Benefits of single-stage incubation to food safety

1

www.pasreform.com

by Dr Marleen Boerjan, R&D, Pas Reform Academy

Typically, papers on single-stage incubation focus on the benefits of all-in-all-out incubator management from the points of hatchability (number of chicks) and uniformity (chick quality). Much less is written about the positive impact of single-stage incubation management on hatchery hygiene. Yet when food safety is such a pivotal issue for the modern hatchery, from tracking and tracing to physical hygiene and biosecurity measures, this is a major benefit that should not be overlooked.

Background

Hastings' invention of the forced-draught incubator in 1911 was a great step forward in the technology of large scale incubators. Cooling in these early, forced-draught machines was mainly based on air cooling to prevent the eggs from overheating, and very little on water cooling. The air temperature was controlled at a fixed set point, by balancing the heat produced by older stage embryos with the heat-absorption demands of the younger embryos: so-called multi-stage incubation.

That innovation has been with us for almost 100 years. Despite an explosion in the physical scale of commercial hatcheries, and massive advancements in climate control technology – simplicity of incubator management, slow replacement rates for hatchery equipment and low labour costs in many countries mean that multi-stage incubation is still favoured by many hatcheries today.

Management

The simplicity of multi-stage management stems from the fact that new, unincubated eggs are placed alternately with eggs containing older, heat producing embryos.

New eggs are placed regularly, once or twice a week. In the multi-stage system, the climate is controlled by the eggs.

Conversely, single-stage incubation is based on climate control technology, geared specifically to meeting the demands of the growing embryo.

The incubator climate controller provides the embryo with heat and cooling as required. Set points of temperature, relative humidity and ventilation are adjusted, according to embryonic age.

Eggs are placed in empty, disinfected incubators.

Single-stage hatchery management may also be based on the daily routine. Single-stage incubation programmes, once set-up for different eggs types, can be applied routinely.

Hygiene and food safety

The climate in a multi-stage incubator is controlled by levels of heat production in 'older' eggs, which heats the freshly placed eggs by air transfer. However, 'older' eggs are not only a source of heat, they are also a source of micro-organisms, for example bacteria or fungi, which can contaminate the 'younger' eggs. Add to this the risk of exploding or gaseous eggs, and contamination early in life may have lasting implications, leading to contaminated broilers with decreased performance, higher mortality – and ultimately contaminated meat products.

Thus, from a hygiene and food safety point of view, the multi-stage incubator becomes a source of contamination, which may lead to economic losses at hatchery level due to lower hatching rates and chick mortality.

The whole production chain is controlled by strict legislation for chain management (tracking and tracing) and hygiene. The integration of a single-stage hatchery in such poultry production systems is a simple task, because the principle of all-in-all-out makes the tracking and tracing of different batches of eggs easy.

To fill the multi-stage incubator, a batch of eggs from one supplier must often be separated into smaller batches and placed in different setters. This complicates tracking and tracing, making errors more likely to arise.

The multi-stage incubator is never completely empty – making thorough disinfection almost impossible. Single-stage incubation, however, allows for the machines to be thoroughly cleaned and disinfected every 18 days (between batches of eggs).

Conclusion

To enhance food safety at hatchery level in the production chain, the single-stage incubation process delivers benefits not available through multi-stage incubation by:

- Preventing cross-contamination from older to younger egg batches, because eggs of different ages need not be mixed.
- Facilitating the simple identification, tracking and tracing of each hatch.
- Enabling thorough cleaning and disinfection between hatch cycles.

Tel: +31 314 659 111 • academy@pasreform.com

The importance of preventing sweating eggs 2

www.pasreform.com

By Gerd de Lange, senior poultry specialist, Pas Reform

'Sweating' of eggs is the result of condensed water sitting on the egg shell surface. This occurs when cold eggs are suddenly exposed to a higher environmental temperature.

The warm air with a certain moisture content cools down rapidly directly around the colder eggs. Since cold air contains less water than warm air, relative humidity will increase until the air is saturated. And at that

moment, condensation will take place on the cool egg surface.

The term 'sweating' is, if taken literally, misleading, because the water on the shell does not in fact come from within the egg. The same physical process is seen when a bottle of water is removed from a refrigerator on a warm summer day.

Sweating of eggs should be avoided because moisture on the shell surface weakens the egg's natural defence mechanisms, providing as it does an ideal environment for the growth of micro-organisms, and further facilitating their penetration through the shell pores.

Once inside the pores, micro-organisms are protected from most routine egg sanitising operations, therefore presenting a potential risk for contamination.

Bacteria and fungi which manage to pass through the shell membranes will multiply at a rapid rate when they are exposed to incubation temperature, because the defence mechanism in the albumen is no longer able to protect the growing embryo.

This of course will lead to increased embryonic mortality, 'exploders' and infected day-old-chicks (increased first week mortality).

Conclusion

Clearly moisture on egg shells should be prevented. Egg sweating is prevented when the difference in temperature between the egg storage room and 'the outside' (for example loading platform of the truck, egg traying room, setter) is small and the 'outside' humidity is low.

Table 1 can be used to predict whether sweating will occur if no additional measures are taken. For a wider range of temperatures and humidities, a so called 'Mollier' diagram or psychometric graph provides a useful tool.

There is also a risk of eggs sweating if they are set too cold in setter that is already running to temperature, as is the case in multi-stage incubation practice.

Advice

- If the risk of sweating is high, prewarm eggs gradually at least six hours prior to removing them from the egg storage room.

  This is achieved by switching off the chiller several hours before taking out the eggs. It is important to realise that not all eggs warm up at the same, uniform speed, especially with low air circulation and if stored on pulp trays and stacked closely together.
- Store at a higher temperature, combined with a shorter storage period, whenever possible.
- Connect the truck picking up the hatching eggs directly with the storage room to minimise any temperature differences from the outside environment.
- Ensure that the climate in the truck is the same as in the egg store.
- Maintain humidity below the levels indicated in the table.
- Prior to placement in the setter, place the filled setter trolleys at a room temperature of 25 °C with good air circulation for several hours. This pre-warming of the eggs before setting is particularly important when using multistage incubation.

Table 1. Eggs will 'sweat' if the relative humidity (% RH) outside the storage room is higher than the temperature of the storage room.

Temperature of storage room[1] (°C)	Temperature outside the storage room 15°C	18°C	21°C	24°C
21	–	–	–	› 85% RH
18	–	–	› 83% RH	› 71% RH
16	–	› 89% RH	› 74% RH	› 60% RH
11	› 74% RH	› 64% RH	› 53% RH	› 44% RH

[1]Assuming that the temperature of the eggs equals the temperature of the egg storage room.

Creating the ideal hatching climate

3

www.pasreform.com

By Marleen Boerjan, senior poultry specialist, Pas Reform

The transfer of eggs from setter trays to hatcher baskets is routine in the hatchery, while the embryo continues to develop.

In the final days of incubation, the embryo prepares for hatching and while embryonic growth slows down at this stage, the maturation of most of the organs continues. The embryo turns its body along the long axis of the egg, with the beak under the right wing and the neck bent towards the blunt end of the egg.

Residual yolk is retracted within the abdominal cavity and the navel closes. Simultaneously, blood flow through the chorion allantois membrane ceases – and the chick uses the egg tooth to penetrate the inner membrane of the air cell.

Exposure to this gaseous environment in the air cell stimulates the lung and air sacs to be filled. And after a period of time, the chick pierces a small hole in the egg shell, defined as external pipping.

Time elapsed between internal and external pipping varies according to breed, flock ages, storage and incubation conditions in the setter.

However, it has been shown that external pipping is triggered by the partial pressure of carbon dioxide in the air of the air cell.

The higher the partial pressure of carbon dioxide, the shorter the interval between internal and external pipping. External pipping is known to be delayed in porous egg shell or by a hole in the egg shell.

Hatching is a stressful and critical period, influenced by the physiological condition of the chick as well as by climatic conditions in the hatcher. If, for example, energy stores in the embryo are low be-cause of poor climate conditions during the last days of setting, the fully developed chick dies shortly after external pipping.

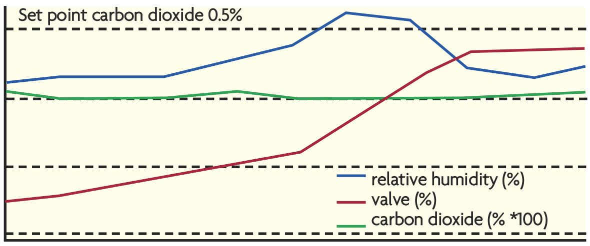
If, during external pipping, humidity in the hatcher is lower than 70%, the shell membranes dry out, leaving the chick stuck in the egg.

When temperature is too low, chicks chill during drying – and when carbon dioxide levels are too high, the chicks will gasp for fresh air when they have hatched and dried.

Advice

- Control ventilation based on carbon dioxide (CO2) levels. CO2 set points of 0.5% ± 0.1 are recommended as optimum for high hatchability and good chick quality.
- If the valves are controlled by carbon dioxide levels, humidity will rise automatically when the first chicks hatch (see Fig. 1).
- Humidity will decrease when most of the chicks have hatched and dried. If using a SmartHatch hatcher, the hatcher's display panel will read: 'chicks are ready to be pulled'.
- Do not lower the temperature before all chicks have dried.
- If the hatch window is longer than 24 hours, review the management of setting. The hatch window will become larger when batches of eggs from different flocks and storage conditions are mixed in one setter and hatcher.
- If the hatch window is longer than 24 hours, review the temperature distribution in the setter. In general the hatch windows will be larger after multistage incubation compared with single stage incubation, because temperature distribution in a multistage incubator is not homogeneous. ■

Fig, 1. Automated hatching system.



Tel: +31 314 659 111 • academy@pasreform.com

Hatching at high altitudes

By Gerd de Lange, senior poultry specialist, Pas Reform Academy

The effects of hatching at high altitude on hatchability and chick quality depend largely on the altitude at which the hatching eggs are produced – and how the hatchery manager adjusts the incubation programme.

Barometric pressure declines with altitude, as does the partial pressure of oxygen and absolute humidity. Fresh ventilating air will tend to be colder and drier than at sea level.

Oxygen availability

The oxygen content of air is always 21%, but reduced partial pressure at altitude provides less oxygen from a given volume of air.

This pressure reduction results in lower levels of oxygen for the embryo, which is partially compensated by the embryo's higher capacity for binding oxygen to blood haemoglobin (Dragon, et. Al (1999). Journal of Experimental Biology; 220: 2787-2795).

At altitudes above 2,000 metres, it can help to inject oxygen into the setter and the hatcher, to raise the oxygen level from 21 to 23-25%. The main drawbacks of using oxygen are cost and safety. Its use may, therefore, be limited to hatching parent stock.

Water loss

It is reasonable to assume that the drier air at altitude will result in increased moisture loss from the eggs. However, it is important to realise that breeder flocks adapt to altitude by producing eggs with a lower effective pore area.

This offsets increased diffusion and, therefore, water vapour loss through the egg shell at any altitude remains the same as at sea level (Reduction of Pore Area of the Avian Eggshell as an Adaptation to Altitude; H. Rahn et. al, 1977).

Conclusions

The following three scenarios are considered:

● **Eggs produced at sea level: hatchery at altitude (1,000-2,000 metres).**
Of the three scenarios, this is the least desirable because it will definitely result in reduced hatchability.

Eggs produced at sea level have a relatively large effective pore area and will, therefore, lose more water at higher altitudes. To compensate, setters and hatchers should be operated at a higher relative humidity.

This is best achieved by pre-conditioning the inlet air to a relative humidity of 75%, with a temperature of 24-28°C (optimum). At the same time, increase the ventilation rate from normal for sea level, to accommodate the reduced oxygen levels.

● **Eggs produced at same altitude as hatchery (1000-2000 metres).**
In general this will give good results. Ventilation rates should be higher than normal for sea level. During humid external conditions, increase ventilation even more, as humidity reduces oxygen levels in the air still further.

This higher ventilation rate may cause reduced humidity in the setters and hatchers. To avoid constant humidifying, humidity set points should be lowered and the resulting more than optimal weight loss (14-15%) is preferred in this case.

● **Eggs produced at altitude; hatchery at sea level.**
Generally, this will give good results. The set points for relative humidity need to be reduced to achieve optimum weight loss as the eggs have a reduced effective pore area.

Advice

Exact set points for relative humidity are dependent on a.o. altitude and egg shell conductivity (age flock, nutrition, genetics). It is, therefore, recommended that relative humidity set points are fine-tuned by weighing trays of eggs before setting and again at transfer at 18-18.5 days.

Optimum weight loss for good hatchability and chick quality is indicated in Table 1 below.

Alternatively the size of the air cell provides an indicator of weight loss. If during an egg breakout too many wet, fully developed embryos that fail to pip are observed, this indicates insufficient weight loss and/or a shortage of oxygen. In this case, set points for relative humidity should be reduced and/or ventilation rate should be increased. ■

Table 1. Optimum weight loss for good hatchability and chick quality based on experience.

Age breeder flock	Optimum weight loss (%)
Young flocks	10-11
Medium flocks	11-12
Old flocks	12-13

Optimum humidity for ostrich incubation

5

www.pasreform.com

By Gerd de Lange, senior poultry specialist, Pas Reform Academy

During artificial incubation, and just as with chickens, it is important that ostrich eggs lose enough weight by evaporating water through the pores in the egg shell.

This creates an air space large enough to facilitate internal pipping, after which the chick gradually changes over from respiration through the chorion-allantois to lung respiration, as it prepares for external pipping.

Unfortunately little scientific data is available on optimal weight loss in ostrich eggs. But in practice, good results are obtained with a weight loss of 15% from setting to external pipping. Losing too little weight results in lower hatchability and oedematous chicks.

However, depending on climatic conditions, it can be difficult to achieve such high weight loss. And when opening unhatched eggs, we commonly find full grown chicks that failed to pip the air cell. These chicks actually drown in their own eggs.

Advice

Weight loss during incubation depends on the relative humidity of the air around the eggs and the porosity of the egg shell. Natural variation in porosity makes it impossible to give exact recommendations but, in general, relative humidity should be between 25 and 35%.

To find the correct level of relative humidity:

- Weigh at least 10-20 eggs individually before setting and again at regular intervals (for example every five days). Calculate the average percentage of weight loss – recommended at 0.37%. for each day of incubation – to achieve the desired weight loss of 15% for external pipping around 41 days of incubation.

If actual average weight loss is too low, adjustments can still be made to correct this. At least 10-20 eggs should be weighed to represent a viable average, as there may be considerable variation between individual eggs!

The temperature and relative humidity in the incubation room – outside the incubator – will also affect humidity inside the machine.

From the Mollier diagram (summarised in Table 1), we see that with a room temperature of 25°C and 50%RH, humidity in the setter at incubation temperature will drop to 24.4%. Evaporated water from the eggs will raise this level.

Remember too that humidity will increase inside the setter when room humidity levels are higher, as well as when room temperatures are higher with equal room humidity.

With this in mind, the following is recommended:

- Ventilate the incubation room to ensure that outlet air (containing water evaporated from the eggs) is not reprocessed as inlet air.
- Aim for a room climate 25°C/ 50% RH or any other combination that results in a maximum relative humidity of 25% at incubation temperature, by using the Mollier diagram. On warm and/or humid days, an air conditioner may be required, to cool and dehumidify at the same time. Remember, the incubator's humidifying system can only increase humidity. It cannot decrease it!
- Ventilate the setter sufficiently to remove water produced by eggs. More ventilation causes (a) lower humidity in setter and (b) higher weight loss of eggs.

If weight loss at transfer is less then 10%, H. R. Wilson, (University of Florida: Incubation and hatching of Ratites) suggests drilling four holes of 2mm diameter in the shell over the aircell at the time of transfer to the hatcher, as an emergency measure.

By that point, it is already too late to correct insufficient weight loss, but this does allow the chick to survive by lung respiration after pipping into the (small) air cell. Embryos assisted in this way will require help in hatching, because they will be malpositioned, due to their oedematous condition. ■

Table 1. Effect of climate in incubator room on RH in setter.

Temperature room	% RH room	RH (%) in setter*
0	50	18.1
20	60	21.7
20	70	25.4
20	80	29.0
25	50	24.4
25	60	29.3
25	70	34.2
25	80	39.1
30	50	32.7
30	60	39.3
30	70	45.8
30	80	52.3

**after warming to incubation temperature*

Relevance of turning

6

www.pasreform.com

By Gerd de Lange, senior poultry specialist, Pas Reform Academy

Broody hens provide optimum conditions for embryos developing in the eggs they are sitting on.

The brood patch provides heat from one direction only, which means that eggs at the side of the patch are cooler than those in the middle of the nest. However because the broody hen regularly turns and moves the eggs in the nest, uniform egg temperature is achieved.

In commercial incubation, we try to mimic the natural conditions in the nest.

From the point of view of uniform egg temperature turning of eggs seems to be of less importance in modern incubators. Are there other reasons for turning eggs?

As summarized by Deeming (2002), egg turning is essential to normal development for several reasons.

Egg turning

- Prevents adhesion of the embryo to the inner shell membrane
- Stimulates the rate of development of the area vasculosa (the membrane which grows around the yolk and is rich in blood vessels). The area vasculosa is important for sub-embryonic fluid formation, as well as for yolk uptake later in incubation.
- Allows normal transfer of albumen proteins into the amniotic fluid, promoting optimum use of the albumen.
- Supports the growth of the chorio-allantois (the blood vessels right under the shell) to maximise oxygen absorption.
- Embryos in unturned eggs grow at a lower rate compared to embryos in eggs turned each hour over 90°
- Facilitates movements of the embryo into the normal hatching position and reduces the incidence of malpositions in unhatched embryos.

Recently Elibol and Brake (2004) confirmed the finding of New (1957), that the most critical period for turning broiler hatching eggs is during the first week of incubation. Elibol and Brake observed differential effects due to an absence of turning between 0 to 2 days (primarily increased early mortality) versus 3 to 8 days (primarily increased late mortality).

The effect of not turning during the first half of incubation is only seen during the second half of incubation, but by then it is too late to take corrective actions. Turning failures during the second half of incubation will generally have less dramatic effects, although the growth rate of the embryo can be affected, depending on the moment and duration of the turning failure.

The angle through which the eggs are turned is important. Hatch of fertiles was significantly better in eggs turned over an angle of 45° either side of the short axis of the egg, as compared to turning of 30° and 15°.

Hatched chicks from eggs turned 45° weighed more and had less dry matter in the residual yolk. (Cutchin et al, 2007)

Advice

- Check the turning device before the start of each incubation cycle, as turning failures, depending on the moment of occurrence, are detrimental to results.
- Check and maintain the turning device regularly, to prevent a breakdown during incubation.
- Make sure that turning does not produce shocks or jolts, as this adversely affects hatchability and chick quality.
- If necessary, check and adjust the turning angle: 45º is optimal.
- Not turning for the first 12 hours in the setter is advised, based on our practical experience and especially when eggs are transported to the hatchery on the same day as setting. Eggs need some rest time to restore their "internal balance".
- Turning is not absolutely necessary after 15 days of incubation.

Especially in incubators with insufficient cooling capacity, it can be beneficial to leave the eggs in a horizontal position to facilitate increased air flow (cooling over the eggs). ■

In some modern setters, there is the option of turning to three different positions: right, horizontal and left positions.

Tel: +31 314 659 111 • academy@pasreform.com

When and how to transfer eggs to the hatcher 7

www.pasreform.com

By Gerd de Lange, senior poultry specialist, Pas Reform Academy

It is common practice to place eggs in the setter for the first 18 days, before transferring them to the hatcher for the last three days of incubation.

Generally, this occurs between the embryonic ages of 17 days and 12 hours and 18 days and 12 hours, to coincide with the normal working schedule of the hatchery (see table), whereby hatchers are used twice a week. In this scenario, incubation time is measured from the (assumed) moment the eggs reach optimum internal temperature for embryonic development, and not from the moment the eggs are placed in the multi-stage setter or from the moment the single stage setter is switched on

Depending on the setting system, heating capacity and initial egg temperature (in relation to the method and duration of preheating) corrections must be made if one wants to express incubation times from machine start-up. For example, in the table below, corrector time equates to six extra hours.

Fluctuations in production planning may dictate transfer either earlier or later than in normal practice.

Transfer to the hatcher can happen as early as 15 days (= 360 hours of incubation), as there is no evidence to suggest that stopping turning after 15 days of incubation in domestic fowl has any deleterious effects on development and hatchability (Deeming, 2002).

However, it is our practical experience that transferring to the hatcher at this moment can reduce hatchability by 0.5-1.0%.

Transferring to the hatcher should not occur after 19 days (456 hours) of incubation, because disturbing the eggs at this time adversely affects the act of internal pipping.

Advice

- Transfer eggs after 17 days and 12 hours of incubation to the hatcher, but not later than 19 days (= 456 hours).

Only in exceptional or unavoidable circumstances, should eggs be transferred as early as 15 days (=360 hours).

- Adjust hatcher climate in relation to the age of embryos, if transfer must occur before the recommended minimum of 17 days and 12 hours.

In practice, the setpoints of the setter should be followed.

However, as there is increased airflow over the eggs once they are positioned horizontally in the hatcher baskets, it may be necessary to increase setpoints by, for example, 0.2°F.

- Maximise the time from setter to hatcher to 20-30 minutes.
- Maintain a good climate in the transfer room (approximately 25°C and avoid draughts).
- Leave the setter switched on as long as there are still eggs inside! Failure to do so will impede the cooling of the eggs, which is likely to produce late mortality due to overheating.
- Empty setter trolleys from top to bottom, to avoid exposure to high temperatures in the topmost trays as a result of rising heat from the embryos in the lower trays.
- Handle the eggs carefully during transfer. Eggs cracked during transfer have reduced hatch potential due to dehydration.
- Make sure the hatcher baskets are dry.
- Fill the warmed hatcher with trolleys according to the manufacturer's recommendations. This is particularly important when the hatcher is not filled to capacity. ■

Table 1. Working schedule for hatchery with four hatch days per week, whereby weekend workdays are avoided. The first hatch and third hatch are in the same hatchers. Incubation time is measured from the moment internal egg temperature has reached optimum incubation temperature.

Time	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
6.00	1st hatch (21d+6h)	2nd hatch (21d+6h)		3rd hatch (21d+6h)	4th hatch (21d+6h)		
12.00	3rd transfer (18d+12h)	4th transfer (18d+12h)		1st transfer (17d+12h)	2nd transfer (17d+12h)		
18.00	2nd set		3rd set	4th set			1st set
24.00	2nd start (0)		3rd start (0)	4th start (0)			1st start (0)

Maintaining the ideal climate for chick handling and transport 8

www.pasreform.com

By Gerd de Lange, senior poultry specialist, Pas Reform Academy

Good post hatch performance and low first week mortality can best be expected from chicks kept in ideal conditions between leaving the hatcher and placement in the farm.

When pulled, chicks leave an ideal climate, with hatcher temperature of approximately 97.5-98°F (36.4-36.7 °C), relative humidity at around 60% and air circulating at high speed.

Movement to the handling room exposes the chicks to a very different climate and boxed chicks are often kept for some time in the chick despatch room, before being transported to the farm.

Normal rectal temperature for a day-old-chick is 40-40.5°C (100.4-104.9°F). Newly hatched chicks are dependent on climatic conditions to regulate their body temperature for the first few days. Good ventilation will drive excess body heat out of the chick boxes, while also preventing a build-up of carbon dioxide.

Chick behaviour is the best indicator of climatic conditions during chick handling and transport. Under ideal conditions, day old chicks breathe quietly through their nostrils, losing only a little water. They spread evenly in the boxes, make little noise and are relatively inactive.

If carbon dioxide levels are too high, the chicks will gasp for air and try to stick their heads out of the chick boxes. This blocks the passage of air into the boxes, so compounding the problem.

When environmental temperature is too low, or there is too much draught, the chicks huddle together to try to maintain body temperature. Chicks are especially prone to chilling if pulled too early ('wet chicks') or after spray vaccination.

Too high an environmental temperature causes chicks to open their beaks and pant, which evaporates water from their lungs and air sacs. Short term, panting will help the chicks to lose excess body heat, but it also leads to faster dehydration.

When the chick's water reserve is depleted, this control mechanism becomes redundant. With further increases in environmental temperature, the chicks become progressively more noisy, spreading their wings to try to reduce body temperature. But if environmental heat remains excessive, this too will fail to keep the chicks' body temperature down and inevitably some chicks will be lost.

Trying to prevent dehydration by increasing relative humidity only makes it more difficult for the chicks to evaporate water. Excessively low relative humidity also leads to dehydration.

Advice

Recommended post hatch climate settings are shown in Table 1 below. The specific recommendations include:

- Look, listen and respond accordingly to the chicks' behaviour. It may help to record the rectal temperatures of a representative sample of chicks occasionally.
- Remember that the room and/or truck climate is secondary: it is the climate in the chick boxes that matters. Temperature at chick level should be approximately 32-35°C (89.6-95.0°F).
- Avoid chilling by pulling chicks too early or after spray vaccination – and beware of draughts!
- Reduce the number of chicks when temperature during transport and (un)loading is too high.
- To provide sufficient ventilation in the chick despatch room, position the chick boxes in uninterrupted rows with a minimum of 30cm between each row, and a fan blowing preconditioned air in alternate corridors between the rows.
- Ensure that trucks are loaded correctly, based on the ventilation principle of the truck type.
- Review the output of 'climate loggers' from the chick boxes during transit: the temperature in the boxes can be between 8-14°C higher than the air temperature in the truck.
- Have the driver measure and record climatic conditions, including floor temperature, in the receiving farm.
- Unload the chick boxes immediately on arrival at the farm, as the house temperature is high and ventilation is too low to drive the additional heat produced by the chicks out of the boxes. ■

Table 1. Recommended post hatch climate settings.

	Temperature (°C)	Relative humidity (%)	CO_2 (ppm)	Air flow
Chick handling/dispatch	22-28	50-60	500-600	Sufficient
Truck	22-28	50-60	500-600	Sufficient
Farm	Air: 32-35/Floor: 28-30	50-60	500-600	Negligible

Tel: +31 314 659 111 • academy@pasreform.com