

Management *Guide*

LOHMANN TIERZUCHT

Hatchery



Incubation under control

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Why should you study this management guide?

Most people who are involved in commercial hatchery practise have seen different management guides and may think 'if you have seen one, you've seen all'. Others take the contents more seriously and expect frequent up-dates to find specific data which apply to the current generation of layers and current management practices. Newcomers in the business may need more detailed explanations than can be presented in this compact format.

This guide aims at giving the reader a prime understanding about the processes that are happening inside a hatching egg from the moment of lay until the chick is hatching and finally processed and transported to the rearing farm. Based on this information practise-proven management recommendations are derived.

When applying them to the individual hatchery the local conditions like technical equipment, climate, legislation etc. have to be taken into account. The recommendation of the machine manufacturer should always be considered.

If you have any questions after reading this guide, we would like to encourage you to contact us. We appreciate all advice, feedback and suggestions from our customers.

The hatching egg

The hatching egg is not "just like any egg". It contains a living embryo which has all the genetic potential the R&D department of Lohmann Tierzucht has combined over many years of selection.

In order to enable the embryo to express this potential during incubation and in later life as a pullet and laying hen, good hatching egg quality is crucial.

The hatching egg quality is mainly influenced by these factors:

- Condition and health status of the parent stock flock
- Age of the parent stock flock
- Medication
- Feed quality
- Water quality
- Type of housing
- Climate
- Percentage and quality of males
- Type and cleanness of nest boxes
- House temperature
- Collecting of the hatching eggs
- Storage and handling of the hatching eggs
- Disinfection of the hatching eggs

The factors are arranged in two groups. The first group determines the quality of the egg at point of lay. This means egg size, shell quality, the nutrients and maternal antibodies transferred to the egg determining albumen and yolk quality and finally the fertility.

Hatching Egg Handling

The second group of factors affects the hygiene status of the egg and the ability of the embryo to survive storage.

The freshly laid egg has the temperature of the hen's body (41 °C) and the egg surface is slightly wet. Cooling down to house temperature causes a contraction of the egg contents leading to air entering the egg which creates the air cell.

To minimise the amount of germs penetrating the egg shell during this critical time, it is very important that the egg is laid in a clean nest.

Floor eggs are not regarded as good hatching eggs. It is very likely that they have already been contaminated by manure contact, before they can be collected, cleaned and disinfected.

If you use floor eggs in the hatchery there is a high risk that these eggs will compromise the quality of the other eggs and chicks. Therefore store and incubate floor eggs separately (or at least on the bottom trays) and transfer, pull and process them after dealing with the good quality ones.

Good quality eggs for the hatchery should match the following criteria:

- Clean egg shell (No manure, litter, feathers or blood)
- No cracks
- Well shaped
- No double yolk
- Weight range according to hatchery policy (usually 52 – 68 grams and some hatcheries go as low as 48 g)
- Set with the pointed end downwards



Second grade eggs which should be rejected, because they are heavily soiled, dirty, bloody, misshapen, thin-shelled, too small or too big, cracked respectively ridged

Hatching Egg Handling

Optimal egg storage condition

When an egg is laid, there is already a small embryo present with approximately 40000 cells. The vitality of this embryo must be preserved until the point when the incubation process finally starts. To achieve this, the eggs have to be handled carefully and temperature ups and downs should be avoided.

Firstly, the development of the embryo that started in the hen's body has to be stopped. Therefore the egg should slowly cool down below "physiological zero" (26 – 27 °C) within six hours after being laid. This process usually happens inside the nest or on the egg belt. When the ambient temperatures are high (summer) the cooling can be a problem. In practice it means that the egg collection has to be done more frequently to avoid the embryo remaining at a temperature between 27 °C and 37 °C for too long a time. This temperature range causes an unbalanced development and hence early embryonic mortality. The hatchery staff recognises the early dead during candling as clear eggs. These are often misleadingly classified as infertile.

Also a too quick cooling of the eggs can cause embryonic mortality.

Once the cell division is stopped the egg needs to cool down further. This is necessary to keep the thinning of the albumen and the amount of necrotic cell deaths under control. Control means that there are different optimal egg sto-

rage temperatures depending on storage length.

For eggs that will be set within the next 4 days it is not necessary to keep them at a temperature below 20 °C, 21 – 22 °C is regarded as optimal. This relatively high temperature promotes the thinning of the albumen, which improves the gas exchange during early incubation. On the other hand it is low enough to maintain the vitality of the embryo. In most layer hatcheries it is common practise to store the eggs up to 10 days. For this storage length the recommended temperature is 16 – 18 °C. To avoid temperature-Ws (ups and downs) when moving the eggs from the farm to the hatchery the truck temperature should be set equal to the farm egg room temperature.

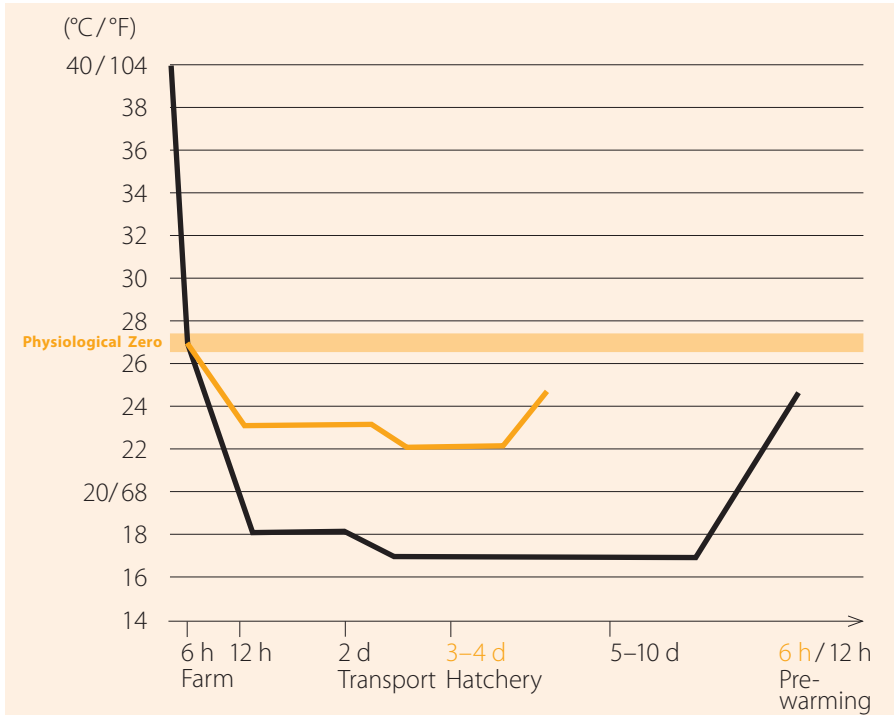
The egg room in the hatchery can be kept at a slightly lower temperature.

For storage beyond 10 days we do not recommend a temperature far below of 16 °C. In most situations this is not cost efficient and creates other problems when it comes to egg setting (egg sweating, long pre-warming time). Condensation on the eggs should be avoided by any means. It allows micro-organism to multiply on the wet surface, penetrate the shell and contaminate the egg. It happens when cold stored eggs are brought to a warm environment – for example the setter room – and the egg temperature is lower than the dew point of the surrounding air. So this is

Hatching Egg Handling

Chart 1:

Optimal development of the egg temperature from the moment of lay until setting depending on the storage length



depending on temperature difference and humidity, but one can roughly say that the temperature increase should not be more than 11 °C in situations with little air movement. As soon as there is considerable air flow over the eggs the risk for egg sweating is minimised.

To preserve the hatchability during long storage it is better to turn the eggs. If there is no automatic equipment installed, turning by hand three times each day is sufficient. Additionally it is possible

to pre-incubate the eggs before storage to improve the vitality of the embryo. If the eggs are stored on cardboard trays it is beneficial to store the eggs upside down – with the pointed end up. Be careful not to transport the eggs like this, because it can cause loose air cells. Beyond one week of storage, even under optimal conditions, the hatchability will drop 0.5 – 1.5 % per day with the percentage increasing as storage extends further. After two weeks of storage, the chick quality will also be impaired.

Hatching Egg Handling

LSL is more negatively affected by long storage than Lohmann Brown. When using Lohmann Silver there is a minimum storage length of 3 days before the best hatching potential of the eggs is reached. There is some evidence that also eggs from young LB and LSL flocks benefit from 2 to 3 days storage before being set. Please check under the condition of your operation.

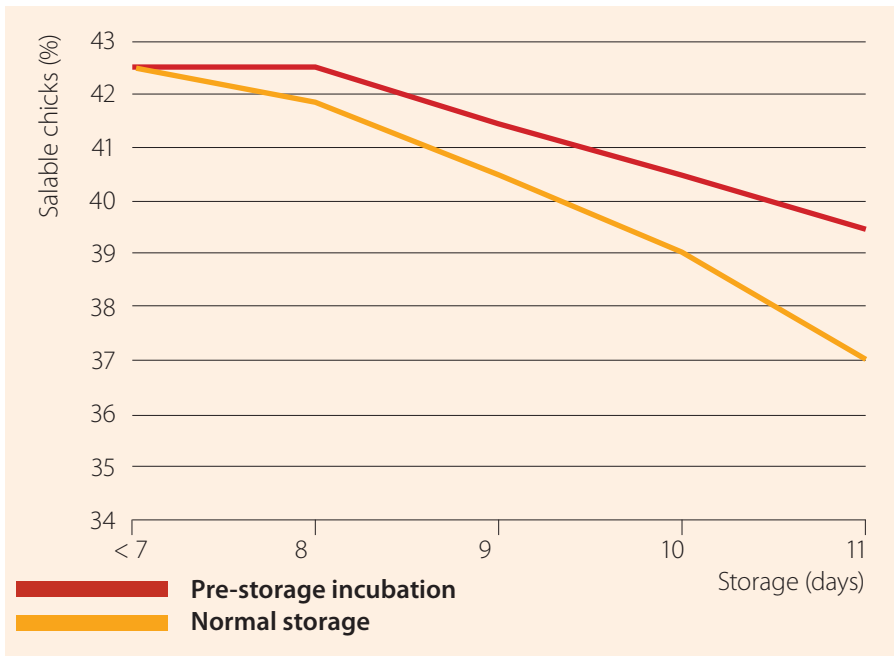
The humidity during storage is not as important as the temperature. If eggs are just stored up to 10 days, 50 – 60 % relative humidity is sufficient. Of course it does no harm if the humidity is higher

as long as it is below 80 %. Under conditions of more than 80 % relative humidity the growth and spread of fungi is facilitated and should therefore be avoided. However, when eggs are scheduled for long storage a higher humidity will help to avoid excessive moisture loss of the eggs. The target value should be 70 – 80 % relative humidity.

Pre-storage incubation

A hen needs approximately 24 hours to produce an egg. Around 30 minutes after an egg is laid the next follicle is ovulated. The follicle falls into the in-

Chart 2:
Impact of pre-storage incubation on the hatchability of LSL



Hatching Egg Handling

fundibulum where the fertilisation takes place. After that the albumen is added, the egg membranes are formed and the egg shell is composed.

Therefore the eggs arriving at the hatchery are containing an embryo representing already 23.5 hours development in the hen's body. However this developmental stage at point of lay is not optimal for long storage. In nature it would be altered by periodical warming of the eggs during the time the hen sits on the nest to produce the next egg of the clutch. In the hatchery it is possible to achieve similar results by incubating the eggs for 6 hours (egg temperature 100 °F) before storage. This leads to further development of the germinal disk to a stage containing 60000 – 80000 cells. At this stage the embryo is less susceptible to cell death occurring during the storage period.

If the heat-up time of the incubator is longer than 6 hours, the time the eggs are kept on 100 °F should be gradually reduced from 6 hours down to 3 hours for a heat-up time of 12 hours. If the incubator needs more than 12 hours the amount of eggs set for pre-storage incubation should be reduced.

Pre-storage incubation can not improve, but can maintain hatchability. Therefore it starts to make sense using this technique, if eggs are scheduled for a storage period which leads to a noticeable decline in hatchability. This depends on the local conditions of the flock and the storage¹.

Pre-storage incubation gives best result when it is done with fresh eggs up to two days after lay.

Disinfecting hatching eggs

Hatching eggs need to be disinfected, as micro organisms multiply rapidly in the warm and humid climate of a hatchery. A widely used method is fumigation with formalin. However this is no longer recommended as it is harmful to the embryo, increasing early embryonic death, and it is hazardous to human health. Especially LSL is susceptible to formalin.

When using formalin keep in mind:

- Never fumigate with Formaldehyde within the first 96 hours of incubation!
- Never exceed a fumigation time of 30 minutes! Room temperature should be 20 – 25 °C, relative humidity 65 – 75 %.
- Re-ventilation of a fumigation chamber has to be done with clean air (not too cold) to avoid the re-contamination of the hatching eggs! Make sure that the equipment has a capacity to re-ventilate the fumigation chamber within a few minutes.

¹ Under conditions causing an improper cooling of the eggs the effect of pre-storage incubation might be negligible or even negative, because the eggs are already containing an embryo at an advanced stage of development.

Hatching Egg Handling

There are modern chemicals available based on glutaraldehyde and different quaternary ammonia compounds, on stabilised hydrogen peroxide and peracetic acid or just H_2O_2 that have the same effectiveness. These agents can be sprayed, fogged or vaporised. The most popular method is fogging as it is safe, the fog reaches all the eggs and the eggs do not get wet.

Vaporisation requires less investment in equipment, but chemicals that can be used in a safe manner are not available everywhere.

Before choosing any chemical please make sure that it is labelled for the use in hatcheries and for the desired mode of application.

Eggs can be disinfected on the breeder farm, in the hatchery or both. We recommend to do the disinfection in the hatchery either after egg traying or before egg setting.

If required, a first disinfection can be done shortly after egg collection. Disinfecting the eggs on the breeder farm reduces the microbiological load as soon as possible, but keep in mind that this can not exclude the risk that floor eggs or dirty eggs may have been already contaminated. In fact what we do is not an egg, but an egg shell disinfection!

Do the basics right

1. Hatching eggs are living organisms. Handle them with care!
2. Grade eggs at the farm. Do not send dirty eggs to the hatchery. Floor eggs are no hatching eggs.
3. Do not try to "clean" eggs by using sandpaper or an iron sponge. This will destroy the cuticle and ease the entrance of microorganism.
4. Check temperature at the farm, during transport and in the hatchery. Aim for a steady decline and stable temperature. There should be no ups and downs. Check not only air temperature, but also egg temperature with an infrared thermometer.
5. Eggs intended to be placed on paper trays and palettes need to be cooled down before. Place them soon after arrival to the hatchery on setter trays. This facilitates a more even temperature.
6. To achieve an even temperature allow a good air flow in the storage rooms. Don't store the eggs directly on the floor, next to the wall or too tight together. Mind direct sunlight entering the room. No water should drop on the eggs from air-conditioner or humidifier units.
7. Avoid using formaldehyde for disinfecting hatching eggs.
8. Especially after long transport to the hatchery, the eggs need to have a 24 hours rest before setting.

Single-stage vs. multi-stage incubation

Single-stage means that all eggs within an incubator are set together. So all eggs are in the same embryonic stage. This enables the user to adjust the temperature, humidity and ventilation setpoints according to the needs of the embryo, possibly leading to improved hatchability and chick quality. The next benefit is the improved biosecurity as provided by every all-in all-out system. The incubator can be easily cleaned, disinfected and also maintained after each batch of eggs. Finally it can be more flexible if the amount of hatching eggs is not constant for each setting.

For this reason many commercial layer hatcheries and all major breeding companies use single-stage incubation.

In contrast a multi-stage incubator is usually filled with eggs of six different embryonic ages. Therefore the multi-stage incubation environment cannot, by its nature, create optimum conditions for every egg. Temperature, humidity and ventilation are set at a fixed point throughout the whole incubation period.

One advantage of multi-stage incubation is its simplicity both with respect to the control system of the incubator as well as the management of incubation. It used to be also superior to single-stage incubation in terms of energy efficiency. Today's single-stage hatcheries

can partly eliminate this handicap with modern heat recovery systems.

The difference between the two systems is only relevant for the first 18–18.5 days of incubation. After transfer the hatcher is always managed in an all-in all-out rhythm.

Pre-warming before setting

Pre-warming, often also called pre-heating, is a procedure after storage and before setting during which the egg temperature is slowly increased to approximately 25 °C (77 °F). Pre-warming is a must, if eggs are going to be set in multi-stage machines to avoid condensation on the egg shells and a big temperature drop for the other eggs. It is also beneficial for single-stage incubation as it accustoms the embryos to the beginning of incubation and in this way decreases the spread of hatch and reduces early embryonic mortality.

Some hatcheries have a special pre-warming room. This is a good way to heat the eggs evenly and the room can also be used for the egg disinfection before setting.

In the absence of such a room most people put the eggs to warm in the setter room or in the incubator with doors left open. The latter is in most cases not recommended as the limited airflow will cause a non-uniform warming.

As a third possibility many single-stage setters have a pre-heat or/and a delayed start function. Using this, the eggs can

be pre-warmed inside the running machine which automatically starts incubation after the preset time. The method is convenient, labour saving and allows a very even temperature during pre-warming. However you have to be aware of what really happens inside the machine. The pre-heat function of most manufacturers quickly increases the temperature to the setpoint and then tries to keep the temperature constant. It usually works, but is not exactly what we are looking for. The delayed start function mostly deactivates heating and cooling and just fresh air is sucked in by the running pulsator. Here it depends on the temperature of the incoming air and the heat produced by the electric motor. A temperature over 25 °C should be avoided as fluctuations around “physiological zero” (26 – 27 °C) can lead to increased early embryonic mortality.

Depending on egg mass, egg storage length, storage temperature, flock age and pre-warming method the optimal pre-warming length differs. The minimum is six hours. As storage length increases or storage temperature decreases pre-warming length should be extended to twelve hours or more. It is no risk to go to 18 – 24 hours as long as the temperature is balanced and not too high.

Setting time and pattern

The setting time is determined by the schedule on hatch day, the source of hatching eggs and the incubation conditions.

In general the incubation time for pre-warmed eggs is 21 days and 3 – 6 hours for LB and 9 – 12 hours for LSL. Lohmann Tradition, Silver and Sandy need approximately the same incubation time as LB.

Extra time should be given depending on:

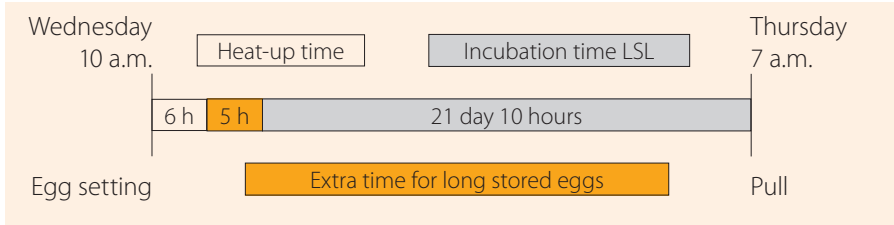
- egg storage time (1 hour per day exceeding 5 days)
- flock age (3 – 6 hours for flocks < 30 weeks and > 50 weeks)

Additionally there is time needed to heat up the eggs to incubation temperature. In a regularly filled multi-stage machine this process happens quite quickly (three hours), but in some single-stage incubators it can take up to twelve hours.

The following example explains the necessary calculation:

- Start of hatch planned for Thursday, week 4 at 7 a.m.
- LSL - eggs, 10 days egg storage, middle age flock
- Incubator heat-up time 6 hours
- 21d10 hours + 5 hours + 6 hours
- Incubator should be started on Wednesday, week 1 at 10 a.m.

Chart 3:
Calculating the optimal setting time



Incubation time can differ depending on the incubation condition in the individual hatchery or flock characteristics. Therefore it is recommended to control the correct timing regularly (see chapter “Hatcher”) and adjust the setting time if necessary. This will help to maintain a high level of chick quality.

Incubators give best results if they are full, and the eggs are of the same age and from the same flock. This is often not possible and a compromise has to be reached. If the setter is not full, the trolleys should be ‘balanced’ which enables the air flow to work correctly. The top two and bottom two trays can be left empty of eggs but the spaces should be filled with empty trays. Occasionally, it is necessary to have whole trolleys empty but they should be put in complete with empty trays. Another way is to fill with eggs from another flock or another storage time. If different batches of eggs are going to be set together please ask your machine manufacturer for advice and experience with your specific incu-

bator type. Incorrect filling in multistage incubators can create big problems, resulting in disappointing results.

Temperature

Temperature is the most important incubation parameter. It mainly determines the speed of embryo development and it has to be kept within a small range to assure optimal hatchability and chick quality. However, the embryo temperature rather than the incubator temperature is critical. As this cannot be measured without damaging the egg, the usual practice is to determine the eggshell temperature (EST) with an infrared thermometer. When doing this, it is important to ensure that the measurement is carried out at the “equator” of the egg and not at the top above the air cell. Otherwise, in the case of a developing embryo, the value recorded will be too low.

EST measurement should be taken by suitably trained Staff only. The required sample size is 10 – 15 eggs per trolley and from the middle of a tray. Readings

of clear eggs are not relevant for the calculation of the average. One should aim for an EST of 100 °F during the first twelve days of incubation. A fluctuation range of 99.6 to 100.4 °F between the eggs is acceptable.

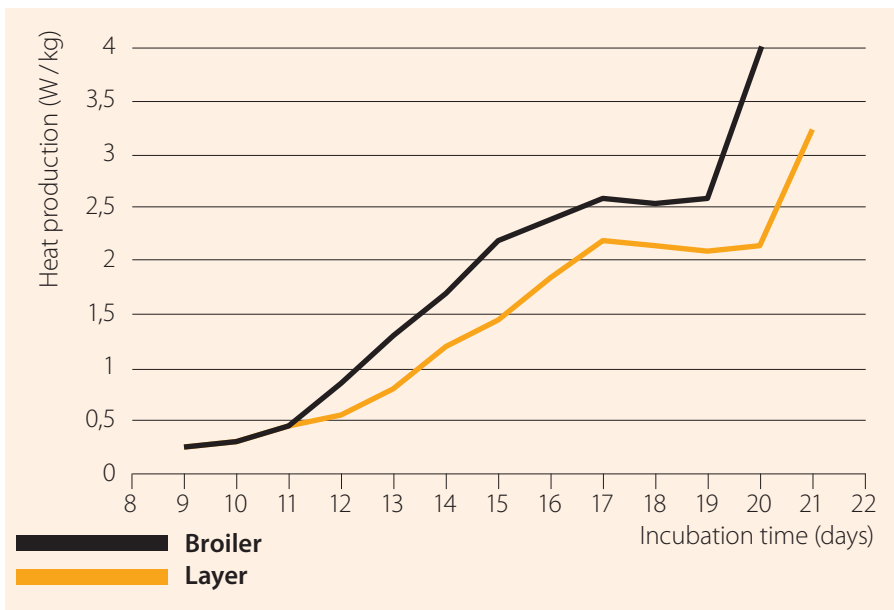
After the twelfth day, the embryo begins to grow more quickly and to produce more heat. This requires increased ventilation and cooling of the incubator which leads to a greater variation in EST. This effect is reinforced by a high number of “clear” eggs which do not produce any heat and create relatively cooler areas on the trays.

At this stage, it may be the case that, at an average EST of 100 °F, even eggs with

living embryos constantly have an EST below 99.5 °F. These embryos develop slowly and there is a risk that they will be rejected as “pips” or “too fresh chicks” when the chicks are taken off. To avoid this, the average EST should be allowed to increase slowly by 1 – 1.5 °F from the 13th to the 19th day when transfer takes place. As a second advantage this limited rise in egg temperature acclimates the embryonic tissues for the body temperature of the hatched chick (40 °C, 104 °F).

In many hatcheries, there is a tendency to very high EST. However, temperatures over 102 °F have a negative effect on

Chart 4:
Heat production of the embryo per kg egg mass



Adapted from Janke, Tzschentke and Boerjan (2004)

chick quality and can also reduce the hatching rate.

To achieve the desired egg temperature, the incubator temperature has to be lowered step by step during incubation until day 16. From that moment on the heat production is only slightly increasing until internal pipping and therefore the machine temperature can be kept constant.

In general the overall temperature should decline from day 0 until day 16 by 1.0 – 1.8 °F. The decrease has to be higher the more heat is produced by the embryos (egg size, fertility, oxygen availability), the lower the air speed (incubator model) and the lower the heat capacity of the air is (humidity). The starting setpoint is mainly determined by the design of the incubator, which means the air flow inside of the machine, the position of the sensors and the way of calibration. There are setters on the market which require a setpoint of 99.6 °F to achieve an average egg temperature of 100 °F and others need to be set at 100.6 °F.

Therefore it is at this point impossible to give a detailed recommendation for an incubation program that works with every equipment available and performs well under the individual conditions of each hatchery. Please seek the advice of your manufacturer and don't hesitate to contact also our technical service department to ask for our experience with your incubator model. There is a proposal for an incubation program, experienced with conventional single-stage

Petersime equipment, in the appendix of the guide.

Naturally in multi-stage incubators, the EST cannot be controlled in this way because adjusting the incubator temperature always involves a compromise for various stages of incubation.

Humidity

Humidity and the way it is provided can influence the incubation success by several ways.

Firstly it affects the moisture loss of the eggs. During incubation water vapour is lost through the pores of the shell. The rate of water loss is influenced by the egg shell conductance and the water vapour pressure difference between the egg and the surrounding air. The water vapour gradient depends on the temperature and the content of water in the air. At a given temperature the water content of the air can also be recorded as relative humidity or wet bulb temperature.

Practically the moisture loss can be determined by simple weighing, because any weight loss is solely due to the loss of water from the egg. There have recently been automatic egg weighing devices introduced by manufacturers, but these systems are relatively expensive and still have to prove their technical reliability. **Manual weighing with a simple and cheap electronic scale is effective and has been used for many years.**

The usual procedure is to mark and weigh 3 – 6 sample trays before setting and reweigh them at transfer. When calculating the percentage do not forget to take into consideration the weight of the empty tray. The same trays can be used for examination of embryo mortality and to measure chick yield.

It is also good practise to weigh a whole trolley using a platform weighing machine.

The weight loss until day 18.5 (transfer) should be 12 %, with an acceptable range from 11 – 13 %. This will ensure that the majority of the eggs experience a moisture loss that is high enough to form the air cell necessary for internal pipping without risking the dehydration of the chicks.

If the weight loss differs from 12 % by more than 0.5 % the humidity setpoints can be adjusted for the next incubation period. By rule of thumb the humidity setpoints during incubation should be increased by 1 °F (2 % relative humidity), if the weight loss target is exceeded by 0.5 %. Of course this works also the other way round.

When flocks are ageing the quality of the egg shell is declining and egg shell conductance is increasing. Therefore for eggs from old flocks a higher humidity setpoint is required to avoid excessive moisture loss. The opposite is often seen when dealing with very young flocks that are producing eggs with very thick shells.

If you incubate eggs for the first time without having an idea about the necessary humidity setpoints it makes sense to re-weigh the sample trays during incubation, for example after 7 days. This leaves time to react, if the moisture loss is not on target. As an initial setpoint, which should be adapted by your own experience, we recommend on average 53 – 55 % relative humidity or 84 – 85 °F wet bulb reading.

These adjustments are only possible if the incubator is filled with one or at least similar batches of eggs. If different flocks or breeds are mixed, it is not possible. Very long stored eggs might require higher humidity settings as they have already lost more moisture during storage (0.1 % per day).

It is generally accepted that high moisture loss during storage is detrimental, although it would be possible to compensate it by higher humidity during incubation. Therefore not only the amount of moisture loss is important, but also the timing. In multi-stage machines the moisture loss is almost linear, because humidity and ventilation setpoints are fixed. In modern gas tight single-stage incubators the humidity during the first days of incubation is very high, because the ventilation is usually kept closed. Thus the eggs lose relatively less moisture during the first days, which is compensated by a low humidity and hence increased moisture loss during the last week in the setter.

There is no evidence that a slight non-linear weight loss per se influences chick quality or hatchability. But a steep one, when keeping the damper closed in modern gas sealed incubators for more than seven to ten days might be negative for layer type breeds. However some manufacturer promote it, as it has other benefits that will be discussed in the next paragraphs. The system has been developed for broilers but has not been proven to be very successful with layers.

The second important feature of humidity is the heat capacity of water. Air is able to carry more heat the higher the humidity (content of water) is. This is easy for everyone to notice when pouring water on the rocks in a sauna.

Air with a high heat capacity inside an incubator leads to a more uniform temperature. Of course this is always an advantage, but during the first days of incubation the embryo is very sensitive to environmental changes and hence can benefit most from a stable one. Additionally, a high humidity can be more easily achieved during the early than the later days, because the oxygen requirement of the eggs and hence the ventilation rate is limited.

As becomes clear at this point humidity and ventilation settings can't be discussed separately. Both partly depend on each other and on the condition of the incoming air. If the incubator is asked to keep a high humidity, when the ventilation rate is high and the water content

of the incoming air is low, it is forced to add a lot of humidity by itself. This water needs to be evaporated, and that takes a high amount of energy. As this energy is provided mainly by the eggs in the machine, it will have a cooling effect on the eggs. The problem with this evaporation is that it happens locally. The eggs that are close to the ventilator and sprayer get all the water and will be cooled a lot. Eggs that are far away will stay warm. This means that high amounts of spraying often lead to non-uniform temperatures of eggs. If water rolls are used instead of sprayers, the effect is less dramatic but will still occur.

The pre-conditioning of the incoming air according to requirements of the incubator (usually temperature 25 °C, humidity 50 % RH) minimise the need for spraying and leads to a more uniform incubation temperature.

One can summarise, that eggs need to loose 11 – 13 % moisture during incubation until day 18.5. This can be achieved by a constant humidity setpoint or by high humidity (87 – 88 °F wet bulb) in the beginning and low humidity towards the end of incubation (81 – 82 °F wet bulb). A slightly non-linear weight-loss can be beneficial, if it leads to significantly less spraying in the incubator. Pay attention that the humidity does not drop too far (35 % RH, 75 °F Wet Bulb) during the second half of incubation. Otherwise the cooling of the eggs can be impaired, because of the low heat capacity.

Ventilation

The primary purpose of the ventilation of an incubator is the supply of oxygen and the removal of CO₂. It is also necessary to remove the water vapour evaporated by the eggs. Depending on the machine type it can also be needed for cooling. The fresh air used for ventilation need to be conditioned according to the requirements of the machines in order to allow them to work at their optimum.

With regard to the whole hatchery the ventilation is also crucial for biosecurity. Via air pressure differences one should make sure that no air can flow from dirty areas of a hatchery (chick processing room, fluff chamber, waste) to clean areas (setter room, egg room). Additionally frequent air exchange helps to dilute aerial contamination. Finally one should not forget that ventilation should contribute to provide suitable working condition for the hatchery staff.

The suggested air volumes for setter and hatcher rooms allow for both the requirements of the machines themselves and the room. **Because the machine requirements will vary from day to day, excess air must be allowed to exhaust from the room without passing through the machines.** As the ventilation systems differ, we recommend to always seek the advice of the manufacturer.

The ventilation of the individual incubator should be based on the oxygen requirements of the embryos. These are very limited during the first seven to ten days of incubation, rise rapidly after eleven to twelve days and reach a plateau after 17 days. To meet the oxygen demand one can either set the ventilation rate for different stages of incubation or let the damper be steered by a CO₂ sensor. The latter has the advantage of automatically adapting the ventilation to the number of fertile eggs in the incubator. Based on observation in practise

Table 1:
Air volume guidelines for hatchery ventilation

Room	Air exchange (m ³ / hour)	Air pressure
Egg holding	1 – 2 m ³ /h per 1000 eggs	+
Setter	5 – 10 m ³ /h per 1000 eggs	++
Hatcher	15 – 20 m ³ /h per 1000 eggs	+
Chick holding	30 – 40 m ³ /h per 1000 chicks	–
Hallways	Air exchange within 5 – 10 minutes	Neutral
Chick Take-off / Waste/Wash areas	Air exchange within 0.5 – 1 minute	--

one should aim at a CO₂ value between 0.2 % and 0.4 %. Higher CO₂ values up to 1 % are not lethal, but also a positive effect has not been proven for layer chicks. As far as our experience goes, the CO₂ is just a hint for the right air exchange. Measuring CO₂ can avoid unnecessary ventilation and by this way contribute to a stable incubation climate. On the other hand it can also detect ventilation problems. There is probably no specific CO₂ value needed for good embryonic development. By rule of thumb, if the ventilation settings are correct for any one setter or hatcher, the CO₂ will be found to be correct.

If one prefers to allow a ventilation range, which is controlled by the humidity, it is a must to set a minimum ventilation rate. It has to be high enough to assure the sufficient supply of oxygen and removal of CO₂.

Turning

During natural incubation the adult bird will periodically rise from the nest to move its eggs around. This turning was recognised to be important for the incubation success and is implemented in today's hatchery practise. It is beneficial by preventing the embryo from sticking to the shell membrane and promoting the utilisation of the albumen.

By tradition, eggs are turned hourly by 45° throughout the setter period. The results of trials using more often or less turning are so far inconsistent and turning 24 times per day is still recommended.

Research has shown, that day 3 to 7 is the most critical period for turning, as failures during this time have the highest impact on hatchability. On the other hand, there seems to be no need for further turning after twelve days of incubation. In single-stage incubators, this could save energy by switching off the turning device. To our knowledge this is so far not implemented in commercial hatchery practise.

Do the basics right

1. Do not set eggs the day of lay.
2. Pay attention that no egg sweating occurs when moving the eggs in the setter room.
3. Properly pre-warm the eggs, especially, if they are going to be set in a multi-stage incubator.
4. Only set eggs in well cleaned and maintained machines. Check heaters, coolers, humidifiers, turning device and dampers.
5. Check that the trolleys are properly connected to the turning device.
6. If necessary, add empty trolleys with empty trays to fill up the machine completely.
7. Control the incubator temperature and humidity by using a mercury door thermometer or a good electronic device. Calibrate if necessary.
8. Check egg weight loss and eggshell temperature regularly to fine tune the incubation program.
9. Check, if the conditions of the incoming air meet the requirements.

Candling and transfer

Candling

Candling is a means of identifying infertile and early dead embryos. Trays of eggs are passed over a strong light source which clearly shows infertile and early dead embryos. Candling is not routinely done in every hatchery, because it requires extra equipment and labour. However we recommend to candle a sample of each flock weekly to monitor the status of the breeders. If candling percentage exceeds 10 %, then all eggs should be candled, the clear eggs removed and hatcher trays refilled to 95 – 100 %. This will improve the technical results.

Candling is usually done between day 9 and 10 or included in the transfer routine. If done at transfer often an automatic candling machine with egg remover is used to keep pace. These machines are quite expensive and do not pay off for small hatcheries. Used in many hatch-

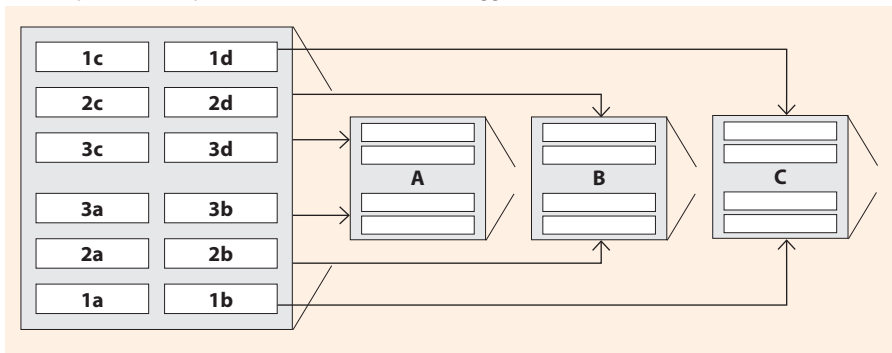
eries is a candling table, which illuminates an entire setter tray from beneath. Ideal for candling samples is a spot candler. It is by far the cheapest and most accurate method, but requires some training and is more time consuming when doing big numbers.

If candling is combined with the breakout of clear eggs, it is the best method to identify fertility (see chapter “Breakout analysis” for more details). Eggs set upside down, cracked eggs and other second grade eggs can be also noted at this stage. Such a candling breakout analysis can be an important part of the quality control program of a hatchery.

Transfer

The setter trays are designed to maximise the amount of eggs that can be set in an incubator and to allow an easy turning of the eggs. However they are

Chart 5:
Transfer pattern example for three different batches of eggs set in one incubator



Petersime (2009)

Candling and transfer

not suitable for hatching, because of the simple reason that the chicks would fall down from the trays. Therefore the eggs are removed from the setter after 18 – 18.5 days, transferred from setter trays to hatcher baskets and put in separate hatcher cabinets. In this way the transfer helps to keep the large quantity of fluff generated during hatching away from the clean areas of the hatchery.

When different batches of eggs are set in one incubator, one should separate them during transfer into different hatcher (if machine capacities allow). This will harmonise the hatching process, reduce the spread of hatch and improve chick quality. However a completely filled hatcher with different batches of eggs is preferred to one only partly filled.

Very important during transfer is to assure a smooth process. The Staff should understand that the growing chick has used calcium from the shell for growth and shells are very fragile at this stage.

Do not expect any chick from an egg that got cracked.

The temperature in the transfer room should be at least 25 °C / 77 °F and no trolley should be outside of an incubator for more than 30 minutes. If the transfer is well organised, each trolley (approx. 5000 eggs) can be done in less than ten minutes. This avoids an excessive, uneven cooling of the eggs, which would increase the spread of hatch. Of course transfer should only be done into clean, warm and dry hatcher baskets and hatcher cabinets.

Do the basics right

1. Clear eggs are not all infertile. You have to open the eggs to differentiate between infertiles and very early deads.
2. Candling, removal of clear eggs and refilling of the trays is recommended, if percentage of clear eggs exceeds 10 %.
3. The temperature of the transfer room should be at least 25 °C / 77 °F.
4. Egg candling and transfer should not last longer than 30 minutes per trolley.
5. Only transfer eggs into a clean, dry, disinfected and heated up hatcher.
6. Preferably set only one batch of eggs per hatcher.
7. Hatcher baskets have to be clean and dry.
8. Baskets are best warmed inside the hatcher and taken out directly before use.

The hatching cycle

In the hatcher the eggs will stay for three days. During this time the embryo will develop into a chick. After 19 days of incubation it will penetrate the inner shell membrane and lung respiration will start. The additional available oxygen enables the chick to break through the shell and hatch.

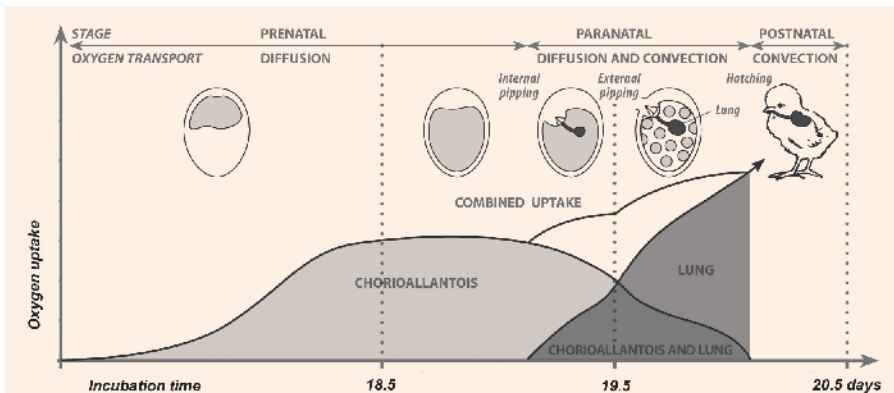
Naturally not all the chicks will hatch at the same time. The time frame during which 99 % of the chicks hatch is called "spread of hatch" or "hatch window". Even under good conditions it can't be much shorter than 24 hours. The spread is caused by natural variation in egg quality, egg weight and by varying conditions during egg handling and incubation. The latter especially can cause a hatch window as wide as 2 days

or more. By this, chick quality will greatly suffer, because the first hatching chicks will have to wait a long time in the hatcher, before they are pulled, processed, transported and finally get access to feed and water.

The hatch window can be easily monitored by taking out three hatcher baskets at several times during the hatching cycle and counting the number of chicks that hatched so far. 36 hours before pull there should be a maximum 1 % and 24 hours not more than 25 %. Twelve hours before take-off one should aim for approximately 75 % hatched chicks and six hours later for 99 %. Then there is still enough time for the last chicks to dry before they are pulled.

Collecting this information and analysing it helps to find the correct setting time according to egg and flock age. If

Chart 6: *The hatching cycle*



Adapted from Rahn, Ar, Paganelli (1979)

early or late hatching occurs, one should also keep an eye on the incubation conditions. Are the machines properly calibrated, are they evenly filled, is the temperature of the incoming air on target, is the spraying nozzle working properly and not too often, is the ventilation correct, did any delays occur during transfer, has the temperature been lowered too early in the hatcher ...?

Monitoring chick yield

Monitoring the weight of the chicks, and their relationship with the weight of the eggs they came from (chick yield) is another hatchery management tool to control the incubation success and find the optimal setting time for the eggs. It is best done using the trays where egg weight loss has already been monitored. The technique involves counting and then weighing in bulk the Grade-A chicks from a hatcher basket in order to calculate the average chick weight and then the chick yield. Chick yield is the average chick weight divided by the average initial egg weight multiplied by 100. An ideal target for best chick quality is a chick yield of 66 – 67 %.

If the egg weight loss during incubation has been correct, but the chick yield is lower than 65 %, then incubation duration is too long. It needs to be adjusted by setting eggs later or by pulling chicks earlier. Every 1% loss in chick yield is equivalent to about four hours extra under optimal condition in the hatcher.

Hatcher operation

It is beyond the scope of this guide to provide you with a detailed program for your hatcher. As the design of the machines differ, always seek the advice of your manufacturer and specify what kind of bird you are hatching. Please consider this chapter as additional information that can help to fine tune the conditions to the needs of the hatching chicks.

Temperature, humidity and ventilation set points are in most hatcheries changed according to time during the hatching cycle. It is either done automatically by a hatcher program or manually. This works and has been proven over many years in commercial practise. However it will never fully optimise the process, as no two batches of eggs are exactly the same and will thus not show the same hatching time. For this reason many incubator manufacturers strive to enable modern hatcher to monitor CO₂ and humidity changes and based on this detect the status of the hatch.

Much more simple, and probably more cost efficient for small and medium size hatcheries, is to open the hatcher one or two times, have a look at the chicks and change the setpoints, if necessary. Beside the number of chicks hatched so far one should pay attention to the behaviour. If the condition are alright, the chicks are quiet and evenly spread in the baskets. Of course once the door is opened, or light is switched on the chicks will start to move towards the light.

Hatcher

If the chicks are noisy and/or move towards the pulsator (area with high air speed, cool air) and put their beaks out of the basket, the temperature is too high. If they start panting, it is far too high. If they huddle together in a corner of the basket, it is too cold. In that situation you would later also find many piped eggs in the baskets at chick take-off.

If you notice lethargic heavily breathing chicks, the CO₂-level in the cabinet is too high. This is caused by a low ventilation rate of the hatcher itself or of the hatcher room. Whereas the CO₂ concentration in the room should be close to the one of fresh air (0.036 %), it is normal that the concentration in the cabinets during hatch rises to 0.5 – 0.6 % sometimes up to 0.8 %. Higher values should be avoided as they might compromise chick quality.

In addition to temperature and ventilation, the humidity is also important for a successful hatch. The following general guidelines for the hatcher operation includes all three variables:

1. Keeping the damper closed to 15 % and increasing the temperature by 0.2 °F helps to quickly bring the eggs back to incubation temperature after transfer. After six hours one should return to the normal settings, which depend on the incubator model. The humidity is usually kept at 84 °F wet bulb, respectively 55 % RH during this stage. Keep in mind that setpoints might need to be adapted, if you do the transfer earlier or later than usual. The CO₂ level is 0.3 – 0.4%.
2. Once the chicks start to hatch you will notice a natural increase of humidity. There is no demand for humidification at this point. If you notice no rise in humidity, check if you need to reduce the ventilation rate. As the ventilation is kept relatively tight to promote the humidity build up, also the CO₂ level might rise up to 0.7 – 0.8 %.
The temperature can be lowered by 0.2 °F.
3. When half of the chicks are hatched the humidity should be approximately 92 °F / 75 %. If it is lower, humidification is required to keep it at the target level.
The high humidity helps to achieve an even temperature, slows down the drying process of the chicks and supports the late hatching chicks by keeping the shell membranes soft.
The temperature can be lowered by 0.2 °F. Do not lower the temperature if the hatch is not on time!
4. When all the chicks are hatched one should aim to create optimal conditions for the chicks to wait in the hatcher until pulled. The humidity setpoint can be reduced to 85 °F / 60 %, the ventilation opened to decrease the CO₂ level below 0.4 % and finally the temperature should be set accor-

Hatcher

ding to the optimal body temperature of the chicks (see next chapter).

5. The chicks are ready to be pulled when they are dry, some still showing slightly wet feathers in the neck. The legs of the chicks should feel smooth. They will feel rough when the chicks start to dehydrate.

Do the basics right

1. Control the hatcher temperature and humidity by using a mercury door thermometer or a good electronic device.
2. Do not fully rely on electronics! Watch the chicks one or two times during the hatching cycle to judge the conditions. Do not be afraid to open the doors. The chicks should be evenly spread and quiet.
3. Even though the humidity is rising during hatch, the cabinet walls and the floor should be kept mostly dry. A wet floor in combination with chick fluff is an ideal breeding ground for germs. Avoid too cold cooling water, which causes excessive condensation on the coils.
4. Check the chicks in the morning on hatch day to schedule the sequence of chick pull. If the chicks in general are too dry or too fresh, search for possible mistakes during incubation. If everything was alright, rearrange the setting times.

Chick processing

Chick Temperature

The chicks are now hatched and ready to be processed. But even a good hatch can still be spoiled. Hygiene, careful chick handling and attention to the chicks are essential for maintaining the best quality. The chicks tell you by their behaviour and noise if they feel good or not. If they do not, the problem should be investigated and solved.

Scientific trials as well as hatchery and brooding practise have shown, that the body temperature of a chick is one indicator for its well being. Occasionally measuring the rectal temperature of a representative sample of chicks can help to identify weak points in the process and by this contribute to safeguard chick quality. The rectal temperature of a day-old-chick measured by an infrared ear thermometer should be preferably in a range between 39,5 and 40 °C.

Checking the chick temperature directly after chick pull gives information about the conditions in the hatcher. This can be used to adapt the temperature profile if necessary for the next hatch. It is normal that the chick temperature drops temporarily during sexing and vaccination. After the processing is completed and the chicks stay in boxes in the holding room the body temperature should be back in the optimal range.

Chick processing

Chick Take-off and Sexing

All Lohmann varieties on the commercial level are either colour or feather-sexable. If the breed allows for colour sexing, it is usually done directly at chick take-off, whereas the gender sorting of the other breeds is done as a second process. Those readers who are interested in getting more information about the sexing are referred to the appendix of this guide.

To achieve optimal conditions during take-off one should consider the following recommendations.

- There should be a separate chick take-off room to keep the fluff away from chick vaccination.
- From a hygienic point of view taking out the chicks by hand is preferred to the use of a separator.
- Do not pull too many trolleys at once. It is a common finding that chicks overheat when chick trolleys are waiting in an aisle or other holding areas with insufficient air movement.

Day-old-chick Vaccination

Chicks can be vaccinated in the hatchery by injection, spray or eye drop. Regardless of the route of administration there are three different factors that influence the success of the vaccination:

1. Physical factors – needle damage/
chilling/ spray particle size

2. Contamination
3. Under/over dosage (inappropriate vaccine strain)

Every layer chick is vaccinated by injection against Marek's disease. There are several vaccines from different producers available. Check requirements in your country.

The Marek's vaccine virus is cell-associated. That means that the virus is grown in tissue culture and the live cells are harvested and frozen in liquid nitrogen to be able to store them. The viability of these cells must be maintained throughout the preparation and injection to maintain the right vaccine titre. If the cells get killed because of wrong temperature or rough handling (squeezing through small needles) the titre will drop and the chicks will not get the necessary vaccination dosage.

Some practical guidelines are listed below:

- There should be dedicated clothes for people working in the vaccine preparation room
- Regular control of the nitrogen tank and record in a logbook is necessary
- Do not take the entire can out of the tank
- Expose only the ampoule(s) to be used
- Thaw ampoules in 27 °C water bath by gently swirling
- Best use distilled water in the bath (or clean fresh tap), change it daily

Chick processing

- Once vaccine has become liquid, remove ampoule from the water bath
- Use new sterile syringe with a new needle (18 Gauge)
- Maximum of 5 – 6 ampoules should be prepared at a time
- Dry ampoule before opening
- Never refreeze thawed vaccine
- Diluent should be clear, not cloudy
- Gently draw up vaccine from the ampoule and add to the diluent bag
- Complete process (thawing + adding to the diluent) in 90 sec or less
- Gently swirl and invert the diluent bag several times
- Record the time of preparation on diluent bag
- Keep the ready prepared bags at a temperature of 15 – 25 °C

During the application of the vaccine it is important to:

- Use sterile infusion kits.
- Use the vaccine within 2 hours after preparation.
- Not allow contaminated air to enter the vaccine bags. Use air inlet filters.
- Keep the vaccination equipment clean throughout the hatch day.
- Change needles frequently (every hour).

Beside the vaccination against Marek's disease, often a spray vaccination against Infectious Bronchitis is done at the hatchery. Prior to use, the vaccine is dissolved in water, after which it expires within hours. Therefore it must be used

immediately after preparation. The water serves as a transport medium for the live virus to the chicks.

Once sprayed the virus will attach to the mucosa cells of the chicks' eyes and upper respiratory tract. The cleaning of the feathers with the beak will optimise the uptake.

When using spray vaccination it is important that the droplet size is not too small (at least 100 – 150 microns).

The spray must not look like a steam. Such small droplets will be inhaled too deeply, which can result in post-vaccination reactions.

When preparing the vaccine it is important that there is dedicated equipment only for this purpose. Any disinfectant present can kill the virus. Make sure that the water is of good quality (no chlorine, low mineral content) and that all the chicks are sprayed evenly.

Chick Holding and Transport

The behaviour of the chicks is the best indicator of the climate conditions during chick holding and transport. Under optimal conditions the chicks are mostly quiet, breathe calmly through the nostrils and are evenly spread within the boxes. If it is too hot the chicks will start panting, which leads to increased moisture loss and dehydration. If it is too cold the chicks will huddle together.

Chick processing

Chilling is likely if wet chicks (pulled early, vaccinated by spray) are placed in a store with high air speed or too cold temperature.

In general an air temperature between the boxes of 25 – 27 °C (77 – 80 °F) and a relative humidity of 50 – 60 % is recommended. However not the room temperature, but the temperature inside of the boxes is crucial for the well being of the chicks. Usually it should be 33 – 35 °C (91 – 95 °F). So the optimal room temperature differs depending on the air movement in the room, the type of the boxes, the way of stacking and the number of chicks per box. In order to give the chicks a good rest the holding room should be kept dark. Light should be only provided if the chicks received feed.

It is a good practise to check the conditions during holding and transport with a data logger.

If the chicks are scheduled for a long journey they benefit from extra moisture, that can be given during vaccination without extra handling. When applying the injection subcutaneously the diluent volume can be increased to 0.5 ml. Of course the vaccine dosage should stay the same. Therefore a different size of diluent bag has to be used. The volume for an intramuscular injection should not be bigger than 0.2 ml to avoid tissue damage.

Do the basics right

1. Always pay attention to the behaviour of the chicks. It is the best indicator for their well being.
2. Prepare the vaccine in a separate, clean room.
3. Don't allow unfiltered air to enter the vaccine bags or bottles.
4. Keep the vaccination equipment clean throughout the hatch day. Change needles regularly.
5. Temperature of the chick processing and holding room should be approximately 25 °C (77 °F).

General hygiene

Good hygiene is paramount to good results. Not everyone has modern, state-of-the-art designer hatcheries but with attention to detail the results can be as good. Starting with personnel, they should be provided with shower facilities and clean clothing daily and showering must include the head. The clean clothing should be placed beyond the shower and the whole ablution block should always be kept very clean. Staff must not leave the building until they stop work.

Visitors should be minimal and must also go through the same process. This must include persons brought in to mend and maintain equipment if it is beyond the experience of your own staff.

In the hatchery itself each section should be kept separate with mats soaked in disinfectant in each doorway and plastic doors will help to reduce problems and keep the airflow in different rooms separate. In many hatcheries now, rooms are separated by solid doors but unless controlled with sensors they are often left open which alters the pressure and compromises biosecurity. The more sophisticated the system and design the easier this is but on the other hand there is far more to go wrong and far more nooks and crannies to keep clean, air socks, conduits, pipes, tunnels etc. The frequency of opening doors should

be minimised to prevent air drawing from one room to the other. In critical areas of the hatchery, the air is maintained at a positive pressure, so contamination can not be drawn in through an open door. Doors, including one-way doors, help stop cross contamination between rooms.

Chick fluff can be a problem to human health and good airflow and a specially designed fluff tunnel will remove fluff which is also a carrier of any disease organisms present in the hatchers. Samples of fluff and also samples of meconium should be regularly monitored in your own or a veterinary laboratory.

The hatchery rooms must be kept clean and this includes all surfaces including the ceilings, ledges and tops of machines. Each room and each machine should be cleaned after use and contact plates should be examined regularly by yourselves or veterinary services to identify any problems. Many hatcheries do not have good enough facilities for filtering air so that bacteria and fungal spores can easily be drawn into the system. The latter can be a problem in some climates and vigilance is necessary. Good monitoring will tell you precisely where a problem might be developing and then you can take action.

It is as well to remember that staff can be carriers of many potential disease bacteria and viruses although it does not affect them in any way. Some hat-

cheries make a point of checking staff and if a problem is found that person can be kept out of the buildings until treatment has been effective.

As staff do not leave the building for meals it is usual to supply a canteen. In some hatcheries mixing of staff from one section to another is forbidden yet at mealtimes they all come together!

In a clean hatchery problems are unlikely but washing hands before and after using the canteen and strategically placed disinfectant mats in the doorways will minimise any disease problem. Large modern hatcheries are equipped with separate canteens for the staff working in the clean or the dirty area in order to avoid the crossing of people.

As with the ablution block, the canteen should be cleaned daily and waste etc. removed. The canteen should be after the shower block so that the staff can leave their food there before entering the main building.

Develop a good relationship with your veterinary services and be aware of regulations in your own country which might affect the hatchery.

Cleaning

For every hatchery room, instructions for cleaning and disinfection should be formulated and pinned up in the particular room. When formulating instructions for

cleaning rooms and equipment, keep the following aspects in mind:

1. First, all debris such as fluff, blood, eggshells, broken eggs and dirt needs to be removed. Since organic material inhibits the chemical action of disinfectants, it is very important that all surfaces to be disinfected are free from debris before applying the disinfectant. Depending on the degree of soiling this is done by:
 - First dry cleaning with a vacuum or sweeping.
 - Soaking of the surface with a foam-cleaner. PH of the detergent should be changed periodically (for example 3 weeks alkaline, 1 week acid) to remove potential biofilms and mineral deposits
 - Rinsing with water
2. Allow to dry.
3. After the surfaces are clean and dry apply disinfectant. A wet surface will dilute the disinfectant and reduce its efficacy. Read the label closely and follow instructions. Factors affecting the efficiency of disinfectants are: contact time, temperature, concentration, pH, nature of soiling and compatibility with detergents.

Table 2:
Room cleaning frequency

Egg receiving / handling room	Once every week
Egg storage	Once every week
Setter room / hallways	Once every week
Setters	After each incubation cycle
Egg transfer room	After each use
Hatchers	After each use
Chick handling rooms	After each hatch
Chick despatch room	After each use
Racks, trays, baskets, boxes	After each use
Egg and chick trucks	After each egg / chick delivery

Hatchery microbiological monitoring²

Microbiological monitoring is an essential element of any hatchery quality assurance programme for the evaluation of cleaning and disinfection procedures. It is crucial to conduct the monitoring programme regularly. Here, guidelines are given describing basic monitoring procedures to evaluate the success of hatchery cleaning. A more intense monitoring programme should be used to solve a specific problem and would include egg washes, chick sampling and bacterial identification.

To evaluate the effectiveness of a sanitation programme, the assessment of cleanliness and sanitation should be

performed only after clean up has occurred. For microbial monitoring, use is often made of solidified agar in Petri dishes containing nutrients that match the metabolic needs of bacteria and fungi. Bacteria and fungi grow on this media when put in an incubation cabinet. They will multiply and become visible as colonies. The number of these colonies indicates the hygienic state of the surface or air sampled.

Flat surfaces

Rodac plates are plastic plates of which the bottom side is filled with agar gel. This agar layer is slightly higher than the edge of the plate so that direct contact is made with the surface to be sampled.

² *Incubation Guide Layer Version 2008, Pas Reform.*

Hygiene

Remove the cover of the plate, press the agar gently upon the surface to be monitored (do not move while contact is made). The cover should be replaced after the impression is made, taking care not to touch the agar.

To detect fungi one can use Sabarrouh plates in the identical manner.

Air

The same plates can be used to monitor the microbiological status of the air. Expose the plate with the selected media, by carefully placing the plate, media half on the bottom, on a flat surface within the environment to be monitored. Gently remove the cover and let the plate rest. For relatively clean areas, a 10 minute sampling time is sufficient.

The agar plates which are being evaluated for bacterial contamination should be incubated for 48 hours at 37 – 37.5 °C in a microbiological incubator or a setter (place the plates in a plastic bag and set

where they will not be disturbed). Plates are incubated upside down so that drops of condensation will not fall on the inoculated surface.

After incubation, the colonies on the agar media can be counted and recorded. The evaluation and monitoring of the hygiene conditions should be based on the hatchery's own criteria. In general, excessive colonies indicate poor sanitation procedures or a hatching egg production problem.

For detailed advice on sampling, reading and evaluating agar plates, see instructions and advice of manufacturers of agar media.

It is advisable to maintain records of all results so that changes occurring over time can be observed in the different areas monitored. Also, the results should be carefully compared with liveability data.

Table 3:
Recommendations for a hatchery monitoring program

Sample type	Place of sampling	Frequency	Number
Contact plates	Surfaces	Every two weeks	20
Contact plates	Air	Every four weeks	20
Meconium	Chick take-off	Every hatch	1 pool of 250 chicks
Fluff samples	Hatcher	Every hatch	Every hatcher

Do the basics right

1. Make sure staff are trained and understand the importance of good hygiene.
2. Check that incoming eggs are clean.
3. Check that soap/hand disinfectant are available daily and that they are being used.
4. Check that mats are soaked in disinfectant.
5. Physically check for accumulated dust/debris on surfaces at all levels.
6. Physically check that all filters are cleaned regularly.
7. Check that all doors are closed between rooms.
8. Physically check equipment after cleaning.

Taking the hatching egg quality as given, an embryo needs five things to grow satisfactorily and to develop into a healthy chick:

1. Correct incubation temperature.
2. Adequate supply of oxygen and removal of CO₂.
3. Loss of a certain amount of water as moisture vapour.
4. Regular turning.
5. A hygienic environment.

If you have a problem with hatchability or chick quality, check these to find out if it is caused by the hatchery. Detailed information about the conditions 1 – 5 are provided by the previous chapters.

When trying to solve a hatchability problem always be aware that it can be also related to egg handling, egg transport or the breeder flock itself. With regard to quality, the performance of the chicks and the mortality during the first week is additionally influenced by the chick handling procedures, vaccination, transport and the brooding conditions on the farm. Therefore good communication between the different parts of the production chain is essential to locate and solve any occurring problem.

The exchange of information between the breeder flock manager and the hatchery manager is especially important for the success of a parent stock operation.

Breakout analysis

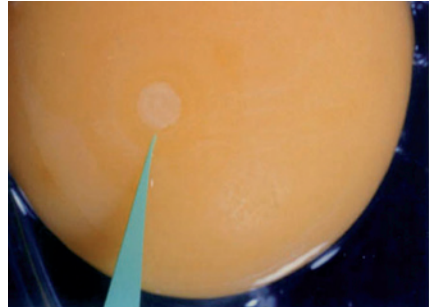
Breakout analyses are useful hatchery management procedures that provide valuable information by helping to relate problems to the breeder flock, the egg handling procedures or the hatchery.

There are three procedures for breakout analysis which can be implemented by a quality control person. Each of the methods has advantages and disadvantages when compared to other methods. The data should be used to continuously control the production procedures and find room for improvement. If a database has been built up, it can be used for a quick and precise troubleshooting if problems occur.

1. The quickest way to estimate the fertility in a breeder flock is a fresh egg breakout. The eggs can be opened just after lay or after arrival at the hatchery. The disadvantages of this breakout method are the loss of valuable hatching eggs, possible errors of prediction because of the relatively small sample size (usually 100 eggs per flock) and the one-dimensional information (fertile or not fertile). It is therefore recommended to limit the use of a **fresh egg breakout** to situations where a short-term fertility check is required:

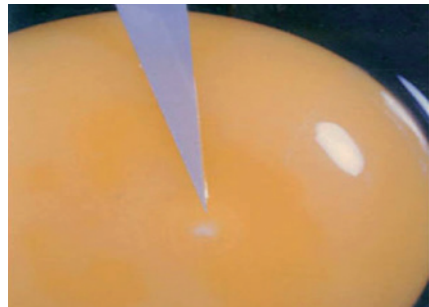
- Planning the first setting of eggs from a young flock.
- Problem flocks.

Infertile and unincubated fertile eggs can be differentiated quite precisely after some practical training.



A fertile egg

- Blastoderm (embryo) always round
- Doughnut shape
- White symmetrical ring with clear centre
- Sometimes white dot present in centre
- Larger than blastodisc



A true infertile egg

- Blastodisc (unfertilised oocyte) rarely perfectly round
- Jagged edges
- Usually more vacuoles (bubbles)
- Small intense white spot, sometimes granulated

2. The **candling breakout** analysis offers the most accuracy in determining fertility. It is also useful in recording other sources of breeder flock or egg handling failures, such as early deads, cracked eggs or eggs set upside down. It is therefore a recommended tool to monitor the week-to-week status of the breeders.

Additionally the candling percentage allows a quite precise prediction of the expected hatch of saleable chicks. As the candling is usually done at day 9 – 10 there is time to react (rearrange settings, shipments ..., search for and solve causes) if a high number of clear eggs is noticed. The sample size should be 4 to 6 trays (at least 600 eggs) from different location inside of one setter.

3. Most often performed in hatcheries is the breakout on hatch days also called **hatch debris breakout**. It gives a full picture about the pattern of embryo mortality, but infertiles and early deads are difficult to distinguish and there is a time delay of usually 4 weeks (3 weeks incubation + 1 week storage) between the date of lay and the breakout.

To proceed take 4 to 6 hatcher baskets of one flock from different position out of one hatcher. Remove all unhatched eggs and place them on pulp trays. Record the number of cull and dead chicks left in the baskets. Classify the unhatched eggs into

appropriate categories, as Infertile, Early dead (day 1 – 7), Mid dead (day 8 – 17), Late dead (>18), Pipped and Contaminated. Additionally the egg shell should be judged and cracked eggs also recorded.

As already mentioned, the differentiation between infertile eggs and very early deads is difficult, because the blastodisc can often not be found. Therefore one needs to judge the appearance of the yolk and the albumen. If at hatch day the egg looks still like a “table egg” it was most probably infertile. If you deal with a very early dead the yolk colour will slightly change and the albumen will be thinner.

The content of eggs containing embryos that died during the second week of incubation will often appear black, because of the breakdown of blood. Be careful not to classify these eggs as contaminated as long as they do not emit an odour.

If breakouts are done regularly with an adequate sample size the use of more categories (Day 1 – 2, Day 3 – 4, Malformation, Malposition, Internally pipped, Pipped alive vs. dead ...) can provide additional information, which might be overseen using a more simple approach.

All results from breakout analysis should be expressed as percentage of eggs set. So if there are 3 cracked eggs in tray of 150 eggs the result is: 2 %. The breakout data should be analysed by using stan-

Troubleshooting

dards based on the results of the individual hatchery. From time to time the standards should be compared to results achieved in other hatcheries. If you notice elevated percentages in single categories have a look at the appendix where you will find a comprehensive listing of the probable causes.

Practical troubleshooting based on technical service experience

1. Problems usually show themselves on hatch day, so trouble shooting begins here.
2. If apparently healthy chicks reach the farm but early mortality is seen work backwards.
3. Was the farmer properly prepared? Was early mortality just seen on this farm? If so the problem is likely to be something the farmer hasn't done or a problem with the transport.
4. What caused the early mortality? Seek veterinary analysis. Aspergillosis may be from the chick litter, unhygienic transport or disease originating in the hatcher or on the farm.
5. Aspergillosis is most likely to originate from a hatcher which has not been well sanitised or the breeder farm. The inclusion of floor eggs in the setters, dirty nests, litter which contaminates eggs. In the setter and hatcher, a contaminated egg can spread this disease to other eggs. Salmonella, Staphylococcus and many others can be spread in the same way.
6. E coli, commonly found on veterinary analysis usually develops through stress, getting too hot or too cold during processing and holding before dispatch.
7. All these diseases can multiply very rapidly during vaccination. The greatest care needs to be taken here, in regard to equipment, technique and general hygiene.
8. Poor hatch results, from one setter or one hatcher, or the whole hatch must be investigated. Breakout analysis will help you here. Obviously diseased chicks may be due to less than ideal conditions on the farm and spread through exploding eggs at any time during incubation.
9. Too many late deads or pipped eggs which fail to hatch. Many possibilities e.g. if chicks are stuck to the egg shells and are dry the humidity in the hatcher was too low. Conversely the chicks may be too soft and not alert and unable to hatch due to too much humidity. Formalin disinfection during the hatch often increases late deads. Too high temperature during last days in the setter can also reduce the hatch.

Troubleshooting

10. Too many early deaths may be due to formalin disinfection being overdone on the farm or in the hatchery. Problems may also be due to feed formulation, vaccination or other treatment of the breeding stock. Some of these problems may be solved by, for instance, a new delivery of feed, before the next hatch. Setting eggs as soon as they reach the hatchery – allow 24 hours rest, or more if they have been shaken during transport by rough roads. Fluctuating temperatures from collection to hatchery egg store.
11. Learn to recognise a truly infertile egg. The skill is easily learnt. Complaints of high infertility often are inability to recognise the stage before a blood ring is seen
12. Hatch window is too long. This may lead to some chicks being over dry and some freshly hatched.
13. Any setter or hatcher giving a problem should be thoroughly cleaned and disinfected, very carefully monitored and adjustments made for the next several hatches. Electronic settings can wander which may lead to less than satisfactory results and such things as blocked nozzles and dirty filters which interfere with air flow and humidity control can lead to poor results.

Do the basics right

1. If a problem occurs, check the basics first.
2. Collect data regularly – also from good hatching flocks – to create your own database. Keep the records simple enough. You need to work with them.
3. Do not take actions just because of the results of one breakout. Check the same flock again incubated in a different machine or vice versa.
4. Assure a good communication along the production chain, especially between the breeder farms and hatchery. This will not prevent problems, but significantly minimise their economic impact.

Appendix

Incubation guidelines

The program was experienced with conventional Petersime equipment. It also works well with other types of incubators, but needs to be adapted to the

individual conditions of each hatchery in the light of experience. Always seek the advice of the manufacturer and ask for their recommendations for the incubation of layer eggs.

Table 4:
Single-stage incubation program

Day	°C	°F	Wet °C	Wet °F	CO ₂
1	37.8	100.0	29	84.2	0.1
2	37.7	99.9	29	84.2	0.1
7	37.6	99.7	29	84.2	0.2
12	37.5	99.5	29	84.2	0.3
15	37.4	99.3	29	84.2	0.4
16	37.2	98.9	29	84.2	0.4
Preferably transfer between day 18.0 and 19.0					
19	37.1	98.7	30	86	0.6
20	36.8	98.2	31.5 - 35.0	88.7 - 95.0	0.8
21	36.5	97.7	35.0 - 29.0	95.0 - 84.2	0.3

Hatchability problem analysis³

Sign	Causes
<p>1. Sign Eggs candle clear; broken out eggs show small white-dot germinal discs; no blood. Infertile</p>	<ol style="list-style-type: none"> 1. Immature males. 2. Too few or too many males 3. Extreme weather conditions. 4. Breeder flock disease. This is often indicated by rough, misshaped, or thin-shelled eggs. 5. Nutritional deficiencies or excesses; 6. Feet and leg problems, bad quality males should be taken out. 7. Certain drugs, pesticides, chemicals, toxins, or mycotoxins. 8. Parasites, such as mites. 9. Inadequate floor space. 10. Decreased mating frequency, or no mating, is commonly seen in many of the conditions listed above; this may often be the direct cause of infertility. 11. Inadequate lighting (intensity or day length). 12. Improper artificial insemination procedures (if artificial insemination is used).
<p>2. Sign Eggs candle clear; broken out eggs show enlarged germinal disc; no blood. Fertile. Very early dead.</p>	<ol style="list-style-type: none"> 1. Eggs stored too long. They should be stored less than 10 days. 2. Eggs held under poor conditions, temperature too high or too low. Fluctuating temperatures. Temperature should be 60 to 65 °F (16 ° to 18 °C). 3. Fumigation improper – too severe or done between 12 and 96 h of incubation. Incorrectly spraying or foaming eggs with disinfectant. 4. Eggs damaged during handling and transport by jarring, temperature shock (temperature increased or decreased too rapidly), etc. 5. Incorrect temperature during the start of incubation. 6. Very young or very old breeders. 7. Breeder flock diseases. 8. Failure of a basic organ system to develop normally. 9. Egg wash temperature too high. 10. Egg-borne infections (e.g., salmonella). 11. Drugs, toxins, pesticides, etc. 12. Infrequent or incomplete egg collection.

³ Adapted from Wilson (1996)

Appendix

Sign	Causes
3. Sign Eggs candle clear; broken out eggs show blood ring or small embryo that died before 3 days of incubation; no dark eye visible.	<ol style="list-style-type: none">1. Eggs stored too long or under improper temperature.2. Fumigation improper -- too severe or done between 12 and 96 h of incubation.3. High temperature in early incubation.4. Low temperature in early incubation.5. Eggs damaged during transport by jarring, etc.6. Breeder flock diseases.7. Old breeders.8. Embryological development accidents.9. Inbreeding, chromosome abnormalities.10. Severe nutritional deficiencies, e.g., biotin, vitamin A, copper, vitamin E, boron, or pantothenic acid.11. Frequently associated with a high incidence of infertility.12. Drugs, toxins, or pesticides.13. Contamination.14. Embryos less developed at oviposition
4. Sign Dead embryos; 3 to 6 days of incubation; yolk sac circulatory system present, embryo on left side, no egg tooth.	<ol style="list-style-type: none">1. See causes 3.1 – 142. Lack of ventilation, or sealed shells, carbon dioxide >1 %.3. Improper turning -- <1/h or >6/h; improper turning angle.4. Vitamin deficiencies -- vitamin E, riboflavin, biotin, pantothenic acid, or linoleic acid.
5. Sign Dead embryos; 7 to 17 days of incubation; each embryo has egg tooth, toenails, feather follicles (8 days), feathers (11 days).	<ol style="list-style-type: none">1. Improper incubator temperature, humidity, turning, ventilation.2. Contamination.3. Nutritional deficiencies -- riboflavin, vitamin B12, biotin, niacin, pyridoxine, pantothenic acid, phosphorus, boron, or linoleic acid.

Sign	Causes
<p>6. Sign Dead embryos >18 days of incubation.</p>	<ol style="list-style-type: none"> 1. Improper incubator temperature, humidity, turning, ventilation. 2. Improper hatcher temperature, humidity, ventilation. 3. Contamination, especially from moulds (aspergillis, etc.). 4. Fumigation too severe or too prolonged. 5. Eggs chilled in transfer, or transferred too late. 6. Broken shell: pre-set, during incubation, or at transfer. 7. Nutritional deficiencies -- vitamin D, vitamin A, folic acid, or pantothenic acid, riboflavin, vitamin E, selenium, vitamin K, biotin, thiamin, vitamin B12, calcium, phosphorus, manganese, or linoleic acid. 8. Embryonic malposition; embryo fails to move into proper hatching position (see #11). 9. Embryological development accident. Failure to change to lung respiration and all intra-embryonic circulation, and/or to retract the intestinal loops and yolk sac. These and other changes are critical at this time. 10. Poor shell quality. 11. Breeder diseases.
<p>7. Sign Pipped. Full-term embryo, dead in shell.</p>	<ol style="list-style-type: none"> 1. Low humidity or temperature for a prolonged period. 2. Low humidity during hatching. 3. High temperature during hatching. 4. Nutritional deficiencies. 5. Breeder diseases. 6. Poor ventilation. 7. Inadequate turning during first 12 days. 8. Injury during transfer. 9. Prolonged egg storage.
<p>8. Sign Chicks hatch late.</p>	<ol style="list-style-type: none"> 1. Large eggs. 2. Old breeders. 3. Eggs stored too long (1 hour increase in incubation time/day of storage >5 days). 4. Incubator temperature too low. 5. Weak embryos. 6. Low humidity at the start of incubation.

Appendix

Sign	Causes
9. Sign Slow, protracted (drawn-out) hatch.	<ol style="list-style-type: none">1. Mix in the incubator of eggs stored for long and short periods (1.2 % loss of hatch/day of storage when all eggs set at the same time; only 0.5 % loss/day when eggs stored for long periods are set earlier to allow a longer incubation period).2. Mix of eggs from young and old breeders.3. Mix of large and small eggs.4. Improper egg handling.5. Hot or cold spots in incubator or hatcher. Improper working spraying nozzles.6. Fresh air supply with too low temperature.7. Incubator or hatcher temperature too high or too low.8. Room ventilation system improper; high positive pressure or low negative pressure. Such pressures may alter incubator or hatcher ventilation.
10. Sign Trays not uniform in hatch or chick quality.	<ol style="list-style-type: none">1. Mix of large and small eggs.2. Mix of eggs from young and old breeders.3. Mix of eggs from different strains or breeds.4. Some eggs stored much longer.5. Lack of uniform ventilation in setter or hatcher.6. Disease or other stress in one or more breeder flocks.7. Variation in egg storage procedures among flocks.
11. Sign Chicks mal-positioned. Normal position after 19 days of incubation: embryo's long axis same as long axis of egg; head in large end of egg; head to the right and under right wing; beak toward air cell; feet toward head.	<ol style="list-style-type: none">1. Eggs set small end up or in horizontal position.2. Inadequate or improper turning.3. High or low incubator temperature.4. High humidity.5. Old breeders.6. Round-shaped eggs or very large eggs.7. Nutritional deficiencies, especially vitamin A and vitamin B₁₂.8. Eggs handled or stored improperly.9. Retarded development.10. Embryos <18 days old may be in a position different from that for hatching but one normal for their age (for example, the head-between-thighs position). The feet-over-head position is hard to distinguish and may be normal. The beak-over-wing position is maybe also a normal variant. Some malpositions are lethal, others are not.

Appendix

Sign	Causes
12. Sign Malformations.	<ol style="list-style-type: none">1. Improper egg storage.2. Jarring of eggs or transporting large end down.3. Heredity.4. Nutritional deficiencies, e.g., biotin, riboflavin, zinc, or manganese.5. Inadequate turning.6. Improper egg orientation, e.g., small end up.7. High or low incubator temperature.8. Breeder diseases.9. Inadequate ventilation or shells with low porosity or permeability.
13. Sign Contamination. Exploders	<ol style="list-style-type: none">1. Dirty eggs from nest. Dirty nests.2. Floor eggs.3. Bad egg shell quality leading to more hair-line cracks.4. Rough egg handling leading to more cracked eggs.5. Eggs improperly washed; eggs wiped or cleaned with contaminated cloth. Cuticle destroyed by sandpaper or iron sponge.6. Dust from breeder house, cooler, transport, etc.7. Water condensation on eggs (sweating).8. Water sprayed, fogged, or splashed on eggs; eggs dipped in contaminated solutions.9. Contamination from earlier exploders, leakers, or broken eggs.10. Contamination from handling eggs with dirty hands or equipment.11. Contaminated trays, air filters, water (humidity) system.

Sexing Guide

Colour sexing – LB



Most of the **males** are pure white.



Occasionally they show a slight faint striping on a light ground colour



or 2 distinct light stripes with a brown edging



and sometimes one dark stripe in the middle of the back.



Most of the **females** are brown with one light stripe in the middle of the back



or are uniformly brown.



Occasionally they show one broad light stripe with brown edging on a lighter ground colour



or seldom have a brown coloured head and a generally lighter colouring of the body.

Sexing Guide



Females are mostly uniform brown or predominately brown with one light stripe in the middle of the back. Occasionally they show one broad light stripe with brown edging on a lighter ground colour. Seldom they have a brown coloured head and a generally lighter colouring of the body.



Males are mostly pure white, sometimes light coloured showing one dark stripe or 4 narrow brown stripes on the back.

Feather sexing – LSL



Males are slow feathering. In cockerel chicks, primaries (2nd row of feathers) are shorter than or of the same length as coverts (1st row of feathers).



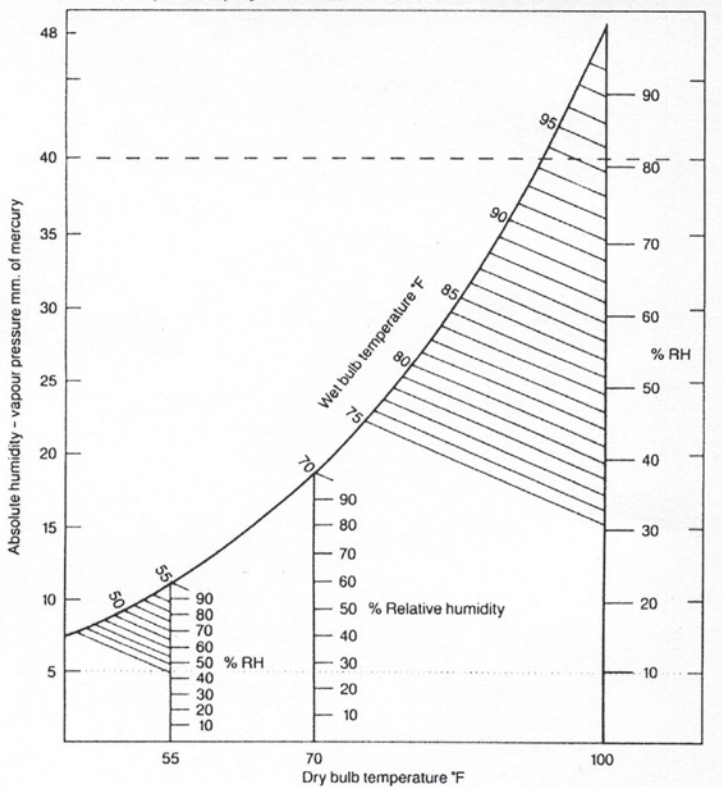
Females are fast feathering. In the pullet chick, primaries (2nd row of feathers) are always longer than coverts (1st row of feathers).

Conversion of temperature and humidity variables

Table 4: °C and °F

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
40	104	35	95	30	86	25	77	20	68	15	59
39	102.2	34	93.2	29	84.2	24	75.2	19	66.2	14	57.2
38	100.4	33	91.4	28	82.4	23	73.4	18	64.4	13	55.4
37	98.6	32	89.6	27	80.6	22	71.6	17	62.6	12	53.6
36	96.8	31	87.8	26	78.8	21	69.8	16	60.8	11	51.8

Chart 7: Simplified psychrometric chart



Reading of the chart allows converting dry and wet bulb temperature in relative humidity values. More convenient is the use of a simple software that can be supplied to those readers who are interested.

How Lohmann Tierzucht is calculating the energy content of feed and raw materials (International WPSA-formula):

$$\begin{aligned} \text{ME MJ/kg} = & \text{ g crude protein} \times 0.01551 \\ & + \text{ g crude fat} \quad \times 0.03431 \\ & + \text{ g crude starch} \times 0.01669 \\ & + \text{ g sugar} \quad \quad \times 0.01301 \text{ (as Saccharose)} \end{aligned}$$

ME = metabolizable energy in MJ/kg **1 Kcal = 4.187 kJ**

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