working rooms. The floors within the machines are to be level and smooth to ensure proper sealing of the floor with the machine cabinet walls and trolleys interlocking as required.

When planning to build a hatchery the floor starts with the base on which the floor is to be constructed. This base should be well compacted. The floor slab should be 100 to 120 mm thick and should the base be suspect, re-enforcement of the slab may be required, as hatchery floors carry a great deal of heavy traffic in the form of egg buggies and trolleys. The floor finish should be smooth and hard but not slippery which is achieved by screening, floating and towelling. Some makes of machines have steel casters fitted to trolleys and such casters are even harsher on wear and tear of floors.

Three types of drains are commonly used:

- Open drains are channels covered with steel grating strong enough to handle the weight of trolleys. These drains are less expensive but are not as hygienic as they are open and often more difficult to maintain and keep clean, especially the area between the floor channel and the steel grating
- Closed drains with drain traps and catchment baskets strategically positioned in every room are more hygienic as they are closed and debris is caught up in the drain traps before flowing into the drainage system. They do have the disadvantage in that water often does not flow readily into the drain traps, especially when foaming agents are used
- Slot drains are more costly but ideal for hatchery floors. They do have a disadvantage in that if not kept clean, especially just under the slot, such drains could be a source of unhygienic conditions

Example of a slot drain in a setter lobby

Whatever the drainage system used, it is essential that they are able to be cleaned easily, they should contain sufficient traps and debris catchments areas, especially in the hatcher, chick rooms and wash bay area were much shell and other debris get washed into the drains. The drains should also be constructed in such a way that drainage is towards the "dirty" end of the building.

1.4 Ventilation

Although most hatchery machines may be able to cope with fairly large differences in environmental conditions, for optimum results it is advisable to ensure that the conditions within the hatchery building are controlled within reasonably narrow limits.

Ventilation is required to:

- Supply oxygen to the developing embryos
- Remove carbon dioxide from the machines and chick rooms
- Remove heat from incubators as well as from the hatcher and chick rooms
- Provide incubators with sufficient fresh air at the correct temperature and humidity
- Provide chick take off and handling rooms with sufficient fresh air at the correct temperature and humidity

Consideration in the ventilation of a hatchery building includes environmental requirement, conditioning of the air, air supply, airflow and air exhaust.

1.4.1 Environmental Requirement

Except for the egg holding and storage rooms the temperature and relative humidity requirements of the different hatchery rooms are generally very similar. The volume of air required in the various rooms will however differ, depending on the biological requirement and activity (egg and chick numbers).

Particular machine types may have slightly different air supply requirements but in general the data presented in Table 1.1 can be used as a guide for the air supply requirement in the hatchery rooms. This data should be verified with specific machine requirements.

Table 1.1: Air supply requirement

Room	Air Temperature °C	Relative Humidity %	Fresh Air Supply M^3/min	Remarks
Egg Storage	15 to 18	75	0.06/1000 eggs	Very little fresh air is required and normally opening and closing of doors will supply sufficient air from passages
Setter Room	25 to 26	55 to 60	0.14/1000 eggs	Air must be ducted into the room and the room ventilated in such a manner that the machines are not over pressurised
Hatcher Room	25 to 26	55 to 60	0.28/1000 eggs	Air must be ducted into the room and the room ventilated in such a manner that the machines are not over pressurised
Transfer Room	25 to 26	55 to 60	0.33/1000 chicks	
Chick Take-off and Holding Room	25 to 26	55 to 60	0.33/1000 chicks	

1.4.2 Air Supply and Flow

The airflow through the hatchery building should be designed in such a manner that the air moves in a positive manner through the building in the direction of product flow. That is from "clean" to "dirty" areas within the building. Consideration should also be given to the fact that no excessive negative or positive air pressure should be placed on the machines and

they should be able to call for air from setter or hatcher rooms or lobbies as required by the respective machines. Exhaust air from the machines should be removed in a positive manner from the respective rooms, again without placing undue negative pressure on the machines.

Rooms and lobbies to which the air is to be moved should therefore have a lower static pressure than those from which the air is to be moved. Most hatcheries utilize a positive airflow with air entering the building via air ducts from the air conditioning plant into the various setter and hatcher lobbies. By controlling the outlets from these ducts into the various rooms, the airflow within the building can be controlled to move in the desired direction. For this reason doors should seal in a positive fashion against the door frame and floor. The amount of air (as well as the pressure) entering the respective rooms should be checked against the machine requirements. Exhaust fans which are balanced to the incoming amount of air are then strategically positioned so as to move air from within the room in the desired direction though creation of a slight negative pressure.

Incubator rooms may be designed in such a manner that a separate closed lobby is created in front of the machines into which the required air volume is ducted. The air intake of the machines draws air from the lobby and escape louvers placed between the lobby and the area behind the machines allow for air escape to ensure that no excessive air pressure is placed on the machines. Any excess air moves through the louvers and out via balanced exhaust fans in the area behind the lobby. Exhausting of air should be done from this area to ensure that the air moves in a positive manner from the lobby, into the area on top of and behind the machines and then out the exhaust area. The advantage of creating lobbies in front of the machines is that this smaller area is kept clean more easily and it is isolated from the exhaust end (dirty) of the machines.

An alternate way is to simply place the machines in the room, supply air through ducting into the room and create exhaust ducts and fans from the room. The exhausting fans should be matched to the incoming air to ensure that the setter room is under a slight positive pressure (over pressure) so that air always moves out of the setter room and not into the setter room from other rooms, especially the hatcher room and lobby.

Some systems will incorporate pressure sensors in the lobby in front of and the area behind the machines and through variable speed controlled fans create a constant slight positive pressure in the lobby area. When doors are opened the fans will increase in supply to compensate for the drop in pressure and likewise the fans behind the machines will increase in speed to compensate.

Due to the cost of heating air, the exhaust air from the setter machines is often ducted back to the air supply unit where, with the use of heat exchangers the heat from the setter machines is recovered and used to heat the fresh air being supplied back to the machines.

Whatever system is applied, the key objective should be to ensure correct volume of air supply at the required temperature and humidity. The setter lobby should be at a slight positive pressure to ensure that airflow within the building is away from the setter lobby. Machines should also not be subjected to undue high negative or positive air pressure.

Installation of an air supply unit

1.4.3 Exhaust Airflow

Areas such as the hatcher, chick take-off and chick handling and holding rooms have the added problem of producing large amounts of fluff. Unlike the exhausted air from the setter rooms the exhaust air from these rooms contains high amount of fluff, which should be taken care of and not simply exhausted to the outside. Outside air movement (wind) could blow such fluff in the direction of the air intake system of the building and thereby back into the building.

As much as possible of the fluff should be removed from the air. This may be done by creating a plenum chamber behind the hatchers into which the airflow from the machine is exhausted, allowing the fluff to settle in this chamber and air is then removed from the top of the chamber.

An alternate method is to blow the exhaust air over water baths.

Example of an exhaust plenum behind hatcher machines

By allowing for a slight negative pressure in these areas, fluff will always be moved in the direction of the exhaust system.

The exhaust outlets of machines should never be connected direct to exhaust ducts as this will result in possible pressurizing of the machines air. Air escape vents should ensure that the air pressure on the intake and outlet side of the machines is continually being balanced.

1.4.4 Conditioning of the Air

It is advisable to provide for conditioning of the air temperature and humidity being introduced into the setter and hatcher lobbies as well as the chick holding room. The most economical way of cooling air, especially in dry climates such as South Africa, is through evaporative cooling where vaporization of water, either through pad coolers or a high-pressure spray (mist), is used to cool the air.

Evaporative cooling of air is based on the fact that heat is required to evaporate water vapour in air. Hot outside air is drawn over a wet pad and as water is evaporated into the air, heat is removed from the air, causing a reduction in the air temperature. The same effect is obtained when mist is sprayed into the air where the fine mist (water vapour) takes up heat from the air. If the air is dry, the extent to which water can be evaporated is increased. Wet bulb temperatures tell us to what extent evaporative cooling can cool air. The larger the difference between wet and dry bulb temperature, the lower the relative humidity and the more cooling is possible. Evaporative cooling does however increase the relative humidity and in certain climatic conditions this could result in excessive humidity in the building. Under such conditions air conditioning through the use of heat exchangers would be more appropriate but more costly.

Air conditioning unit

Heating of the air is usually done by electrical heater coils within the air ducts, which may be supplemented by heaters in areas such as chick take off and holding rooms. Heat exchangers, fired by coal, diesel, oil or gas are also commonly used to heat the air being ventilated into the hatchery building.

When evaporation of water is used to cool the air, the humidity will automatically be increased but if the relative humidity is still below 55% after cooling, humidification is corrected by fine mist spray into the ducted warm air. This mist will again cool the air and the initial air should therefore be at a temperature slightly higher than required to allow for this cooling effect.

Hot steam is very effective for humidification as steam will not cool the air but assist in maintaining the desired temperature. It is however more costly to install and operate.

Cooling of the egg holding room is normally done by conventional cooling units using gas filled high-pressure heat exchangers.

The sizing and calculation of the required cooling and heating capacity is best left in the hands of competent engineers.

1.5 Incubators

Through the years many types of forced-draft incubators have been developed, utilizing lighter yet more effective cabinet materials, machines without floors so as to allow for buggies to be wheeled in and for easier cleaning, improved temperature and humidity control through electronic control and automatic egg turning in the setters. Single-stage incubation systems preceded the larger more efficient multi-stage, walk-in systems introduced in the 1950's. During the last decade there has been a move back to single-stage setters mainly as a result of concern for food safety and control of diseases such as salmonellosis.

In most modern chick hatcheries the incubation process consists of the first 18 days in the setter and the last days in the hatcher, requiring eggs to be transferred from setter trays to hatcher baskets during the 18th or 19th day of incubation. Most large hatcheries will hatch 4 times per week (Monday, Tuesday, Thursday and Friday). In such operations, two sets of hatchers are utilized, one set for the Monday and Thursday hatches and the second for the Tuesday and Friday hatches. Where twice a week hatching is practised only one set of hatchers will suffice for Monday and Thursday hatching.

1.5.1 Multi-Stage Setters

Multi-stage setter machines utilize the system of eggs being set on a regular basis. In these machines, the heat being generated by the older embryos in the setter cabinet is used to assist in heating the newly placed eggs that require heat. Eggs of different placements are therefore evenly scattered and intermingled so as to ensure even spread of the heating of newly placed eggs by older eggs in the cabinet.

Due the heat generated by older embryos being used to heat young embryos, multi-stage setters are effective in utilization of heating requirement and heating and cooling capacity is therefore lower compared to single stage setters. As a result these machines are therefore less costly to install and operate. Multi-stage setters are normally operated on fixed temperature and humidity settings, which could be altered to a degree to suite particular circumstances but the different requirement for young and older embryos cannot be catered for.

Two types of single-stage setters are commonly found:

Fixed-rack machines are machines in which the racks, into which the setter trays are placed, are fixtures in the machine cabinet.

Trolley machines utilize a system in which the trolleys that the carry the racks onto which the setter trays are placed, are pushed into the cabinet.

1.5.1.1 Fixed Rack Setters

In these machines the racks onto which the setter trays are placed are fixed to the side walls of the cabinet and cannot be removed other than dismantling the racks. Fixed rack machines have the disadvantage that they are difficult to clean, as the racks are a fixture to the cabinet. They are also very labour intensive as eggs cannot be placed by trolley into the machine. Each setter tray has to be manhandled at setting and again at transfer from and into transfer trolleys.

The 6 settings over a three week period are placed in a set configuration to ensure that the newly placed setting is closest to the oldest egg in the machine. Various types of fixed rack machines have distinct setting patterns which must be adhered to when setting eggs.

The advantage of fixed rack machines is that due to old and fresh eggs being dispersed through the cabinet by a particular setting pattern in a very uniform manner, there is more even distribution of hot and cold areas. Results therefore tend to be better compared to trolley machines as in the latter, different setting are done by trolley which results in larger areas of cold and hot eggs close to one another.

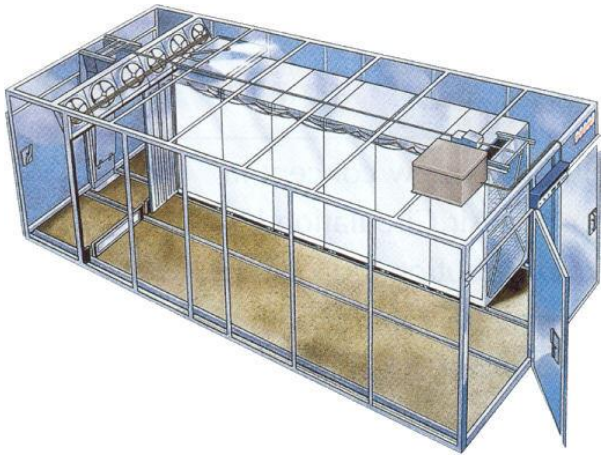
A fixed rack setter

1.5.1.2 Trolley Setter

Trolley machines are normally operated on the basis of placing entire settings on trolleys which are then intermingled in the cabinet to have newly placed eggs (cold) adjacent to older embryos (warm). This setting pattern does however lead to greater temperature differences within the cabinet compared to a fixed rack incubator. In addition, during the stages when a particular placement position is empty (between transfer and a new setting) a large open area is created where the trolley would normally stand and this leads to interference of air movement through the eggs being incubated.

For this reason, trolley machines are often operated as fixed rack machines in terms of placing of eggs. Due to the advantage of the eggs being on trolleys, such trolleys may be removed from time to time to clean the setter cabinet.

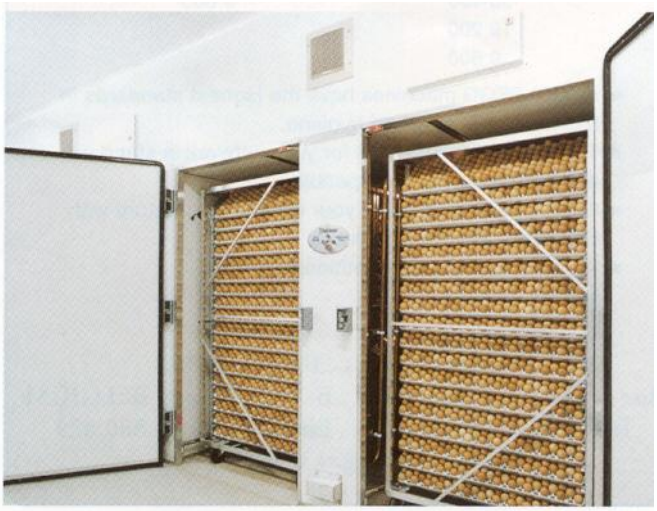
Trolley setters may also have a tunnel configuration where the trolleys are moved into the cabinet from one end and over the incubation period are moved forward with each setting, eventually being removed at the other end for transfer to the hatcher.



Example of trolley setters

1.5.2 Single-stage Setters

Single-stage setters are operated on the principle of the machine being set on an all-in, all-out basis. This gives opportunity for the entire machine to be thoroughly cleaned and disinfected between settings, thereby breaking the cycle of whatever bacteria or disease that may be present. The operation of the these machines is more complex but more effective in that temperature and humidity setting during incubation are changed according to the requirement being demanded at the particular stage of development of the embryos.



Single stage setter

Single-stage machines are also less efficient on energy utilization. Compared to multi-stage machines, additional heating capacity has to be provided during the early stages of development of the setting, while heat has to be removed from the setting in increasing amounts toward the latter part of embryonic development which requires additional cooling capacity. They are therefore much more costly to install as well as operate.

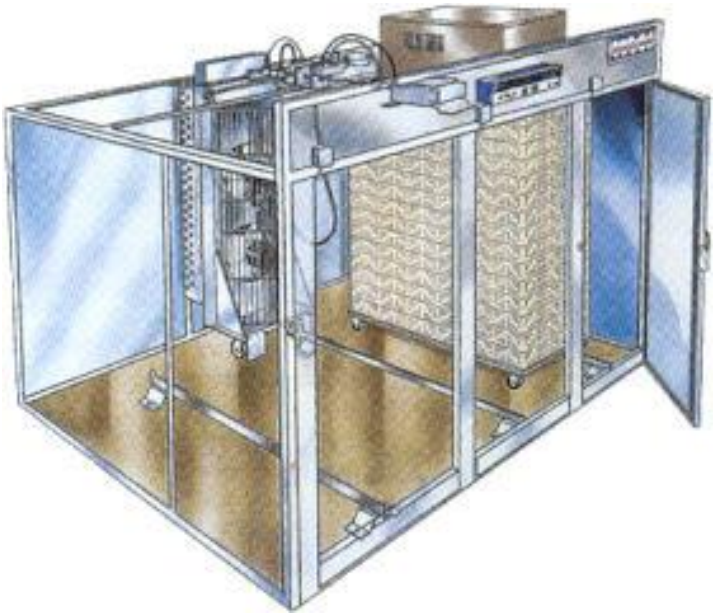
These systems are particularly advantageous in breeder hatcheries where control of vertically transmitted diseases is more critical. With increased emphasis on food safety as well as increased evidence that it is beneficial to set cabinet conditions more closely to the desired requirements during the various stages of embryonic development, single stage incubation is becoming more popular in commercial layer and broiler hatcheries.

1.5.3 Hatchers Machines

In the incubation process of chickens, eggs are normally transferred from setter machines in which eggs are able to be turned through 90° (45° either way) into hatcher machines in which the fully developed wet chick will emerge from the shell.

The hatcher machines therefore have specially designed "baskets" in which eggs are placed at transfer from the setter trays.

It is essential that hatchers are operated on the basis of all-in, all-out placement of eggs and removal of chicks to ensure proper cleaning and disinfecting between hatches thereby reducing the risk of any disease developing and spreading between hatches. For the same reason it is advisable to ensure that hatchers being used on different days in the week are placed in separated rooms.



Hatcher machines

1.6 Ancillary Equipment

Other equipment will be found in hatcheries depending on the extent of automation.

1.6.1 Egg Transfer Machine

Eggs need to be transferred from the setter trays into the hatcher baskets before the chicks hatch. This could be manually or by semi-automated or completely automated systems in larger hatcheries and could include a candling device enabling clear eggs not to be transferred to the hatcher.

Example of a small egg transfer machine

1.6.2 Chick Take-off

These systems that are used during chick take-off and handling would normally comprise a combination of carousel table with chick transfer belt transferring chicks from one carousel to the next for sexing, vaccination and grading before the chicks being counted and boxed.


Chick Take-off

1.6.3 Infrared Beak Trimming

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

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

Many hatcheries are offering this procedure and it is preferred by those involved in the welfare of poultry. These machines are also capable of applying sub-coetaneous Mareks vaccination.

1.6.4 Other Ancillary Equipment

Other ancillary equipment in a chick hatchery would include high pressure wash bay equipment, electric standby plant in case of power failure, vacuum and air pressure pumps.

In very large hatcheries the extent to which the chick take-off can be automated is considerable requiring limited labour in such hatcheries. Such equipment could include chick separators, chick counters, boxing and spray vaccination as well as automated cleaning and re-stacking of baskets and setter trays. These systems are only economically viable in very large hatcheries where labour costs may be high.

2 Biosecurity and Hygiene Control

It is desirable that the chick hatchery should apply strict biosecurity rules to reduce the chances of diseases spreading from parent farms to commercial rearing farms as well as from commercial rearing farms back to the parent farms. Day old chicks have very little immunity to most common diseases and should not be subjected to poultry diseases prior to being inoculated against such diseases. It is furthermore essential that the hatchery insures that no disease develops within the premises which may be spread via the chicks to farms with which contact is made.

The hatchery therefore plays a significant part in combating spreading of diseases within the poultry industry.

2.1 Biosecurity Program

A good biosecurity program at the hatchery would depend on the following key considerations:

- Isolation of the hatchery from other poultry activity
- Control of movement of traffic entering the premises
- Control of movement of staff, visitors and equipment within the hatchery building
- Strict hygiene and cleaning measures
- Sourcing hatching egg supply from disease free farms

It is not possible to subscribe a single program that will suite all conditions. Each circumstance needs to be evaluated separately and the necessary measures developed accordingly. Precaution and risk measures will be stricter for hatcheries producing chicks intended to be used as breeding material compared to hatcheries producing commercial chicks for the broiler and egg production industries.

The eventual program should be well documented and known to all members of staff working in the hatchery.

In developing such programs, some pertinent questions need to be posed:

- To what extent is the hatchery well separated from other poultry activity and if not, what measures are in place to address such shortcoming?
- Is there a sound cleaning and disinfecting control program in place and followed?
- Are staff and visitors controlled in respect of movement into the hatchery?
- Are there strict procedures in place controlling movement of staff and equipment within the building?
- Are the premises properly fenced off and free of movement of stray animals onto the premises?
- What control is there on the movement of outside people such as electricians, outside contractors, especially in respect of tools?
- Are eggs purchased from a reliable source that is known to be free of diseases that are spread via the egg to the chick?
- How is hatchery waste disposed of?

- Is water available from a reliable source and is the quality thereof known and tested regularly?

2.2 Disease Risk

Heat, humidity, flow of air and damp surfaces which occur in a hatchery create and ideal media for growth of organisms such as bacteria and fungi. The content of eggs also provides an ideal growth medium for these organisms and the potential disease risk in a hatchery, is therefore significant.

Diseases which pose a risk in day old chick production include bacterial infection, fungal infection and vertical transmitted disease.

2.2.1 Bacterial Infection

Bacteria are micro-organisms, which are larger than viruses, and many are pathogenic (disease causing) to other micro-organisms and to plants and animals.

2.2.1.1 Omphalitis

Omphalitis is an infection associated with improper closure of the navel and subsequent bacterial infection. The cause of this is poor hatchery sanitation, excessive incubator humidity, as well as chilling and overheating of the newly hatched chick. The navel closure is incomplete, causing the entry of a variety of bacteria should they be present. Poor shell quality will also permit easy bacterial penetration into the egg.

Incubation period for the bacteria is 8 to 24 hours and the disease could last for 6 to 7 days after incubation. Most common bacteria isolated with an omphalitis infection could include E Coli, Pseudomonas, Streptococcus, Staphylococcus, Salmonella and Clostridia.

Chicks are weak, have large abdomens, moist and inflamed navels, pasted vents and lack body tone. Chicks will huddle and those severely infected will die within the first week. The mortality rate will vary but could be as high as 20 percent in severe cases.

There is usually no treatment as non-infected chicks need no treatment. Treatment of infected chicks has very little positive effect. Treatment started early in anticipated cases could be considered. Severely infected chicks should be culled out early. The control of this condition is through effective hatchery sanitation, hatchery hygiene procedures, breeder flock surveillance and proper pre-incubation handling of eggs.

2.2.1.2 Salmonella Infection

Salmonella organisms are found in the digestive tract of breeding birds which contaminate the shell surface when the egg is laid. Multiplication and transmission of the organisms to other chicks occurs rapidly at hatching and during sexing and handling of chicks. The organisms could result in high chick mortality and certain salmonella are dangerous to human health as well.

A control program will include testing and possible vaccination of breeder flocks. It is also advisable to have staff working with chicks certified salmonella free on a regular basis.

2.2.2 Fungal Infection

Fungi produce spores and infection is usually associated with respiratory problems. The most common fungus associated with chick hatcheries is Aspergilloses.

The symptoms are gasping, emaciation, bluish dark skin and high mortality. All birds are susceptible but chicks in particular are highly susceptible. Mortality will vary and could be 20 percent and higher.

Diagnosis will involve the isolation of the fungus.

The source of the fungal infection could be the breeder farm as well as the hatchery and in some instances the rearing house could be the cause of the fungal infection. In the hatchery the areas of possible cause will include especially the ventilation ducts which are difficult to clean. Air into ventilation ducts should be filtered and clear of dust particles and from time to time the ventilation ducts are to be fogged with a fungicide. Infected eggs and generally poor hatchery hygiene may also be the cause of a fungal infection.

2.2.3 Vertical Transmitted Disease

Certain diseases are carried vertically from the parent flock via the egg and chick to the rearing farm. Some of these diseases could be disastrous to the producer and the industry as a whole. Examples of disease which are vertically transmitted include:

- Salmonella
- Mycoplasma Gallisepticum (MG)
- Mycoplasma Synoviae (MS)
- Lymphoid Leukosis
- Avian Encephalomyetitis (AE)
- Egg Drop Syndrome (EDS)
- Chicken Aneamia Virus (CAV)
- Reo Virus

The chick hatchery is to ensure that parent farms from where eggs are purchased are regularly tested and certified free of these diseases.

2.3 Chemical Disinfectants

A variety of chemicals which are suited for hatchery cleaning and sanitation are available. It is best to establish suitable products with the assistance of a qualified veterinarian. All products on the market have advantages and disadvantages. Effectiveness is greatly improved if equipment, surfaces and floor and other areas are clean. For this reason, thorough cleaning is the first and probably the most vital step in sanitizing buildings and equipment. Organic matter seriously interferes with the action of the disinfectant.

Many disinfectants have a selective action on different types of microbes depending on the structure of the organisms and on the environmental pH. For example, fungi are extremely acid resistant, whereas most viruses are highly susceptible to acid disinfectants. Some disinfectants which are called "broad-spectrum" are almost equally active against most species of micro-organisms, while others show specificity and are only active against a restricted number of species. Most cleaning and sanitizing programs will incorporate a process of cleaning by using a detergent, followed by sanitizing with a disinfectant. Dirt is removed by high pressure spray assisted by use of a detergent and disinfectant is then applied to the cleaned surfaces. Areas which cannot be cleaned by high-pressure spray should be hand cleaned prior to disinfecting.

Disinfectants must be given time to inactivate the micro-organisms. Also important is the fact that surfaces are only disinfected while they are wet or moist. The concentration of disinfectants influences the rate of death of micro-organisms.

The following factors affect to a lesser or greater extent the successful use of chemicals:

- It is important that the prescribed concentration is used, since a lower concentration means it takes longer for micro-organisms to die off and the long-term effect of this is that some bacteria will become resistant
- Generally speaking, disinfectants act on micro-organisms more quickly at higher temperatures. Formalin has no effect at temperatures below 15°C. An exception is caustic soda, which at a minimum concentration of 2% is more effective at 5°C than at 15°C
- Different chemicals may require different water pH and it is essential to ensure that the water pH is suited for what is being used
- When disinfecting, it is not only the micro-organisms that need to be considered but also with organic material that may be involved. Proteins especially have an unfavourable influence on the disinfecting process
- It is essential that the chemical in question is suited to combat the particular organism involved. Differentiation should be made between viruses, moulds and bacteria and whether the bacteria involved is Gram- positive (includes Enterococci and Staphylococcl), Gram- negative (includes E.coli, Salmonella, Proteus and Pseudomonas) or Spore-producing bacteria (includes Bacillus and Clostridium)

2.3.1 Phenols

Phenols are coal-tar derivatives and include a large number of compounds. Synthetic phenols are more germicidal and less toxic than natural phenols to animal tissues and have generally replaced the natural phenols as general disinfectants. Many of the synthetic compounds are combined with soap during manufacture. The cleansing action enhances their germicidal contact and effectiveness.

Phenols have a characteristic odour, turn milky when added to water, and are effective germicides especially against bacteria and fungi. By certain additions their veridical activity is increased. Organic materials have a diluting effect but do not inactivate phenols. Phenols have high dilution coefficients i.e. small changes in concentration give rise to large differences in their killing rates and they are always more effective as the temperature rises.

2.3.2 Oxidising Agents

Hydrogen peroxide and other oxidizing agents include per acetic and propionic acids and acid per oxygen systems are emerging as increasingly popular disinfectants. At quite low concentrations they are active against bacteria, bacterial spores, viruses and fungi. Several new and very safe forms are available for use in poultry houses and hatcheries.

Ozone (0_3) is also a powerful oxidizing agent attacking almost all organic compounds. It has been shown to preferentially destroy gram-negative rod-type organisms (e.g. E. coli, Pseudomas). Ozone is a natural gas formed when oxygen (0_2) takes on an extra molecule and becomes Ozone (0_3). A big advantage is that ozone reverts to oxygen, leaving no harmful residual chlorides or other by-products as is common with chemicals.

Oxidizing agents are safe, biodegradable; corrosive, readily soluble, severely inhibited by organic material, relatively expensive, wide spectrum, have no or very little cleaning power and all application methods such as spraying and fogging can be used.

2.3.3 Iodine

Iodophors are mainly effective against bacteria and fungi but with a long contact time, some viruses will also be killed. Iodophors are not used widely in hatcheries. When the characteristic iodine colour fades, effectiveness is gone.

Iodine, the active chemical in iodophors is a member of the halogen group (includes Cl and Br) of chemical elements. Iodine vaporizes (passes off a vapour) very rapidly after application. It is widely used in dairy and food processing. All halogens are rapidly destroyed in the presence of organic material, so the areas to be disinfected must be clean. The iodophors are good disinfectants in acidic situation (pH 2 to 4), but activity diminishes in an alkaline pH.

These solutions are used for egg dipping, hatchery and poultry house disinfecting and for sanitizing processing plants, footpaths and poultry drinking water.

2.3.4 Chlorine

Chlorine is an effective constituent of certain disinfectants. Included are the powder/liquid forms of sodium or calcium hypochlorite combined with other chemicals. One major use of chlorine is in purification of water. Various types are available. Common household bleach contains 5 percent available chlorine; products manufactured for use in swimming-pool sanitation contain 15 percent available chlorine.

It is also used for washing and dipping eggs but mainly in disinfecting of water.

2.3.5 Quaternary Ammonium

The quaternaries are called "quats", short for quaternary ammonium compounds (QAC). Quats vary in composition and a trade formulation may be a mixture of two or three.

Quats are clear, odourless and non-irritating to the skin. They provide deodorizing as well as detergent activity. They are to be used with care, as soaps, detergents, and organic materials will destroy their germicidal properties.

Quats are used for egg washing and dipping and disinfecting hatcheries, poultry houses and equipment.

2.3.6 Formaldehyde

Effective fumigation of hatching eggs is a proven means of reducing the burden of shell bacteria provided the eggs are correctly fumigated soon after lay. It will help to ensure that eggs do not contaminate the hatchery with potential pathogens such as Salmonellae.

It is advantageous to fumigate hatching eggs on the farm as soon as possible after lay and again before setting in the hatchery. The first fumigation is designed to kill shell bacteria before they penetrate the shell; the second is designed to reduce shell contamination that occurs between the farm and setting.

For effective fumigation, the following concentrations are commonly used:

- 45 ml of 40% formalin and 30 g of potassium permanganate per m^3 of fumigation chamber. Water is produced during this reaction and provision of extra moisture is

unnecessary. At 21°C there is no significant variation in efficiency when fumigation is carried out between 60 and 80% RH.

- Heating 10 g of paraformaldehyde per m^3 in a pan, assuming the prills are 91 % paraformaldehyde. Some moisture should be provided and the addition of a few millilitres water to the evaporator is satisfactory.

Poor fumigation is often due to:

- Leaks in the chamber
- Insufficient time of exposure to the gas (20 minutes)
- Absorption of the gas by chamber surfaces
- Excessive or too little moisture
- Inadequate gas circulation
- Insufficient chemicals
- Absorption of gas by pulp trays

Eggs are often fumigated at half strength immediately after transfer into the hatchers. Caution should be taken when applying this practice as chicks should not have started pipping.

Trickle fumigation is often applied in the hatcher cabinets to reduce the cross contamination by chick fluff. This is done by using a 40% aqueous solution of formalin at a rate of 15 ml per m of hatcher space, placed in enamel pans at transfer. Very low concentration of formaldehyde is achieved but the effectiveness lies in the long exposure time.

2.4 Monitoring Hatchery Hygiene

The hatchery hygiene program should be regularly monitored. This is done by regular sampling (twice per month) of air and hatchery surfaces.

Nutrient-agar contact plates, which may be obtained from veterinary laboratories are used for all surfaces and nutrient-agar exposure plates (30 second exposure) for testing of air in the hatchery. The agar plates are then incubated at 37°C for 18 to 48 hours and the amount of bacterial growth evaluated.

3 Development of the Chick Embryo

The chick embryo derives its nutrients from the egg itself and not from nutrients supplied via the blood from the mother as is the case with mammals. Although some embryonic development takes place while the egg passes through the oviduct in the body of the hen, most of the development occurs outside of the mother's body in the egg itself.

The process of incubating chicken eggs should be prefaced by knowledge and understanding of the makeup and structure of the egg and how fertilization of the egg cell takes place.

Embryonic development in the chicken egg may be classified into two phases. The first phase being the development of the blastodisc which occurs in the hens body prior to the egg being laid, where after development ceases if egg temperature is maintained below a certain threshold. Embryonic development will again commence when egg temperature increases above this threshold. This unique phenomenon allows for large volumes of eggs to be stored and then incubated at the same time.

3.1 The Chicken Egg

3.1.1 The Shell

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

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

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

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

Chemically the calcified layer is mainly calcium carbonate.

3.1.2 The Shell Membranes

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

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

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

3.1.3 The Albumen

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

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

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

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

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

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

3.1.4 The Yolk

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

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

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

3.1.5 Egg Shell Strength

Selection for improved shell strength, especially towards the latter part of the production cycle remains a priority for most layer breeders. This poses particular difficulties in the hatching of egg originating from layer breeds as the improved shell quality affects the moisture loss during incubation. Hatching of these eggs would therefore require different incubator settings compared to broiler hatching eggs since egg shell strength is not such an important trait in broiler breeding but is nevertheless not ignored in these breeding programs.

3.1.6 Microbial Contamination

In large scale production hatching egg production micro-organisms associated with the production could pose major problems, especially when eggs are handled and stored under poor hygienic conditions.

Contamination may occur even before the egg is laid but the incidence thereof is very low. It is important that flocks are regularly tested for bacterial infections such as salmonella that may be passed on to the progeny.

Most contamination occurs immediately after the egg has been laid and the main sources of microbial infestation include:

- The cloaca
- The atmosphere
- Dirty equipment
- Dirty hands of staff handling eggs
- Poor handling resulting in hairline cracks causing easy penetration of the micro-organisms.

Contamination during handling and storage could also occur and are due to:

- Poor environmental conditions
- Poor storage
- Rough handling causing hairline cracks
- Poor washing of eggs if this is practiced.

3.2 Early Embryonic Development

Fertilization occurs within 15 minutes following ovulation and this occurs while the ovum is in the infundibulum. As the egg moves through the reproductive tract of the female, the albumen, and shell membranes are added and eventually the shell itself. At the time that the egg enters the uterus (5 hours after ovulation), the zygote is at the first stage of first cell division. The egg will remain in the uterus for approximately 20 hours during which the shell is formed and in this period, approximately 16 cell divisions will occur to produce the blastoderm containing 50 000 to 60 000 cells. It is therefore important to regard fertile eggs as being at a reasonable advanced stage of embryonic development.

At this point the blastoderm consists of three distinct layers of cells from which all the organs and parts of the body will develop.

The ectoderm is the uppermost layer of cells and gives rise to the nervous system, parts of the eyes, feathers, beak, claws and skin.

The endoderm is the lower layer of cells from which the respiratory system and secretary organs as well as the digestive track develop.

The mesoderm is the third layer between the two mentioned above and forms the skeleton, muscles, blood system, reproductive organs and the excretory system.

The embryo in the newly laid egg will cease development and cell division when temperature drops below 24°C. Hatching eggs are therefore generally stored at 18°C when kept for short periods of time. A colder temperature is applied (12°C) when eggs are stored for longer than 7 days.

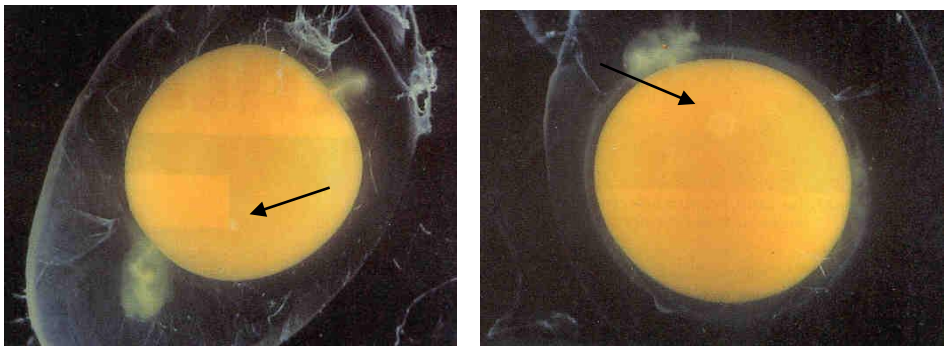
The cessation of embryonic development is reversed when egg temperature is increased again to levels above 24°C and the development will be sustained at temperatures of approximately 37°C.

Parthenogenesis is a process where cell division occurs in an unfertilized ova. It is rare but does occur in chicken. Most of the development found will have ceased before oviposition or during the first few hours of incubation.

3.3 Fertility

It is possible to distinguish between fertile and infertile eggs prior to placement in the incubators. It does however require practise and the egg has to be broken to evaluate the content. The egg is broken out on a white plate or flat surface and the germinal disc (blastoderm) must be found. This is often the more difficult part as the germinal disc could have landed under the broken out yolk material.

Prior to hatching a fertile egg will show a large germinal disk (3 to 4 mm in diameter) with a light centre and a thick, white perimeter. It appears like a doughnut, with the thick, white circle around the outer perimeter of the disc. An infertile egg will show a smaller germinal disk with a solid, bright white centre, which may or may not be in the centre of the disc. The white centre of the infertile egg is much brighter than the white centre of the fertile egg. The germinal disk of an infertile egg could in the odd occasion be large but the centre will be solid and bright and the perimeter will be irregular.



Typical infertile egg on the left and a fertile germinal disc on the right

Fresh egg breakout has the advantage that it is the quickest way of determining fertility (even before incubation starts) but it does have the disadvantage that it is a slow process and valuable eggs have to be broken.

It is however a good practice at the start of a new flock to know in advance what the fertility would be like as well as when disease and fertility problems are being encountered. Fertility can be determined on the day that the egg is laid rather than having to wait for 3 weeks until final hatching.

Because of the value of hatching eggs, sample size of 100 eggs should suffice but results could be variable as a result of the small sample size. This practise is generally only followed when specific problems are being investigated.

3.3.1 Male Fertility

Since half the germ plasma of the developing embryo originates from the male, the few males in the breeder pen play a significant role in the reproductive performance of the flock. The role of males therefore cannot be over emphasized.

Too many as well as too little males will affect fertility. No fixed rules exist and the mating ratio will depend on the breed as well as other factors affecting male activity. In general however light commercial layers (Leghorns) will be mated at a lower ratio (7 to 8 males per female) than heavy meat type breeders (10 to 11 males per female). Brown egg layers are mated at a ratio of 8 to 10 males per 100 females. Aspects such as the pressure on culling peck outs, general culling of males, and housing systems (ie. slatted floors) will all play a role in the ideal ratio of males in the poultry shed.

Too often the importance of male body weight, especially in broiler breeders is neglected. Excessive male body mass at point of lay as well as excessive weight gain in the breeder house will lead to obese and inactive males. Separate male feeders have been developed for broiler breeder males, which ensure that the males can be fed a different regime (rates and often ration as well).

Wire grids are placed over the normal feed troughs that are designed in such a manner that the males are unable to get their larger heads and combs through. Separate feeders are then suspended at a higher height to stop females feeding from these male feeders. There is however a critical period at onset of production just after the flock is mated up, when males are still able to feed from the female feeders. Close supervision and management is required in this period to ensure that all the effort to produce the correct body mass and uniformity at 20 weeks is not undone. For a period the flock may have to be fed as one so that males and females can feed from either system. Once it is noticed that a larger proportion of the males are no longer feeding from the female feeders, the male feeders are then lifted to a higher height.

Culling of males would also play a role in fertility. There is a tendency for males to mate with certain females and should a particular male not be active a tendency may exist where his particular females are not being mated with. On the other hand culling of males should be approached with care. In some breeds, should a male which could be at the lower end of the pecking order be removed, the flock will merely find the next bird in the peck order. This aspect should be carefully managed. Should males be dying off or having to be culled at a higher rate than females, then the reasons have to be found and corrected in order to maintain a satisfactory rate of fertility towards the end of the flock's productive life.

Exercising of males through the introduction of grain feeding on the litter in the afternoon could also assist in keeping males active and stimulating mating behaviour. The amount of scratch feed would be in the order of 5 kg per 1000 per day. The grain of choice is whole wheat or oats.

Often males will develop enlarged footpads and hock joints caused by injury and resulting in an infection (staphylococcus) in the joints. This condition could also have a nutritional background as excessive protein consumption could be the cause of urate deposits in the foot pad area.

Spiking of males is sometimes used to overcome the problem of reduced fertility towards the end of the breeding cycle. This is done by replacing the old males with young males. It is however costly and should be approached with care. It is usually done at night and all males in the breeding pen should be removed and replaced. When only a part of the males are removed and replaced by younger males, the younger males do not only then have to contend with dealing with older and more dominant females but also with a number of older and generally heavier males. If partial spiking is to be done then it is best to split the pen in two, leaving older males with part of the females and the younger males with a separate number of females.

3.3.2 Other Factors affecting Fertility

Other factors that will affect fertility include:

- Disease - The mating activity of a diseased flock will be reduced and when diseases such as IB, NCD, etc. occur it is normal to expect a reduction in fertility
- Temperature - Both extreme cold and hot environmental temperatures, especially when such temperatures prevail over a couple of days will affect mating behaviour and hence fertility
- Nutrition - Although nutrition also plays a role in fertility (vitamins and minerals) under normal circumstances breeder diets are adequately fortified with these nutrients. Practical conditions such as long storage time of feed under very hot conditions and allowing feed to get wet and become mouldy could destroy certain vitamins or create chemical reactions within the feed that make the vitamins and minerals indigestible to the bird. Where feed is to be kept for longer than a week the use of anti-oxidants and higher fortification of vitamins and minerals should be considered

3.4 Embryonic Development during Incubation

The chicken embryo is not connected to the hen but certain membranes are present in the egg that will ensure utilization of the nutrients within the egg by the developing embryo.

3.4.1 Yolk Sac

The membrane that envelops the yolk sac secretes enzymes that change the nutrient contents of the yolk into a soluble form that will be used by the embryo. During the latter part of embryonic development just prior to hatching, the remaining content is drawn into the abdominal cavity of the chick and serves as the initial source of nutrients for the newly hatched chick.

3.4.2 Amnion

The amniotic sac is filled with a transparent fluid in which the embryo floats and prevents the embryo from injury during its development.

3.4.3 Allantois

This membrane serves as the circulatory system in the egg. It starts to develop on the 3rd day of incubation and is fully developed by the 12th day covering the complete inside of the shell and has the following functions:

- It supplies oxygen to the blood of the embryo and removes carbon dioxide
- The excretions from the embryonic kidney is held in the allantoic cavity
- It aids in the transportation of albumin and absorption of calcium from the eggshell

3.4.4 Chorion

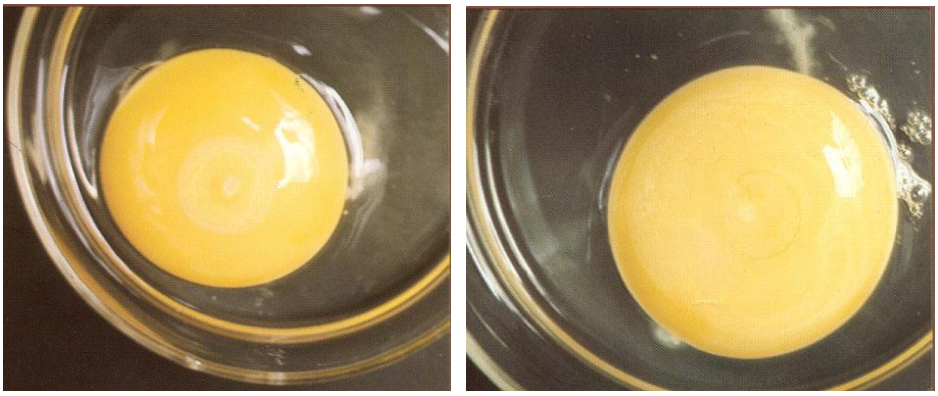
This membrane fuses the inner shell membrane with the allantois and in so doing assists the allantois in its metabolic function.

3.4.5 Development of the Embryo

During incubation, moisture is lost from the egg through the shell and by the 19th day the air cell would occupy about one-third of the egg and is deeper on one side compared to the other. Although much more detail will be visible microscopically, the following is a summary of what can be seen at various stages of development of the chick embryo.

Day 1

After one day of incubation the blastoderm will be seen as being whitish and saucer-shaped. The outer area opaca and the centre area pellucida which is raised from the yolk surface by the segmentation cavity, can be seen as a darker ring. Within the area opaca, blood islands will be formed resulting in the area vasculosa.



Embryonic development day 1 and day 2

Day 2

After two days of incubation the primitive streak will be visible. This is seen as an elongated darker line in the centre of the blastoderm from which the chick will develop. Fine red lines on the yolk sac are the start of the circulatory system. The yolk sac plays a key role in the nutrition of the developing embryo. Together with the amniotic sac and the allantois, they are collectively called the extra embryonic membranes.

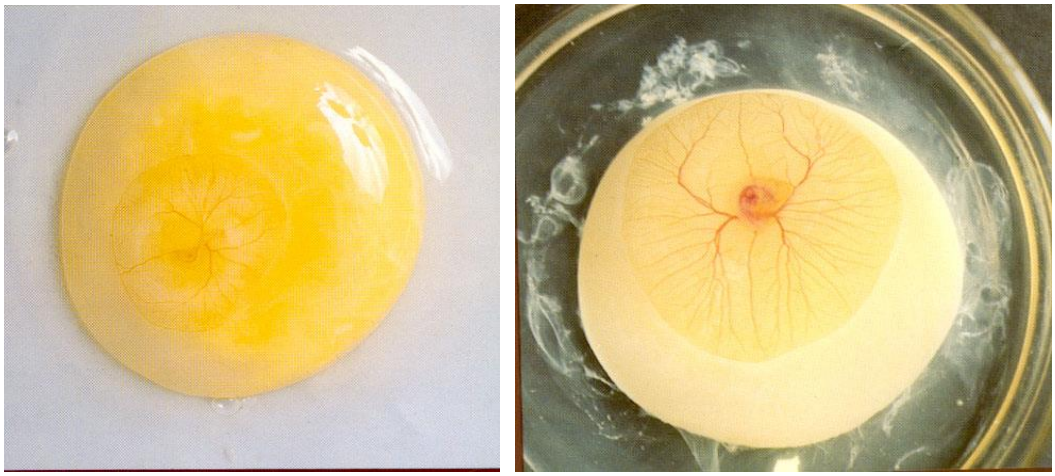
Day 3

After three days of incubation the heart will be visible along with further development of the blood system that will carry nutrients to the developing embryo. The embryo has completed turning onto its left side. The tail bud has formed and primary division of the brain is evident as a transparent bubble on the left side of the embryo. The amnion covers the entire embryo

and is filled with amniotic fluid which protects the embryo from shock and allows the embryo to move.

Day 4

During the fourth day the brain divides into three parts - the forebrain, the midbrain and the hindbrain and can be seen at the top. One of the eyes will be visible from the top as a dark spot. The heart has enlarged and the vascular system of the yolk sac membrane shows up very well as it increases over the yolk area.



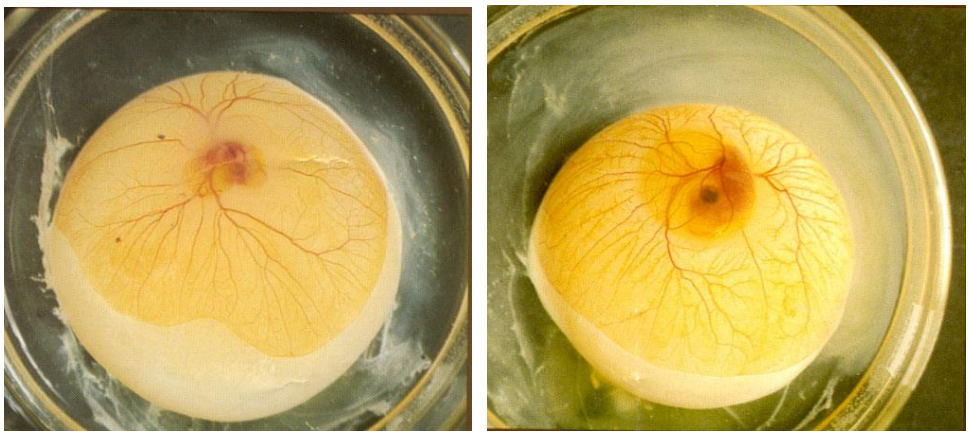
Embryonic development day 3 and day 4

Day 5

During the 5th day the embryo shows a marked increase in size. Elbows and knees (limb buds) start to be visible and the head and knee area move towards one another causing the embryo to take the shape of a letter C. The allantois (seen here as the darker fluid around the embryo) covers approximately one third of the embryo and acts as a container for excretory waste. The complete four chamber heart will be present.

Day 6

The shape of the embryo is becoming typical that of a bird. The thoracic cavity is starting to envelope the enlarged heart and the brain and eyes are very prominent. The maximilla and mandible of the beak are also prominent. Rhythmic amniotic contraction is evident. The amnion and allantois are very clearly defined and the yolk sac covers well over 50% of the yolk.



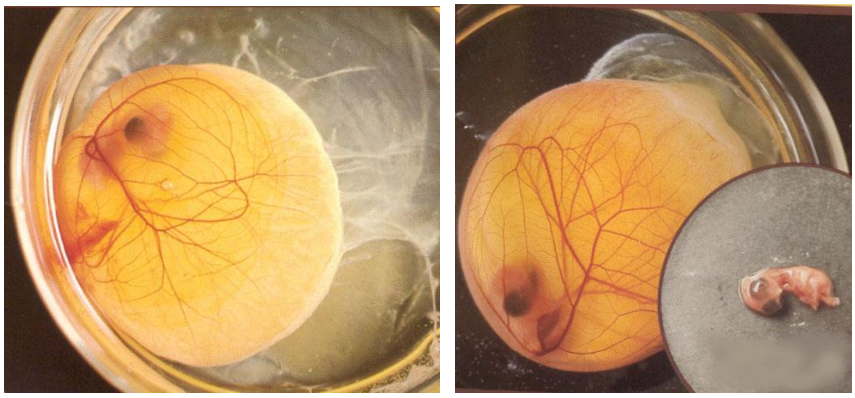
Embryonic development day 5 and day 6

Day 7

The beak is forming as a dark spot at the bottom of the head and the egg tooth is evident at the end of the maxilla. The embryo will also respond to touch. The neck starts to separate the head from the thorax. The heart will be completely enclosed and the yolk sac surrounds the yolk almost completely.

Day 8

If the embryo is removed, the upper and lower beak will be clearly distinguishable. The neck is longer and wings and legs will be clearly defined. The brain is completely enclosed.



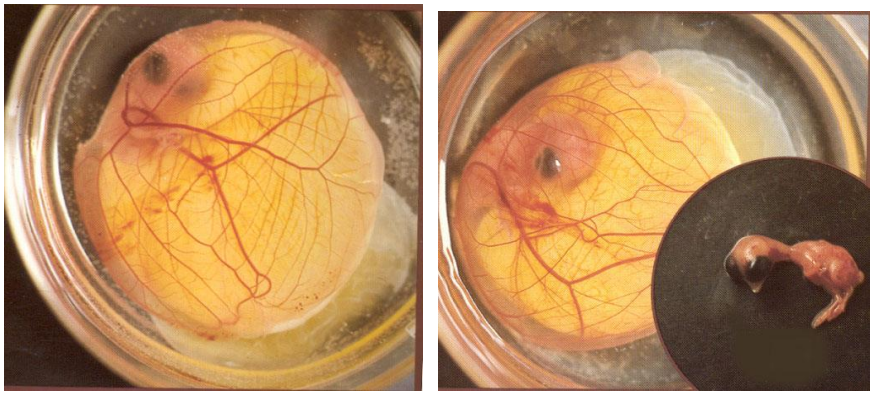
Embryonic development day 7 and day 8

Day 9

By the ninth day the yolk sac has enveloped the yolk area and it becomes increasingly folded and vascular in appearance. The transparent allantois is enlarging. Toe digits will now be noticeable if the embryo is removed.

Day 10

If the embryo is removed, a clear distinction can be seen between wing and feet digits and the egg tooth also becomes more visible. Flight feather follicles will be conspicuous along the margin of the wings.



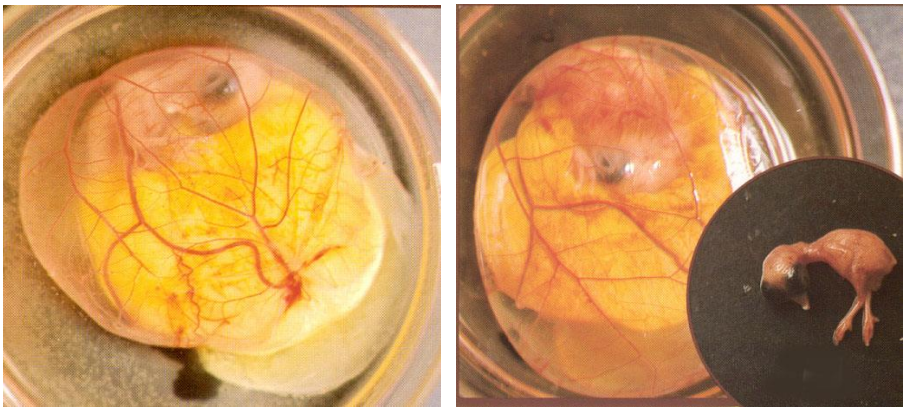
Embryonic development day 9 and day 10

Day 11

At this point the embryo will be looking like a chick. Feathers become evident and tail feathers become prominent. The embryo is able to move independent of the amnion. The chorion and allantois membrane have fused with the eggshell membrane and the allantois is at maximum size.

Day 12

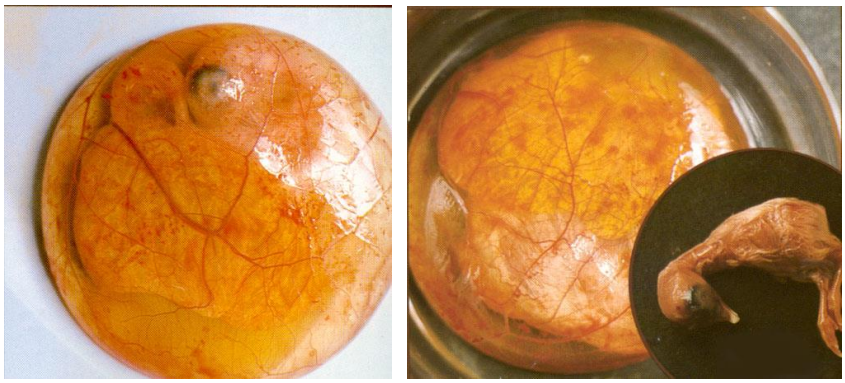
Toes will be clearly defined and the embryo will be sinking deep into the yolk material due to its weight. Down feathers will also begin to appear. The amniotic connection opens and the embryo begins to swallow albumen. White uric acid precipitates may be noticed within the allantoic sac as the pH decreases.



Embryonic development day 11 and day 12

Day 13
The only noticeable external changes seen will be in the growth of down and production of feathers. Toenails and leg scales are more noticeable.

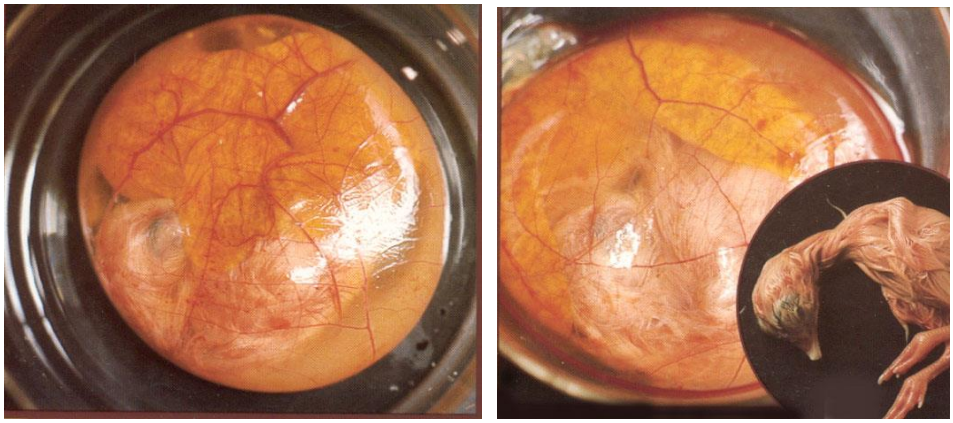
Day 14
Feather growth is rapid and down feathers will almost cover the entire body. The embryo will be orientated along the long axis of the eggshell and beak clapping movements may be observed.



Embryonic development day 13 and day14

Day 15
Other than a fairly rapid increase in size at this point there is very little other evidence of change. The head starts to move toward its shell-pipping position under the right wing. This is the normal embryonic position for breaking the shell. The yolk has become thick and dense and has decreased in size.

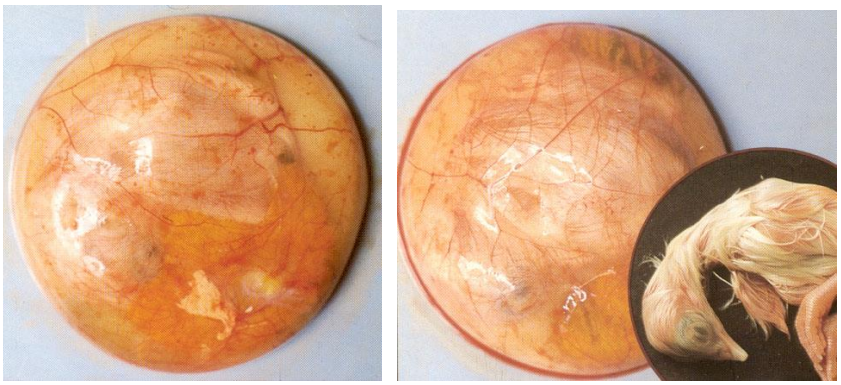
Day 16
The yolk sac will be positioned ventrally in front of the embryo and becomes the important source of nutrients as the albumen has been absorbed almost completely. The beak will be tucked under the right wing.



Embryonic development day 15 and day 16

Day 17
Some white urate waste material can be seen in the allantois fluid. The air cell is enlarged and in the proper incubation position, it should be above the chick. The beak which is under the right wing will be pointing towards the air cell. The albumen will have been almost completely utilized and some yolk sac contraction may be observed.

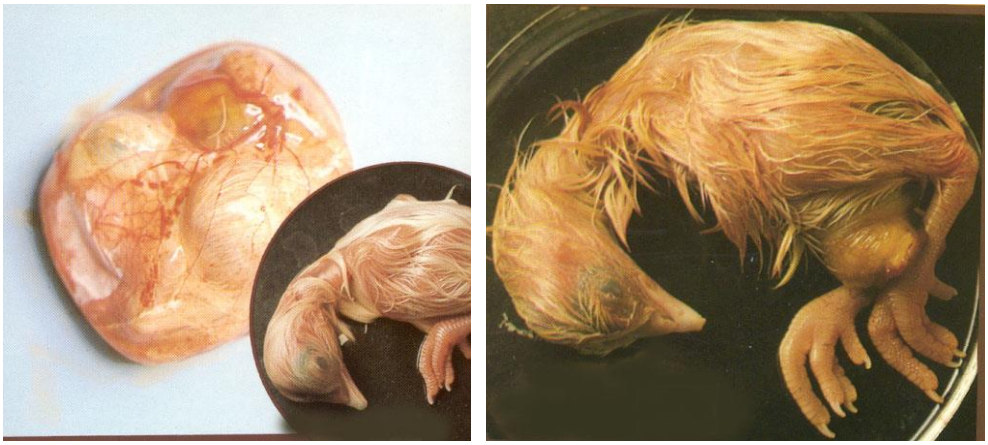
Day 18
During day 18 the chick will start preparing to hatch. The yolk sac has started to be incorporated into the abdominal cavity. This is the stage during which the eggs are transferred to the hatcher baskets.



Embryonic development day 17 and day 18

Day 19
On day 19 the beak pierces through the inner shell membrane into the greatly enlarged air sack (internal pipping) and the embryo starts with pulmonary respiration. The yolk is almost entirely absorbed into the abdominal cavity and the allantoic fluid is completely reabsorbed.

Day 20
The yolk is completely absorbed into the abdominal cavity but the naval will not have healed completely. The allantois is drying up and allantoic circulation and respiration ceases as pulmonary respiration has taken over and the chick is utilizing the yolk material absorbed into the abdominal cavity. External pipping starts with the chick using its wings to move in a circular fashion around in the egg, breaking the shell from the inside.



Embryonic development day 19 and day 20

Day 21

The chick will immerge from the shell and dry and fluff out for take-off 21 days plus 6 to 12 hours after setting.

4 Chick Incubation

The incubation of chicken eggs comprises the process of storage of eggs destined for incubation, preparation of such eggs for incubation and the incubation process itself.

The actual process of incubation is complicated and there are many factors that will affect the process and eventual hatch results and chick quality. To a large extent the optimum incubation temperature, humidity and air supply requirements have been well documented but in many instances hatch results and chick quality often remain poor.

It is necessary to distinguish between poor hatching performance as a result of farm related problems, egg storage and transport conditions and those factors that can be ascribed to the hatchery and incubation conditions.

A good record and analytical system is required on an ongoing basis to analyse the causes of varying hatch results and chick quality. It is also advisable to do the analyses regularly to ensure that when any abnormal results do emerge, a historical picture is available to which the abnormal results can be compared.

4.1 Hatching Eggs

Hatching eggs should at all times be sourced from a reliable source to ensure good disease control measures and supply of eggs of known quality.

Prior to incubation various aspects will impact on hatch results and chick quality and include transportation of hatching, egg size, shell quality, shell contamination and egg age.

4.1.1 Transportation of Hatching Eggs

Ideally the temperature of the vehicle transporting hatching eggs should be controlled to the temperatures at which the eggs have been stored to eliminate possible condensation of moisture on the shell, commonly referred to as "sweating" of eggs. Condensation of moisture on the egg shell will occur when the air immediately around the egg is cooled due to the colder temperature of the shell, causing the moisture in the air to condense at this lower temperature commonly referred to as the dew point. The dew point is the temperature at which the water vapour in the air condenses into liquid.

The excessive moisture will in turn enhance bacterial growth and should be avoided.

Eggs destined for hatcheries are transported on either plastic or pulp egg trays on farm trolleys or direct in the setter trays on trolleys. When transporting eggs over distances, it is advisable to place the eggs on pulp egg trays in carton containers for added protection.

Moisture condensation on the shell

Hatching eggs should at all times be handled as gently as possible and allowed to settle for a couple of hours after transport prior to setting. When handled properly there is little evidence to indicate that transportation of hatching eggs over large distances is harmful.

On farm traying of hatching eggs onto setter trays is often practised to save labour costs as the eggs are then not re-handled at the hatchery. On farm traying does however pose a potential biosecurity risk when setter trays are not properly cleaned and disinfected prior to being moved back from the hatchery to the farm.

When pulp trays are used it is advisable that they be used once only and not returned to the breeder farms. Fumigation of pulp trays is not effective in disposing of pathogens and micro-organisms.

When transporting eggs it should always be done with the round ends up and sharp end to the bottom. Transporting eggs with small ends up could result in damage to the chalazae which hold the yolk to the centre of the egg and the blastodisc could then move into an incorrect position in the egg, which in turn will result in the chick hatching in an incorrect position.

4.1.2 Egg Size

Chick size is related to egg size as well as the incubation temperature and relative humidity of the air during incubation. Whilst aspects such as nutrition, environmental temperatures, breed, etc. influence egg size within a given set of circumstances, flock age has the major influence on egg size and hence size of the chick. Extremely large and small eggs should not be set. Small eggs will produce small chicks which will be of poor quality and more difficult to rear. Very large eggs will have the tendency to break in the setter trays and could in fact be double yolk eggs. Large egg size is a particular problem with some meat type breeds that produce excessive number large eggs towards the end of the production cycle, especially under poor management conditions.

As a rule of thumb the chick mass will be 66 to 67% of the initial egg mass at setting. This does depend on the initial egg size as chick size of a 52 g egg is roughly 66.5% of egg mass and 67.5% of a 60 gram egg under normal hatching conditions. A 52 g hatching egg should therefore produce a 34.5 g chick under normal and ideal hatching conditions. The minimum weight for broiler hatching eggs is generally 52 g.

In layer strains chick size may be of less importance, especially in integrated operations where higher chick mortality experienced with chicks hatched from small eggs is justified by improved utilization of hatchable eggs. Most modern rearing farms use battery cage systems where small groups of chicks are housed (17 to 40 per cage) and if separated from larger chicks, the chicks from such small hatching eggs or young parent flocks may be tended to with more care. A lower limit of 50 g egg size producing a 32.5 g chick is normally accepted for layer strains.

Normally eggs will be saved for hatching purposes two to three weeks after commencement of production which will be 25 to 26 weeks of age for broiler parents and 23 to 24 weeks of age for commercial egg laying parents. Breeds will however differ in this respect and it is best to seek the input of the supplier of such stock.

4.1.3 Egg Shell Quality

Many eggs have shell imperfections, some of which are inherited and such eggs should therefore not be set as hatching eggs, especially in commercial egg layer production. Most eggs with shell imperfections are poor in shell quality causing eggs to break easily during transportation and incubation or to lose excessive moisture during the incubation process.

These imperfections would include:

- Misshapen eggs
- Round eggs
- Wrinkled eggs
- Rough shells
- Banded eggs
- Thin shells

Cracked eggs may be seen as:

- Open toe cracks
- Impact cracks
- Hairline cracks

4.1.4 Shell Contamination

Soiled eggs are a major source of microbial contamination and should not be used for hatching purposes. Even when washed under good conditions they pose a potential risk of microbial contamination into the hatchery. Dirty eggs should preferably be removed during the collection and selection process on the farm and should not be stored in the same room as eggs intended to be used for hatching purpose.

It is also advisable that floor eggs not be used for hatching. There is uncertainty as to how long such eggs have been lying on the breeder house floor and litter is generally contaminated very highly with microbes.

Should it be required that soiled and floor eggs be used for hatching purposes they must be washed by proper egg washing machines. The wash water and rinse water temperatures must be properly controlled to reduce the risk of microbial contamination on the surface being drawn into the egg via the porous shell. Water temperature should be 10 °C higher than egg temperature and rinse water 2 to 3 °C higher than the wash water. Washed and floor eggs when used, should preferably be placed in separate machines.

4.1.5 Egg Age

Due to scheduling of hatches, especially in commercial layer chick and parent chick hatcheries, where the weekly production could be erratic, eggs may be held over for longer than ideal periods of time to fit the setting requirements. The conditions under which eggs are held will affect hatching results.

Hatching eggs held under optimum conditions for less than 5 days show very little deterioration in hatchability. As a rule of thumb hatching time will be delayed by 30 minutes and hatchability reduced by 1 to 2% for every day that eggs are stored for more than 5 days. The rate of deterioration is less between 5 and 10 days but could accelerate to 3 to 4% for every day after 10 days of storage.

4.2 Hatching Egg Storage

Hatching eggs will normally be a couple of days old by the time they reach the hatchery. In addition, hatching schedules may required eggs to be stored for longer periods to enable egg

availability to match chick requirement. Conditions in which eggs are held prior the incubation will impact on hatching performance.

4.2.1 Egg Holding Room Temperature

Although the incubation temperatures of chicken eggs is in the order of 37.5°C the embryo will show development at temperatures above 24°C, generally referred to as the embryonic threshold. At lower temperatures embryonic development will cease. The embryo will tolerate temperature fluctuations above and below this point before it dies, but every time the temperature goes beyond this point the embryo is weakened and its chance of hatching is reduced. Eggs are therefore to be held at even an temperature.

Eggs are stored below this threshold of 24°C and if for a short period (5 to 7 days prior to setting) then temperatures of 17 to 18°C are common. It is also preferable to have the farm egg storage temperature a degree or two above the hatchery storage temperature to ensure a declining egg temperature from the farm to hatchery with the transport temperature in between.

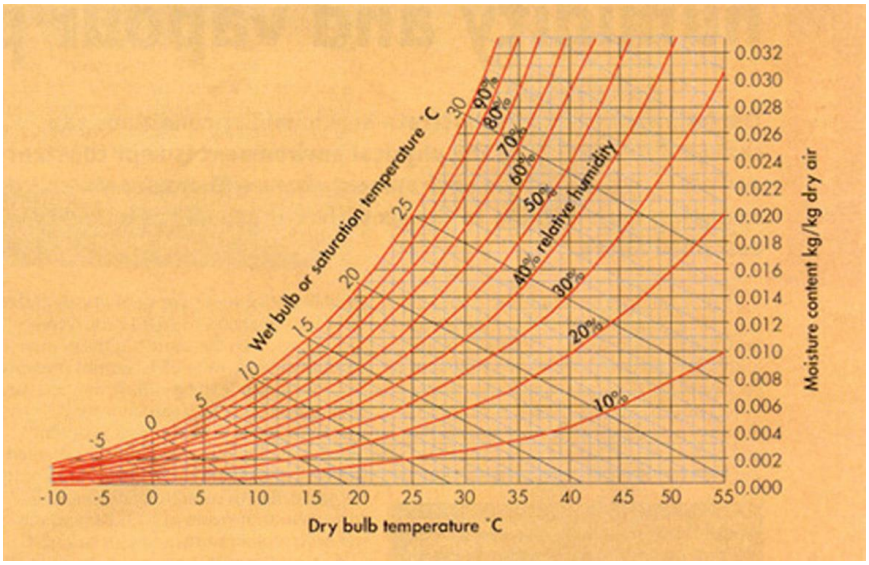
When eggs are to be stored for periods in excess of 10 days then colder temperatures may be used (12 to 15°C). In parent hatcheries this is often the case and a second cold room being kept at a lower temperature would be beneficial.

The internal egg temperature of 18°C will be reached in roughly 20 to 24 hours after being laid and placed at a room temperature of 18°C on setter trays on trolleys. When placed in boxes it will take much longer (up to 4 days). It is important to allow hatching eggs to cool down before placing them in corrugated boxes for shipment.

4.2.2 Egg Holding Room Humidity

The moisture content in the egg is continuously being lost to the environment through the porous shell. A high relative humidity in the air will reduce the rate of loss and when humidity is low the rate of loss is increased due to a higher rate of vaporization.

The relative humidity of 70 to 75 % is commonly used in egg holding rooms and this is measured by reading the wet-bulb and dry-bulb temperatures and reading the relative humidity from a chart. Higher relative humidity will not harm eggs but will result in any fibrous egg-cartons becoming soft. High relative humidity would also enhance mould growth.



The Psychrometrics and the relationship between dry bulb temperature, wet bulb temperature and the moisture content of air may be illustrated in the Psychrometric Chart above.

In order to understand what is meant by relative humidity, it is important to understand the relationship between temperature and the amount of moisture in the air.

At a dry bulb temperature of 16 to 18 °C (read on the bottom axis of the chart) the wet bulb temperature should be in the order of 14 to 15 °C (diagonal lines and read on the top red slanting axis) for the relative humidity to be 70% (red slanting lines). Good management of an egg holding room would consist of regular checks of the daily maximum and minimum dry bulb temperature as well as the wet bulb temperature reading or reading the relative humidity.

4.2.3 Moisture Condensation on Shell Surface

"Sweating" of eggs occurs when the air immediately around the shell is cooled due to the colder temperature of the shell causing the moisture in the air to condense at this lower temperature. "Sweating" of eggs will enhance bacterial growth and should be avoided. Should condensation of moisture on the shell surfaces be noticed then it is advisable to increase the holding temperatures slightly or reduce the holding room relative humidity or ensure good air movement over the eggs to ensure that the air temperature immediately surrounding the egg does not cool down to the point of condensation. For this reason egg transport trucks should also be cooled down to the egg storage temperature and cooled eggs not be allowed to stand around in passages during transfer. The danger of moisture condensation and the shell is also of importance when fumigating cold eggs.

4.2.4 Positioning and Turning of Hatching Eggs during Storage

Eggs are to be stored rounded ends up as this is the position in which they are to be placed in the setter machines. The rounded end is the end in which the air cell of the egg is situated and if incubation occurs with sharp ends up, there will be a tendency for the chicks to hatch in the wrong position. Chicks hatching in the wrong position will not be able to start with pulmonary respiration prior to pipping.

When eggs are to be stored for a long period of time, there is evidence that storing them with sharp ends up will assist in reducing the decline in hatchability caused by the long storage time. When such eggs are stored in closed cartons the loss of moisture from the eggs will be further reduced and hence hatching results improved. It is necessary to revert back to the normal setting position of rounded ends towards the top at least 6 hours prior to setting.

Turning of eggs through 90° similar to what occurs in the setter machines has also been shown to assist in the negative effect of storage time on hatching results.

4.2.5 Pre-storage Incubation

Pre-storage incubation is a practice whereby the initial development of the embryo is in a controlled manner, taken beyond the cell divisions that have occurred while the egg was passing through the hen's body. The controlled development of the germinal disc to an estimated 80,000 cells, results in an embryo that is less susceptible to cell death occurring during the storage period.

In practice this is achieved by controlled heating of the eggs for 3 to 6 hours at a temperature of 37.7 °C. The eggs need to be fresh (< 4 days) and the heat-up time would depend on the time the incubator takes to heat the set eggs to 37.7 °C. If it takes longer than 6 hours for the

incubator to heat the eggs to normal incubation temperature, the time that eggs are kept at 37.7 °C in the pre-incubation process should be reduced.

Pre-incubation will not improve hatch results but could be a consideration to assist in maintaining hatch results which deteriorate with longer storage time.

4.2.6 Pre-heating and fumigation of hatching eggs

When eggs are set direct from the cold holding room some setters may not be able to cope with the heating that is required. This will result in a prolonged time for the newly set eggs to reach incubation temperature (delay in hatching time) and it also lowers the hatchability of eggs already in multi stage machines as the temperature of these eggs will decline, resulting in embryonic death.

The warming process of the eggs at temperatures of 24 to 26 °C will be 4 to 6 hours if eggs have been kept at normal storage temperatures of 16 to 18 °C.

When pre-heating of eggs is considered it should be done in properly designed pre-heating chambers. By simply transferring eggs into hatchery lobbies more damage could be done. The eggs will not heat up uniformly because eggs to the centre will take longer to reach lobby temperature compared to eggs on the outside of the trolley. This will result in uneven hatching. Poor air movement over the eggs will also result in the tendency for moisture to condense on the cold egg surface. Should no pre-heating chamber be available, large movable fans placed between trolleys could assist in increasing the air movement over the eggs placed in the hatchery lobbies prior to transferring the eggs into the machines. It is however also to be noted that such large volumes of cold eggs in the setter lobby will affect the lobby temperature and consequently the machine temperatures.

A well constructed pre-heating chamber should be capable of maintaining a temperature of 25 to 26 °C at a relative humidity of 50 to 55 % with very good air movement over the eggs, very much the same way in which air is moved over the eggs in the setter machines. The eggs should be uniformly heated to 25 to 26 °C within a period of 6 hours.

In some instances condensation of moisture on the shell surface may occur when eggs are moved from the egg holding room. This should however not pose a problem if the eggs are moved into the fumigation room and air circulating fans switched on immediately. Rapid movement of air over the eggs will assist in moving the moist air away from the eggs and hence reducing the risk of condensation of moisture on the cold shell surface of the eggs.

The pre-heating room may then also be used to fumigate the eggs prior to setting. Effective fumigation of hatching eggs is a proven means of reducing the burden of shell bacteria. It will help to ensure that eggs do not contaminate the hatchery with potential pathogens such as Salmonellae. Although eggs may have been sanitized at the farm they may have become re-contaminated, especially after longer periods of storage and it is advantageous to sanitize the eggs prior to setting.

For effective fumigation the following concentrations are commonly used:

- 45 ml of 40% formalin and 30 g of potassium permanganate per cubic meter of fumigation chamber. Water is produced during this reaction and provision of extra moisture is therefore not necessary.
- Heating 10 g of paraformaldehyde per cubic meter of room area in a pan, assuming the prills are 91 % paraformaldehyde. Some moisture should be provided, the addition of a few millilitres water to the evaporator is satisfactory.

Note that fumigation should only be done once the chamber temperature has reached 26 °C. The fumigant should be allowed to be circulated over all the eggs for 20 minutes in the chamber before being extracted via an exhaust fan. It is important to ensure that all of the fumigant has removed before setting of the eggs in the machine. In multi-stage machines especially the embryos that were set in the previous setting will be very susceptible to be killed by the fumigant if carried into the machine. Having removed all fumigant the eggs are then allowed to remain in the chamber for up to 6 hours for pre-heating before being set.

In single stage setters the process of pre-heating and fumigation is carried out in the cabinet.

4.3 Incubation Process

The process of chick incubation in essence requires the correct embryonic temperature to be maintained at the correct relative humidity, supplying the correct amount of fresh air and ensuring that eggs are turned through 90° during especially the initial stage of embryonic development.

4.3.1 Temperature Requirement

Embryonic growth may be divided into three phases in respect of temperature:

- When the embryo is still in the hens body cell divisions take place during the first 23 hours prior to the egg being laid. This temperature is at 41.5 °C or body temperature (106 °F)
- During the first 18 to 19 days of incubation where in most forced draught multi-stage machines the required incubation temperature is 37.2 to 37.6 °C (98.9 to 99.7 °F).
- During the last 2 to 3 days where in most machines the incubation temperature is lowered to around 36.8 °C (98.3 °F)

Many modern machines operate with Fahrenheit thermometer control since the larger Fahrenheit scale gives finer adjustment to incubation temperature.

The optimum incubation temperature will differ between machines and each manufacturer has established temperatures best for particular circumstances. When temperatures deviate from the optimum, hatchability and chick quality are affected. High incubation temperatures would shorten the incubation period and low incubation temperature will lengthen the period of incubation. Temperatures above and below the optimum will also influence chick quality.

The normal incubation time from setting to chick take off should be around 21 days and 6 hours from setting (excluding pre-heating time). Standard control temperatures of 37.5 to 37.6 °C (99.5 to 99.7 °F) in a multi-stage setter may be too high for modern broiler breeds. These temperatures could force the modern high yielding embryo to develop more rapidly than required resulting in an increased number of small pale chicks with short down and black navel buttons. Lowering the setter temperatures by as little as 0.1 to 0.2 degree could solve this problem.

The following factors influence optimum incubation temperatures:

- Size of the egg
- Shell quality
- Strain of bird
- Humidity of the air

- Age of the Embryo

The air temperature in the incubator cabinet is only an indirect measure of knowing what the egg (embryo) temperature is. Air velocity and humidity around the egg will also influence the heat exchange between the air and the egg and hence the embryo temperature.

It is advisable to know what the actual egg (embryo) temperature is as the norm is to ensure that embryo temperature remains within the narrow limits of 37.5 to 38.0 °C (99.5 to 100.5 °F). Adjustment to machine settings should only be based on knowledge of the egg temperatures.

Temperatures of eggs within the cabinet may vary a great deal and a wide spread of temperatures should be taken in establishing the mean egg temperature within the cabinet. Hand held infra red digital thermometers sold by chemists may be used for this as they enable egg temperatures to be taken without having to break the shell. In multi-stage setters a compromise must be found to suite all eggs from day 1 to 19 of incubation. In single stage setters, the incubation temperatures may be reduced as the incubation time progresses, thereby maintaining egg temperatures as close as possible to the ideal of 37.5 to 38.6 °C (99.5 to 101.5 °F). In these machines the initial temperature would be in the order of 37.75 °C (100 °F) to ensure an egg temperature of 37.75 °C (100 °F). The machine temperature is then gradually reduced in line with the developing embryo and the consequent increase in heat output by the embryo itself in such a manner that the egg temperature remains as close as possible to the ideal of 37.75 °C (100 °F).

4.3.2 Relative Humidity Requirement

For the embryo to develop at the required rate the egg contents (water) must be evaporated at the desired rate. Should the egg be allowed to dry out too rapidly, the chicks will be smaller and should this be too slow, the chicks will be larger. In both instances chicks are weaker and of reduced quality. In order to regulate the rate of moisture loss from the egg, the humidity is to be controlled together with the incubation temperatures.

The measurement of humidity is done by temperature recording of wet- and dry-bulb thermometer readings. The dry bulb records the normally known temperature of the air. The wet-bulb thermometer is a normal thermometer to which a wet water-wick has been added. The water from the wet-wick evaporates to the surrounding air and as a result of this evaporation the temperature of the wick (and hence the thermometer) is reduced measuring a lower temperature than of the normal thermometer. The drier the air, the more water can be evaporated and vice versa. The temperature of the air therefore determines the amount of

moisture the air will hold, increasing as temperature increases and decreasing as the temperature decreases. A graphic relationship between dry-bulb and wet-bulb temperatures, moisture content and relative humidity as well at heat content of the air is known as the Psychrometric Chart.

The importance of relative humidity is to ensure the correct rate of loss of water from the egg. Depending on the type of machine these limits are between 50 to 60 % but it is advisable to experiment under local conditions to find the optimum.

Generally excessive relative humidity during the first 19 days will cause chicks to hatch later than normal and they will be larger and soft in the abdomen. Too little humidity will shorten the incubation period and chicks will be smaller and show signs of dehydration.

Large eggs have less shell aria per unit of egg mass than do small eggs. As evaporation of moisture depends mainly on the shell area, smaller eggs will lose a greater proportion of their mass than will larger eggs at given relative humidity. Furthermore smaller eggs will produce smaller chicks and chicks from such eggs have a double disadvantage in respect of producing smaller chicks. The reverse is true for larger eggs producing larger chicks as a result of egg size per se as well as the result of lower moisture evaporation.

An egg with a mass of 56-57 g should lose in the order of 12% of weight through evaporation during incubation to 19 days. Eggs vary in mass and the ideal relative humidity should be adjusted to suite the majority of eggs in the machine.

Older flocks have a greater egg mass and usually shell quality deteriorates with age. The relative humidity for eggs from older flocks therefore has to be adjusted in the setter to ensure the correct moisture loss. The same may apply to modern layer breeds with very good shell quality. A balance needs to be found between moisture loss and heat transfer to and from the egg.

The chicken, be it in the shell or out of the shell cannot withstand conditions of high temperatures and relative humidity. During the last two days of incubation, when the eggs spend time in the hatcher, the relative humidity has to be increased but only within certain limits. Correct moisture will prevent the beak of the chick from sticking to the newly pipped shell and allows freer movement of the chick's head at the time of pipping. The relative humidity in the hatcher is therefore increased compared to that of the setter. A temperature reduction of 0.3 to 1.0 °C (0.5 to 2.0 °F) is necessary at the same time and it must be remembered that this temperature reduction will automatically result in an increase in relative humidity as colder air holds less moisture. A temperature reduction of 0.6 °C at this point will increase the relative humidity by 2.5%.

There is also a natural increase in relative humidity once chicks emerge from the egg and begin to dry. No fixed guide is possible as each circumstance will require particular setting for best results.

4.3.3 Air Supply Requirement

The more important components of air with respect to incubation are oxygen, carbon dioxide and water vapour. At sea level, approximately 21% of the air is oxygen and it is generally impossible to increase this other than the introduction of oxygen.

As the embryo advances in age its oxygen requirement increases and more carbon dioxide is produced. By the 18th day of incubation, 1000 eggs will require 4.1 m^3 of fresh air per 24 hours at sea level. A 90000 capacity machine will therefore require 369 m^3 of fresh air per day or 15.3 m^3 per hour. During the initial stages of embryonic development far less air

volume is required. Single stage machines are set to introduce increased volumes of air as the incubation process advances while multi-stage machines are set at a level which is a compromise between the requirement of older and embryos at the early stages of development.

It should be noted that with most machines, opening and closing of air inlet dampers (allowing more or less air into the cabinet) serves as the first stage of temperature correction.

Carbon dioxide levels of 0.3% during the first 4 days will be tolerated and this increases linearly with age and a upper maximum level of 0.75% in the hatcher is advisable. In fact many single stage setter programs will introduce no fresh air for the first couple of days to ensure a uniform cabinet temperature.

Ventilation and fans within the machine cabinet has two important components:

- Controlling and distributing the fresh air introduced into the machine to provide sufficient oxygen and dispose of carbon dioxide and moisture
- Maintain proper internal circulation of air to prevent uneven temperatures and concentration of gas and moisture around the eggs.

This is normally achieved by the fans circulating the air over the eggs within the cabinet and a damper system controlling the volume of fresh air flow into and exhaust air from the machine.

Several factors may impact on machine ventilation resulting in decrease hatch results and chick quality.

- Inlet and exhaust openings not functioning or balanced properly
- Obstruction of inlet and exhaust ducts
- Cold winter conditions causing decreased airflow into lobbies
- Excessive humidity in summer
- Loose fitting gaskets and seals resulting in temperature loss
- Incorrect fan motors and fan blades
- Dirty fan blades
- Lobbies excessively pressurized on intake side
- Excessive negative pressure on exhaust systems

4.3.4 Hatching at Altitude

As altitude increase air becomes less dense thereby containing less oxygen per unit of volume. The effect of altitude on hatchability is curvilinear causing limited effects up to 700 to 1000 meter above sea level. This negative effect however accelerates as altitude increases above 1000 meter.

Increasing the air pressure on the machines may be used to correct the negative effects of high altitude on hatchability. The incubator room however has to be air tight to enable the increased air pressure to be maintained.

It has also been shown that by increasing the level of oxygen in the setter and hatchers to 23 to 23.5% will assist in improving hatch results at altitude. The oxygen is introduced by a tube from oxygen supply cylinders and the level of oxygen needs to be monitored regularly to

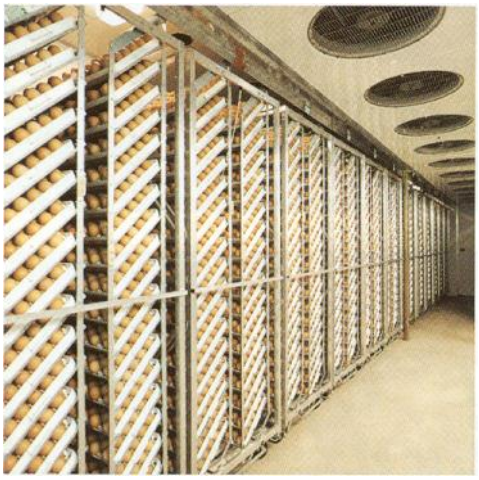
adjust for the changing ventilation and embryo needs. This is however costly and not practiced under normal circumstances.

Research has shown that eggs produced at altitude hatch better at altitude compared to eggs produced at sea level and hatched at altitude. Eggs produced at altitude and hatched at sea level will hatch at the same rate as eggs produced at sea level and hatched at sea level.

4.3.5 Turning

The yolk of the newly laid egg has a specific gravity that causes it to settle in the thin albumen. Once the embryo starts to develop, the specific gravity reduces and the yolk in a stationary position will rise to come into contact with the outer thick albumen resulting in embryonic death.

For this reason eggs are turned through 90 degrees (45 degrees to either side). It is important to ensure that turning at least achieves 40° as it has been proven that less will affect hatch results.



Eggs turned in the setter

Under normal circumstances it is sufficient to turn eggs 6 times per day and most machines provide for turning the eggs automatically every 1 to 3 hours. Turning is most important during the first week, less important during the second and there is no need to turn eggs during the third week of incubation.

4.3.6 Egg Transfer to Hatchers

Eggs are to be transferred from the setter to the hatcher after 17 to 19 days of incubation. This process should be done as gently and as quickly as possible and is generally referred as “tray-over”.

This process can be done manually by placing the hatcher basket over the setter tray and two people then turning the setter tray and hatcher basket together. The hatcher basket ends up below with the eggs in it and the setter tray on top for it to be removed and placed back into the setter trolley. This process must be carried out as gently as possible.

Manual transfer on the left and a small transfer machine on the right

Transfer machines are available and these machines can be either semi-automatic or fully automated. The semi-automated machine will lift the eggs from the setter tray by vacuum suction cups, allowing the setter tray to be removed and replaced by a hatcher basket into which the eggs are then gently placed. The placing and removal of setter trays and hatcher baskets is done manually. With fully automated machines the feeding and removal of setter trays and hatcher baskets is fully automated requiring very little labour.

Although smaller transfer machines may not save labour, the process is done much more gently and pneumatic tray over will reduce the percentage of cracked eggs, resulting in improved hatch results.

4.4 Candling of eggs at transfer

Candling is the process of placing eggs over a bright light. Eggs with no embryonic development (infertile and early death) will show much lighter than eggs with embryonic development.

This can be done manually by placing the setter tray over lights to identify and remove eggs showing no embryonic development at transfer. Some transfer machines are equipped with automatic candling allowing for clear eggs to be removed.

The advantage of candling eggs at transfer (removal of clear eggs) includes:

- Clear eggs are usually the eggs that will be contaminated and inclined to explode, resulting in the rest of the chicks and eggs being smeared with egg content
- Due to removal of 5 to 7 % of the egg mass, there will be fewer eggs to keep warm
- Hatcher space could be utilized more effectively if the trouble is taken to replace the clear eggs removed with eggs showing embryo development

4.5 Analyses of Hatch Results

There are various factors that will influence hatchability but first it is important to know what is meant by hatchability. Hatchability may be measured in two ways:

- The number of chicks hatched as a percentage of all eggs set, or
- The number of chicks hatched as a percentage of fertile eggs.

Example of various performance measures in a hatchery may include:

Infertility % = (Number of infertile eggs ÷ Total number of eggs or sample) x 100

Hatchability % of all eggs = Number of chicks hatched ÷ Number of eggs set x 100

Hatch % of fertile eggs = (Number of chicks hatched ÷ (Number of eggs set – number of infertile eggs)) x 100

Pullet yield % = (Number of 1st grade pullet chicks ÷ Total number of chicks) x 100

Second grade chick % = (Number of non saleable chicks ÷ Total number of chick) x 100

4.5.1 Determination of Fertility and Embryo Mortality

When hatchability is expressed as a percentage of fertile eggs then the number of infertile eggs must be known. It is difficult to distinguish between infertile eggs and early embryonic death, especially after 21 days of incubation. Candling of eggs after a couple of days of incubation (often done at transfer to hatcher trays) is a crude yet practical and quick way of determining the incidence of non-fertile eggs. So called "clear eggs" detected via the process of candling does however not distinguish between infertile eggs and early embryonic death. The only true way of determining infertility is to break open eggs and visually observe whether the egg is fertile or not.

4.5.1.1 Fresh Egg Breakout

It is possible to distinguish between fertile and infertile eggs prior to placement in the incubators. It does however require practise. The egg must be broken out on a white plate or flat surface and the germinal disc found. This is often the more difficult part as the germinal disc could be under the broken out yolk and often some would prefer to break the egg into the hand and by rotation of the egg content in the hands, find the germinal disc.

Prior to hatching, a fertile egg will show a large germinal disk with a light centre and a thick, white perimeter. It appears like a doughnut, with the thick, white circle around the outer perimeter of the disc. An infertile egg will show a small germinal disk with a solid, bright white centre, which may or may not be in the centre. The white centre of the infertile egg is much brighter than the white centre of the fertile egg. The germinal disk could also be large but the centre will be solid and bright and the perimeter will be irregular.

Fresh egg breakout has the advantage that it is the quickest way of determining fertility but it does have the disadvantage that it is a slow process and valuable eggs have to be broken. It is however a good practice at the start of a new flock to know in advance what the fertility would be like as well as when disease and fertility problems are being encountered. Fertility can be determined on the day that the egg is laid rather than having to wait for 4 weeks until final hatching.

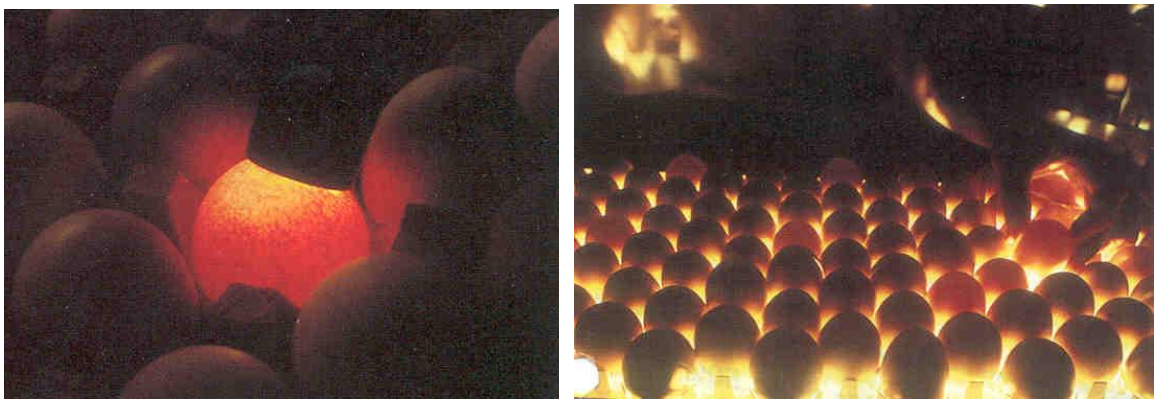
Because of the value of hatching eggs, sample size of 100 eggs should suffice but results could be variable as a result of the small sample size. This practice is generally only followed when specific problems are being investigated.

4.5.1.2 Candling Breakout

Breaking out candled eggs offers accuracy in terms of determining fertility and it is useful in determining other sources of breeder flock or hatchery failures such as cracked eggs, eggs set upside down and early death of embryos. Although candling can be done as early as five days of incubation, generally the best earliest age to perform candling is at 10 days. Very few errors will occur when performed at this stage of incubation.

The fastest way to candle eggs is to place the setter tray on a set of lights for all eggs to be inspected. Clear eggs will then consist of infertile as well as eggs that have early dead embryos and these eggs emit more light than eggs with viable embryos. The clear eggs are then removed and counted, and expressed as a percentage of all the eggs candled. During the

process the number of eggs set wrong way round as well as cracked eggs may be recorded. The sample size should be 3 to 4 trays per flock.



Candling of eggs with a single light (left) and set of lights (right)

Spot candling is more accurate as cracked eggs are more easily seen and eggs set wrong way up are seen more readily. The process is however more time consuming.

Embryos that have shown at least some development to the point where the embryo is noticeable under the light when quickly rotating the egg under inspection may also be detected and separated from absolutely clear eggs. The former is then classified as being early death. The only way to distinguish between infertile eggs and embryos that have died at a very early stage is to break open the egg.

This is done by breaking and pealing the round end of the eggs. Whatever development could have taken place would normally occur there. Should the germinal disc not be noticeable, then rotate the egg and pour off some of the albumen so that the germinal disc may be noticed. If still no development is found the contents may be poured into an empty pan and examined more closely.

Ten day egg breakout

The data is then classified into:

- Infertility (eggs showing no sign of development). If the blastodisc is found it will appear as per the infertile disc described above. The yolk of infertile eggs appear well defined, have the normal yolk colour and will generally be set towards the centre of the egg
- Early embryonic death (eggs that show some development). Embryos that have died during the first day will show paler and not so well defined yolk, with whitish material on the yolk. However do not confuse the chalazae with embryonic

development. Be on the lookout for signs of development of blood vessels around the area of the air cell. Should some development of blood vessels be noted this would indicate embryonic death during the second to third day of incubation. Embryos that have died during the fourth day will be distinctly visible as an embryo

- Mid embryonic death are eggs classified as having died between day 8 and 14 of incubation
- Cracked eggs
- Eggs set upside down
- Other such as rotten or microbial contaminated eggs

4.5.1.3 Hatch Debris Breakout

This involves sampling of unhatched eggs from the various breeder flocks, and classifying them into various causes of reproductive failure. This should be performed regularly and even on good performing flocks to obtain a sound picture of hatching results.

Eggs from at least four trays are taken. Data required for good assessment of hatch debris would include:

- Infertile
- Early embryonic death (1 to 6 days)
- Mid Term embryonic death 8 to 14 days
- Late embryonic death 15 to 19 days
- Pipped but not hatched
- Cull Chicks
- Cracked eggs
- Eggs that are contaminated
- Other

It is more difficult to distinguish between very early death (day one) and infertility after the eggs have spent 21 days in the machines. It is however possible by looking for any sign of development and examining the yolk colour and albumen consistency.

- Generally an infertile yolk will have a brighter yellow than a fertile yolk
- The albumen of infertile eggs is thicker than that of fertile eggs
- An infertile egg is held in the centre of the egg while in a fertile egg the yolk would tend to sink to the pointed end

The eggs are opened by breaking and pealing the large end of the eggs. Whatever development could have taken place would normally occur there. The dead embryo can also be removed and inspected for further classification into stage of embryonic death and position of the embryo.

21-day egg breakout

4.5.2 Weight Loss during Incubation

An egg is about 70% water. As the embryo utilizes nutrients from the within the egg, carbon dioxide and water is produced. For the embryo to survive and later hatch, this water must be lost by diffusion through the shell in order to maintain the same relative percentage of water throughout the development process.

Inadequate moisture loss results in residual albumen, increased late death (at the start of pipping), an increase in the number of chicks pipped but not out of the shell because they are slower to hatch and an increase in the incidence of button navels and red hocks.

Throughout the incubation process the egg looses weight at a rate of 11.5 to 12% over the 19 day period (or 0.61 to 0.63 % per day) that the eggs remain in the setters. This loss is affected by egg size and is also slightly greater at the end of the incubation period. The relative humidity should be in the order of 50 to 60% and most types of machines have recommendations in this regard.

In single stage machines this weight loss will not be linear as these machines are kept relatively closed in term of ventilation for the first couple of days, often up to a week. The daily weight loss from the time of opening dampers in these machines then needs to be accelerated in order to achieve the 11.5 to 12.0% loss by 18 day transfer.

Various factors such as breed, flock age, shell quality, etc. will affect the eggshell conductance of moisture and the weight loss must be manipulated to maximize chick quality. Should the weight loss be insufficient, the relative humidity should be decreased.

Moisture loss during incubation is a topic of special importance in modern egg laying strains with very good shell quality and a smaller egg size. Conventional incubator conditions may result in insufficient weight (moisture) loss, resulting in smaller chicks with poor naval healing. A reduction in moisture levels may be considered but this should only be done with knowledge of the effect on embryonic temperature. Reducing the moisture will reduce the ability of air to exchange the heat requirement or loss to and from the embryo and a simultaneous minor reduction in air incubation temperature may be necessary.

Some makes of machines use continual determination of the weight loss in sample areas for the machine to make adjustment to temperature and humidity control. Hygrometers and other recording devices register relative humidity and are used as measure of conditions within the setter machines.

The practice of determining weight loss during incubation should be made part of the hatchery control program.

The most practical way of determining weight loss during incubation is as follows:

- Determine the weight of an empty setter tray and fill and weigh it with eggs from the designated breeder flock
- Subtract the weight of the setter tray from the total to determine the weight of the eggs and divide this by the number of eggs to determine the mean egg mass
- After several days of incubation replace any cracked or broken eggs with similar eggs from another tray and obtain the new mean egg mass as above
- Calculate the loss as a percentage of the original egg mass and divide this by the number of days of incubation
- Check the calculation against the recommended percentage daily weight loss

4.5.3 Embryonic Temperature during Incubation

Embryonic temperature as opposed to incubator temperature has been shown to be of importance in modern high yielding broiler breeds. Embryos of modern broiler breeds may easily become overheated when incubated at conventional temperature, resulting in high embryonic temperature and consequent poor development and early hatching. The embryo temperature has to be maintained as close as possible to 37.75°C (100 °F).

During the initial stages of embryonic development, the embryo requires heat in order to maintain the correct temperature, while from 10 days of incubation, the embryo will start to dispose of heat in order to maintain the correct temperature.

The embryo temperature within the egg is determined by:

- Temperature of the air surrounding the egg
- Moisture content of the air as moisture is the vehicle by which heat is exchanged
- Air flow around the egg

Conditions within the cabinet may not always be uniform and air temperature, airflow and moisture content of the air in particular positions within the cabinet will influence the embryonic temperature of the eggs in that position.

Embryo temperature may be measured by using infrared digital thermometers. By establishing the variation of temperature within an incubator cabinet, alterations and adjustment could be made to ensure that the majority of embryo temperatures are correct and finding a compromise for machine settings. Factors to be considered include:

- Seasonal effects (environmental temperature and humidity)
- Lobby conditions and the ability of air conditioning equipment to cope with seasonal changes
- Machine maintenance (poor air circulation, poor humidification nozzles, poor heater maintenance)
- Breed

For this reason embryonic temperature should be measured frequently and minor adjustment made to machine setting in accordance with observations seen.

5 Chick handling and Quality

The process of chick hatching in commercial hatcheries involves the removal of large numbers of chicks from the incubators and separating the chicks from the hatch debris.

Chicks should not be subjected to stress in any way and the fact that in many instances the process of hatching and chick handling may call for sexing and vaccination, makes it essential that chick handling and storage facilities should be good.

In commercial layer chick and breeder hatcheries, unwanted chicks need to be disposed of in a humane manner. This applies to the disposal of second grade chicks in broiler hatcheries as well.

Chick hatcheries play an important role within the poultry industry which is regarded as a small margin, high volume business. Large volumes of chicks are handled and the quality of chicks originating from such large commercial hatcheries will impact significantly on the success or failure of the industry.

5.1 Removal of Chicks from the Machines

The process of removing chicks from the hatcher is generally referred to as pulling of chicks or chick take-off. Excessive dehydration by holding chicks for too long in the hatchers should be avoided. They should be removed from the hatcher at a point when all have hatched and they are about 95% dry, which normally would be 21 days and 6 hours after setting. Since the process of chick take-off takes time, especially in layer and breeder hatcheries where chicks are sexed and vaccinated for Mareks, it is advisable to make adjustments to the original setting times.

With broiler chicks it is advisable to get the chicks to the farm on the same day as hatching as they are to start feeding and drinking as soon as possible after hatching. In layer pullet hatcheries it is not all that essential to have chicks on the farm on day of hatching provided the chick holding room temperature and ventilation is controlled. This does however not mean that the process of pulling could be done over a period of a nine hour shift as this places stress on the chicks remaining in the hatchers for too long. As a rule the process should be completed within 5 to 6 hours.

In broiler hatcheries, chicks are removed from the hatcher trays, selected for second grade chicks and boxed in the same process. This could be done manually in smaller hatcheries or the process could be automated in larger hatcheries requiring staff to load the system, do the selection for removal of second grade chicks and the final stacking of chick boxes.

Carousels in chick take-off and handling

In layer and breeder hatcheries the chicks have to be sexed and vaccinated and they are therefore transferred onto a conveyer system of some sort on which they would go through the process of being sexed, vaccinated and boxed. A system of round revolving tables is usually preferred as such a system acts as a reservoir for the various tasks being performed.

5.2 Chick Quality

The characteristics of first grade chicks will include:

- They are clean and free from any contamination and egg residue
- Have down that is be soft, dry and covers all parts of the body
- Down on the head and neck should be long and fluffy not short and hard.
- Have eyes that are clear and bright
- Have no sign of deformed beaks or any other deformities
- Navels are completely healed, clean and dry with no dried membranes protruding
- The chick is firm and stands easily
- The chick should not show signs of distress such as panting
- The chick should be alert and interested in its environment
- The body temperature of chicks should be maintained within the range of 39.5 to 40°C (103 to 104°F) from point of take-off to delivery to the farms
- The chick should not have excessive quantity of yolk material left (10% of chick weight or 4 g for a 40 g chick)
- Chick size (weight and length) in relation to eggs size is important

Conditions in the chick take-off and holding rooms should be 24 to 26°C with a relative humidity of no less than 55% to avoid excessive dehydration. Particular conditions should always be monitored against the body temperature of chicks. If body temperature drops or increases, adjustment to holding conditions must be made.

Day old chicks should not be subjected to draughty areas. The Wind Chill will result in chicks chilling, despite normal temperature conditions.

Chick boxes of varying sizes and configurations exist but in most cases the compartments hold 25 chicks in two or four compartments per box (25 cm per chick). Boxes without compartments are used successfully over short deliveries.

Materials used on the base of boxes consist of clean wood-wool (especially when chicks are to be dispatched over long distances) or rough paper pads with a high moisture absorption capacity. Smooth paper should be avoided as this results in chicks slipping and being injured. Especially with heavier broiler chicks and increased incidence of splayed legs would be noted.

More detail on reasons for poor chick quality is dealt with in the section on Trouble Shooting

5.3 Sexing of chicks

Broiler chicks are normally dispatched as hatched although some broiler breeds do exist where sex can be determined by feather sexing. In the case of commercial layer breeds, the

sex may be determined by either feather sexing or colour sexing, depending on the breed. Colour sexing is obviously a lot easier than feather sexing and may be performed direct on the hatcher tray. Feather sexing requires individual chicks to be handled and therefore requires the chicks to be placed as hatched onto an accumulating table from where the sexer may handle them.

5.3.1 Vent Sexing

In breeder hatcheries vent sexing is done by specially trained people. This comprises a special technique of voiding the cloacae of its contents, opening the cloacae and visually distinguishing between the male and female chick. This is by distinguishing between the presence or absence of a very small rudimentary copulatory organ.

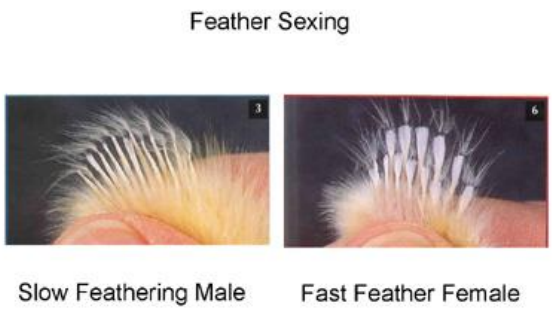
Vent sexing of chicks

It is a slow process and a good sexer will handle between 700 and 800 chicks per hour (350 female chicks). Normal sexing errors with vent sexing should be in the order of 2 %.

Some breeds are more difficult to vent sex than others and chicks from young flocks are also more difficult to vent sex.

5.3.2 Feather Sexing

Slow feathering in young chicks is due to a qualitative sex-linked dominant gene "K". It's allele, rapid feathering, is the result of the recessive gene, "k". The predominant feature of the recessive gene is to cause feathers to develop slower during the initial 6 to 8 weeks of the birds live. The difference between slow and fast feathering can already be detected at day old by the difference in length of the primary wing feathers in relation to the length of the primary wing coverts, which are the small downy feathers covering the base of the primary feather shafts.



The genetic background of feather sexing is explained in the Breeder Management Book.

Feather sexing is much easier to perform that vent sexing and less training is required. Good sexers will handle 1500 chicks per hour. In the slow feathering males the coverts are the same length or longer than the primaries. In the fast feathering female chick the primaries will be longer than the coverts.

5.3.3 Colour Sexing

Another sex linked gene S which produces silver feather colour (a certain type of white) is dominant over the recessive allelomorphs s, which produces gold feather colour. Since this gene is sex linked the makeup of birds can be fixed genetically. This is explained in the Breeder Management Book.

Colour sexing is much easier to perform and up to 3000 chicks per hour can be handled. Male chicks have light down and possibly one faint brown stripe down the centre of the back. Some male chicks may be light brown with two darker stripes on the back the middle part of the back being pale. Female chicks are dark brown with a possible light stripe on the back. Some females are a lighter brown with a single dark back in the centre and two lighter stripes to the side of the back.

Colour sexing

5.4 Vaccination of Chicks

Chick vaccination in the hatchery could consist of spray vaccination, eye drop vaccination as well as sub coetaneous injection. Spray vaccination is often called for to protect chicks against early challenges of diseases such as Infectious Bronchitis and Newcastle Disease. It could be performed by hand held sprays after boxing of chicks. In larger hatcheries automatic spray vaccinators are used. In this system, the boxed chicks move through a chamber, which sprays the vaccine onto the chicks as the box passes through.

Breeder and commercial layer chicks are to be protected against Mareks disease. This is performed manually by injecting the vaccine sub coetaneous in the neck or on the inside of the thigh. The vaccine could consist of as freeze dried product kept under frozen condition at below 0°C. Cell associated vaccines are kept at much colder temperatures in liquid nitrogen containers (-196 °C).

Mareks vaccination could be administered by handheld syringes or semi-automatic197 vaccinators. Vaccination of the embryo before hatching (In Ovo Vaccination) is also practised but the cost of the machines makes them viable only in very large commercial hatcheries

With automatic vaccinators, the area of vaccination is held against a trigger plate and the needle is inserted by the machine, under the skin. If not serviced and properly maintained, these machines could damage the chicks.

Hand vaccination of chicks

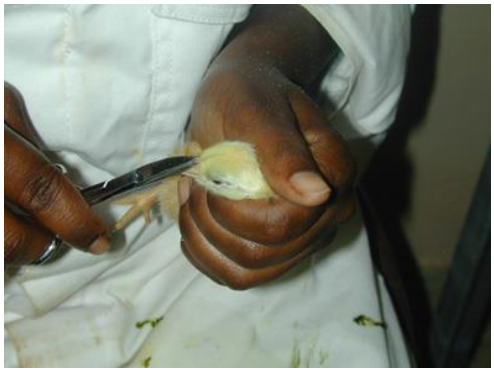
In all circumstances, the vaccine is to be handled strictly in accordance with manufacturer and veterinary recommendations. Vaccines could be destroyed be incorrect storage, handling, thawing and administration. Especially with Mareks vaccination, should the procedure not be correct a large number of chicks could be susceptible due to the disease manifesting itself and diagnosed only very much later in the birds life.

Vaccination equipment should be thoroughly sterilized before and after use, as the diluent is an ideal medium for bacterial growth. Acute pseudomonas infection is often associated with poor cleaning and sterilization of vaccine equipment.

5.5 Morphological Alteration of Chicks

5.5.1 Dubbing of Breeder Males

Some breeds of males are very aggressive and tend to fight causing damage to large combs. To overcome this, males are dubbed by cutting the comb with a sharp rounded manicure scissors at day old.



This is a specialized procedure and should only be carried out by trained staff and also only if it necessary to do so due to males damaging one another during fighting. Seek veterinary advice before carrying out such procedure. The chick is held in one hand with the head held firmly between the thumb and first finger. A sharp scissors is then used to cut the comb as close to the head as possible, following the round shape of the head against the scull from front to back. Mentholated spirits or alcohol should be used to disinfect the scissors after every cut. This process is normally not followed in broiler parent stock as the intact comb is required to keep males out of female feeders.

5.5.2 De-Spurring and Toe Cutting of Breeder Males

Females are often injured unduly by the males during mating and could call for the males to be de-spurred as well as toe clipped. This procedure is to be performed by specially trained staff and veterinary advice should be sought before carrying out the procedure. Special hand held machines are used for this purpose. The de-spurring machine consists of an apparatus that is very similar to a small electric soldering iron with a heated wire point at the end. A transformer controls the heat at the wire end, which should have a red glow when in use. The chick is held in one hand with one leg stretched forward and the spur knob is touched with the hot iron. The process is then repeated with the second leg. A small burned spot should be all that is noticed.

Toe trimming is performed by a similar looking hand held machine but with this apparatus, two hot wires are mounted on a pliers-like pincher which cuts and cauterizes the toe end. The chick is again held in one hand with toes extended and the innermost toe trimmed at the last joint, just behind the toe nail. The process is then repeated with the second leg.

The toes as well as the de-spurred area are disinfected by dabbing cotton wool soaked in alcohol or mentholated spirits on the cut and cauterized areas.

5.6 Chick Holding and Transport

Conditions in the chick take-off and holding rooms should be 24 to 26 °C with a RH of no less than 55% to avoid excessive dehydration. The chick holding room should also be free of draughts and the minimum ventilation supplied should be 0.33 to 0.35 m3/1000 chicks/minute. Stacks of chick boxes should allow for sufficient ventilation between stacks/trolleys. When stacked too close to one another, ventilation in the middle will not be sufficient and these chicks will soon overheat.

Carton chick boxes of varying sizes and configurations exist but in most cases the compartments hold 25 chicks in two or four compartments per box. Returnable plastic containers holding 100 chicks are used successfully over short deliveries. Materials used on the base of boxes should be clean wood-wool (especially when chicks are to be dispatched over long distances) or rough paper pads with a high moisture absorption capacity. Smooth paper should be avoided as this result in chicks slipping and being injured.

In most cases chick delivery would take place on the day of hatch but also not too late in the afternoon so as allow the farm staff to get chicks settled prior to the evening. In broiler operations it is especially important to get chicks started as soon as possible.

Fully air conditioned chick truck

Some pullet customers would however prefer to receive chicks the following morning, to have sufficient time for staff to get the chicks settled into the cage systems. Whatever the preference, the driver should be aware that there are live chicks on the truck generating much heat and moisture in a confined space and especially when stationary, the heat build up in the vehicle could be very rapid and harmful.

The type of truck to be used for delivery of chicks to the farm will depend on the distances involved. For short distances and mild temperature conditions, it is sufficient to provide for adequate ventilation only with avoidance of excessive draughts in the truck body. When the distances to be travelled involve diverse conditions (such as travelling over long periods or when environmental conditions are bound to vary) it would be advisable to consider a tailor made fully air-conditioned vehicle.

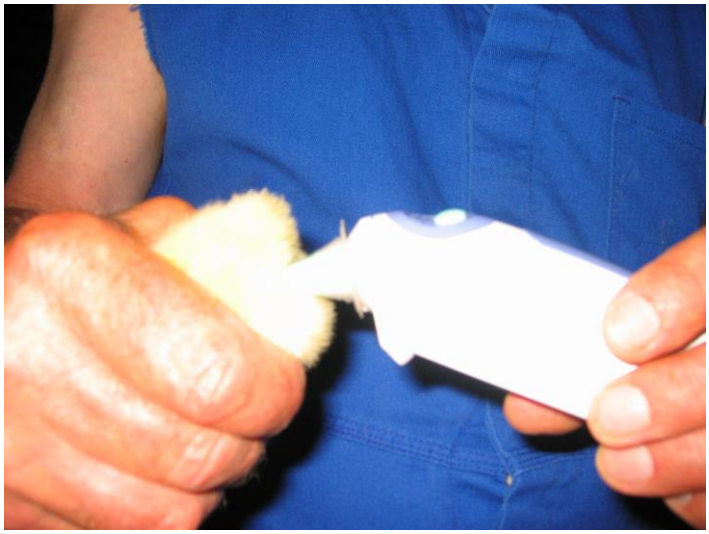
With chick trucks the load is confined to a very small space and ventilation and movement of air throughout the entire load is of utmost importance. Specially designed vehicles are equipped with air conditioning units to heat or cool a minimum amount of fresh air introduced into the truck body while a larger amount of air is circulated within the truck to remove heat from the chicks in a similar fashion as air movement in a hatcher cabinet.

5.7 Chick Temperature

Chick body temperature is an important tool in evaluating whether the condition in which chicks are held and transported is adequate. The body temperature of chicks should remain within the range of 40 to 40.5°C (104 to 105°F). Chicks however react as if they are "cold blooded" during the first 4 -5 days (poikilotherm). This means that they have limited ability to regulate their body temperature and the body temperature would depend largely on temperature conditions surrounding the body.

Chick body temperature is measured by determining the cloacal temperature. This is done by means of a hand held infrared digital thermometer obtainable from chemists. Sampling chicks at various points within the holding area as well as immediately upon arrival on a farm will soon indicate whether chicks have been handled without undue stress.

Some variation due to flock age (chicks from young parent flocks tend to have lower body temperature) may occur but by evaluating the differences in air movement and varying temperature conditions within the room, the variation can to a large degree be reduced.



Measuring chick temperature

6 Trouble Shooting

Embryonic mortality and chick quality are influenced by various aspects including nutrition, diseases, management of the breeder flock, hatching egg handling as well as management of the hatchery and hatchery conditions. In order to effectively analyze poor hatching results, it is important to know the normal pattern of embryonic death so as to compare results to this.

The procedure to determine the stage at which embryonic mortality occurred as well as the procedure to identify between early embryonic death and infertility is described in the section on Chick Incubation.

6.1 Normal Embryonic Mortality

With normal hatch results of between 80 and 90 % chicks of all eggs set, eggs that fail to hatch (10 to 20% of all eggs set with a mean of 15%) can be classified as per Table 6.1.

Table 6.1: Classification of eggs that do not hatch

Classification	Normal %	Low Range %	High Range %
Infertility	5.5	3.0	8.0
Embryonic death 1 to 7 days	2.5	2.0	3.0
Embryonic death 8 to 14 days	1.0	0.8	1.2
Embryonic death 15 to 21 days	4.0	3.0	5.0
Eggs piped but not hatched	2.0	1.2	2.8
Total	15.0	10.0	20.0

It is advisable to regularly break open eggs to establish the normal pattern for the hatchery. Embryonic mortality should normally show a peak in the first seven days (30% of total embryonic mortality), where after it declines in the second week of incubation (10% of the total embryonic mortality). Sixty percent of the total embryonic mortality will occur during the last week but especially during the last 3 to 4 days of incubation.

The initial peak mortality should always be lower than the latter peak (30 to 50% thereof).

Pre-oviposital mortality could also occur which is normally as a result of eggs which are in the hen too long or when the period that the egg spends in the hen is too short. Several factors will affect the time that the egg spends in the oviduct and include size of the egg (large eggs move slower), eggs with thick shells move slower, disease often cause eggs to be laid prematurely and eggs move slower down the oviduct of poorer producing hens.

6.2 Embryonic Mortality during First Week of Incubation

Embryos show a high rate of mortality during the first 3 to 4 days of incubation and during the first 7 days it should be between 2 to 3 %. Factors normally contributing to high rate mortality in this period would include:

- Poor flock health
- Infrequent egg collection
- Poor handling of eggs prior to storage
- Poor transportation of eggs

- Poor holding conditions of hatching eggs
- Long storage time
- Improper fumigation of eggs prior to setting
- Incorrect incubation temperature
- Poor pre-heating
- Insufficient turning

6.3 Embryonic Mortality during Second Week of Incubation

The mortality during the period 8 to 14 days should be very low and not exceed 10% of total embryonic mortality.

Should mortality be high during this period it usually would imply nutritional deficiencies in the breeder feed.

Other causes of embryonic mortality during this period could be due to poor incubation temperature control (setting cold eggs that affect embryos already developed) as well as poor turning and infected eggs (poor egg sanitation).

6.4 Embryonic Mortality during the Third Week of Incubation

The last seven days are very critical in the development of the embryo and it can therefore be expected that embryonic mortality will increase during this period. Mortality in this period should be about 50% greater than the mortality in the first week. The main causes of mortality in the last three to four days of incubation include:

- Malposition
- Dehydration due to low humidity
- Dehydration due to poor shell quality
- Suffocation due to lack of oxygen
- Low moisture loss
- Excessive temperature leading to overheating
- Low incubation temperature
- Insufficient turning during incubation
- Rough transfer

6.5 Malposition

The normal position of chick development at 19 days is for the head to be at the round end of the egg (close to the air cell) with the head to the right and tucked in under the right wing, the beak facing toward the air cell and feet toward the head. Many eggs do not develop in this position, some of which will hatch and others not.

The reasons for chicks developing in the wrong position could be:

- Eggs set wrong way round (small ends up)
- Old breeder flocks tend to have more malpositioned embryos

- Eggs that are very round and difficult to assess blunt end could have been set wrong way round
- Inadequate turning (frequency and angle)
- High incubation temperature

6.6 Specific Problems

Analyzing problems that affect hatch results is complicated and numerous interacting factors could be involved. When investigating specific problems it is advisable to endeavour to firstly establish whether the egg was in fact fertile and secondly the stage at which embryonic death occurred. Listed here is a series of identifiable signs together with possible causes that may be used to assist in resolving problems.

Observation	Possible Cause
High number of clears under candling lights	Infertility • Immature males • Poor mating ratio • Poor male body weight • Extreme temperature • Flock age • Disease • Breed Early embryonic death
Eggs are fertile but no blood ring noted (> 3 days)	Egg collection • Infrequent collection Egg transport • Jarring and rough handling • Poor temperature during transport • Eggs not allowed to settle after transport Egg storage • Eggs stored too long • Incorrect storage temperature • Fluctuating storage temperature • Other • Diseased flock • Feed toxins • Pesticides in feed • Egg wash temperature • Incorrect use of drugs in the flock
Embryo died after blood ring was formed (< 3 days)	Pre-incubation • Poor egg transport • Poor egg storage temperature control • Poor fumigation • Old breeder flock Poor setting of eggs • Low setter temperature • Setter looses excessive temperature at setting Other • Feed toxins • Pesticides in feed • Incorrect use of drugs in the feed

	• Severe vitamin deficiency in feed • Investigate setter ventilation
Embryonic mortality in second week of incubation	Setter problems • Turning infrequent and not enough angel • Poor ventilation supply and air circulation • Temperature high, low or fluctuating • Machine has hot and cold spots • Excessive temperature drops Other • Nutritional deficiencies • Microbial contamination
Embryonic mortality in third week of incubation	Setter problems • Poor lobby conditions • Temperature high, low or fluctuating • Poor humidity control • Poor turning • Poor ventilation supply and air circulation • Machine hot and cold spots Transfer problems • Eggs loosing excessive temperature • Rough handling of eggs • Transfer too late Hatcher problems • Poor control on lobby conditions • Temperature high, low or fluctuating • Poor ventilation supply and air circulation • Poor humidity control • Excessive trickle fumigation • Malposition • Hatcher being opened too often
Embryos pipped but dead in shell	Setter problems • Eggs set small ends up • Old eggs (long storage time) • Poor machine temperature control • Insufficient turning Transfer problems • Rough handling of eggs Hatcher problems • High temperature causing small pipping area • Low humidity • Excessive trickle fumigation • Poor ventilation
Chicks hatching early	Breeder flock • Young flock Machines • High temperatures • Low humidity • Poor lobby temperature and humidity • Poor lobby ventilation and air pressure
Chick hatching late	Breeder flock • Old flock Egg storage • Eggs stored long Machines • Low temperatures • Poor lobby temperature and humidity • Poor lobby ventilation and air pressure

Drawn out hatch	Pre-incubation • Mixed egg age • Mixed breeder flock age • Varying egg size • Poor egg handling Machines • Uneven cabinet temperature • Poor lobby temperature and humidity • Poor lobby ventilation and air pressure
Dirty chicks with smeared egg content	Pre-incubation • Old eggs • Poor shell quality • Poor egg sanitation • Very large eggs breaking Incubation • Pops causing egg content to smear chicks • Low incubator temperature • High incubator humidity
Small dehydrated chicks	Pre-Incubation • Young breeder flock • Small eggs • Low humidity during storage • Poor shell quality Incubation • High machine temperature • Low machine humidity
Unhealed navels, dry with rough down	Incubation • High incubation temperature • Fluctuating incubator temperature • Hot spots in incubators • High or low hatcher humidity
Unhealed navels with infection, chicks lethargic	Poor sanitation • Dirty eggs • Poor egg fumigation • Setting floor eggs • Dirty trays and baskets • Poor sanitation of machines
Weak chicks lying in hatcher basket	Incubation • High hatcher temperature • Chicks too long in hatcher • Excessive trickle fumigation • Contamination
Crooked beaks and other head and facial abnormalities often also brain hernia	Incubation • High temperature • Hot spots in machines • Poor control on lobby temperature and humidity causing uneven machine temperature • Poor control on lobby ventilation causing uneven machine temperature
Spraddled legs and crooked toes	Pre-incubation • Inadequate nutrition Incubation • Smooth hatcher baskets • High hatcher temperature Post hatching • Smooth paper in chick handling systems and boxes
Short and wiry down	Pre-incubation

	• Inadequate nutrition especially riboflavin • Mycotoxins causing nutritional deficiency Incubation • High machine temperature
Red hocks and beaks are indicative that chicks have struggled to break out of the shell	Incubation • High temperatures • Hot spots in machines • Low humidity • Small pipping area
Small pipping area different to the normal pipping of almost one third from the rounded end of the egg	Incubation • High temperature • Uneven cabinet temperature with hot spots • Poor lobby conditions creating uneven machine temperature
Rots and smelly egg content	Pre-incubation • Dirty eggs set • Floor eggs set • Poor egg sanitation • Unhygienic egg storage • Moisture condensation on shell • Poor washing of eggs if practiced • Eggs being wiped with dirty cloth • Re-contamination by dirty hands and equipment Incubation • Egg and chick contaminated by other eggs exploding • Re-contamination by dirty equipment • Poor water quality in spray nozzles
Chicks gasping and showing sign of aspergillus infection	Poor sanitation of lobbies, machines and ducting