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Understanding Hatching Egg Moisture Loss

At lay, the large end of the egg has a small air cell. The size of the air cell increases as the egg loses moisture throughout incubation. When moisture loss is insufficient, the air cell may be too small, leading to sticky chicks and difficulty hatching. If egg moisture loss is excessive, chicks can become dehydrated, hatch too early, and may be lighter than expected.

The process of moisture loss

During incubation, water vapor is lost from the egg through the pores of the shell. The rate at which this moisture is lost depends on the number and size of the pores (the gas conductance of the shell), temperature, and humidity in the air around the egg. Due to differences in shell structure and hence gas conductance, when all the eggs are incubated under the same humidity conditions, the amount of moisture loss across the eggs will vary. In addition, when age, nutrition or disease reduces egg quality, it may be necessary to adjust incubator humidity conditions to maintain optimum hatchability and chick quality.

There are many factors to consider in achieving optimal moisture loss, and these can include humidity settings, damper positioning, variation in ventilation and conditioning the incoming air. The percentage of moisture loss can vary according to the age of the breeder flock, seasonal influences, or egg size.

Percentage of moisture loss for eggs after 18.5 days of incubation*		
Breeder Flock Age (Weeks)	Multi-Stage Incubator	Single Stage Incubator
25 to 30	10 to 11%	10.0 to 10.5%
31 to 40	11 to 12%	10.5 to 11.5%
41 to 50	12.0 to 12.5 %	11.5 to 12.0%
51 to 60	12.5 to 13.0%	12.0 to 12.5%
61 +	13.0% or more	12.5% or more

*Guidelines may change according to breed and incubator manufacturer.

Impacts of Storage on Moisture Loss

During storage, eggs lose weight as gases and water vapor escape the egg through the pores in the shell. When CO_2 diffuses out of the egg, the pH increases and alters the albumen proteins. Thick albumen becomes thin and watery and water previously bound within the protein matrix is released. This "free" water is able to migrate within the egg and evaporate through the shell pores. As storage time increases, both CO_2 and water loss accelerate together, leading to measurable egg weight loss.

The rate of moisture loss is temperature, humidity, and time dependent. Eggs lose less water when stored under refrigerated temperatures with controlled humidity.

In general, the moisture loss of eggs while stored under optimal conditions is approximately 0.5% per week. This loss should be taken into account when calculating weight loss over the incubation process.

Incubators and Moisture Loss

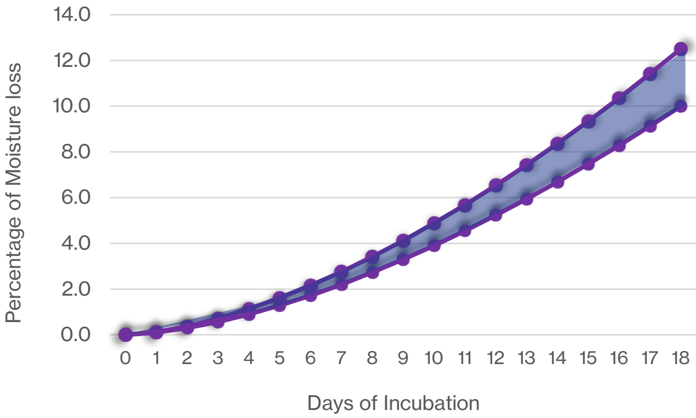
The **single-stage incubation** environment allows set points to be adjusted dynamically by day of incubation to match embryo needs. In a **multi-stage incubator,** eggs of different embryonic age share the same environment, so set points are held fixed as a compromise. To achieve optimal moisture loss there are 4 key factors: relative humidity (RH), damper position, air exchange rate, and eggshell temperature. The same 4 factors apply to both types of incubator but are managed differently.

	Single-Stage Incubator	Multi-Stage Incubator
Relative Humidity (RH)	The relative humidity set point can be adjusted through the cycle starting higher in the first week and decreasing later to accelerate air cell development. A constant RH is often more practical in hot, humid climates.	The relative humidity is maintained at a constant set point. The condition of the incoming air (incubator room temperature and RH) has a strong influence on achievable in-machine humidity.
Damper Position*	The damper position is adjusted automatically based on CO_2, humidity and temperature and is typically closed early in incubation, then progressively opened as metabolic demand increases.	The damper position is generally fixed or manually adjusted, since closing dampers for early-stage eggs would restrict ventilation for late-stage embryos in the same machine.
Air Exchange Rate	The air exchange rate is scaled to the embryo's changing needs. Minimal ventilation early, increasing progressively toward transfer. Requirements are model/ machine specific.	The air exchange rate is a fixed compromise across all embryo ages. Fan speed can be adjusted to influence the evaporation rate from the egg surface.
Eggshell Temperature	Higher eggshell temperature increases vapour pressure at the shell surface, increasing moisture loss. Single-stage machines can manage eggshell temperature precisely by adjusting air temperature as embryonic heat production increases.	Eggshell temperature cannot be optimised for each age group as air temperature is held near-constant. Older embryos produce metabolic heat, raising their eggshell temperature and vapour pressure, which increases their moisture loss rate. However, heat transfer from hot (older) to cold (younger) eggs naturally helps balance this difference across the machine.

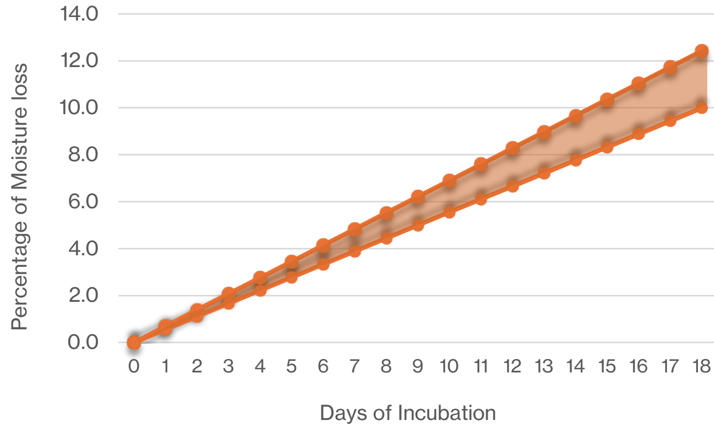
**Note that opening the damper one day early or late can account for 0.5% moisture loss.*

Moisture-loss patterns (linear vs non-linear)

In **single-stage incubation**, variable RH and ventilation programs can produce a non-linear profile – less moisture lost early, more in the second half.



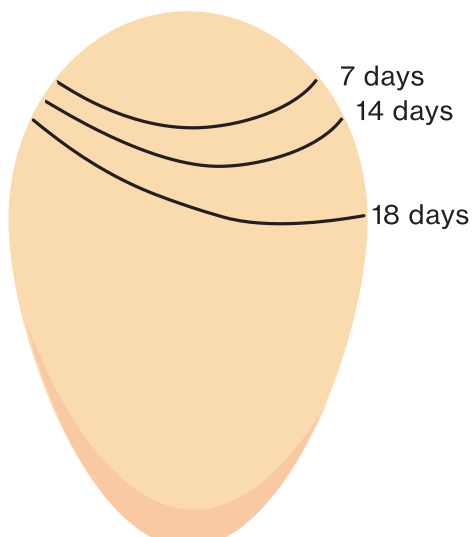
Because **multi-stage incubator** set points are fixed, egg moisture loss tends to follow a linear pattern from set to transfer.



Regardless of incubator type or profile, the key metric remains achieving the correct total egg weight loss by transfer based on egg age (10 to 12.5 %; see Moisture Loss Table on page 1)

Visible signs of moisture loss

A flashlight or torch just prior to transfer can be used to determine the egg air cell size. An air cell that is too large or too small, can be an indication of excessive or insufficient moisture loss. The air cell of the egg should be at least one-third of the egg or just above the equator of the egg at transfer (see diagram right).



Considerations for calculating moisture loss

Calculating moisture loss from the egg during the incubation process is a vital tool in achieving good chick quality and hatchability. Moisture loss should be calculated each hatch day. At a minimum evaluate one of each flock source: young, prime and old. Typically, hatcheries calculate moisture loss percentage each week for each flock source at the hatchery.

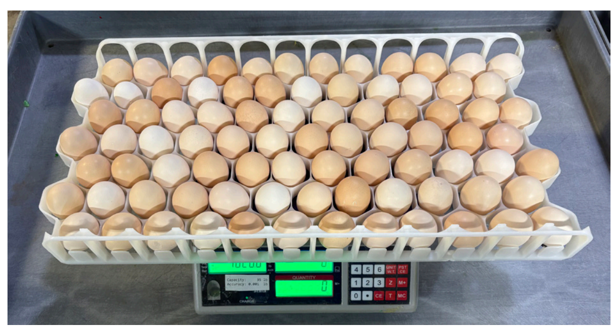
To calculate moisture loss, clearly mark three to five trays of hatching eggs per flock or incubator. These hatching trays should be clearly marked throughout the incubation process to ensure accuracy and continuity. Place these trays in different locations throughout the incubator to achieve an average calculation (i.e. in the top, middle and bottom of the incubator cart or fixed rack system). To increase the accuracy of the data, try to place the trays in the same locations within the incubators each time for subsequent calculations.

Weighing each component in metric units (grams) will provide more accurate data compared to imperial units (ounces). The eggs used in this calculation should be quality hatching eggs free of any shell quality issues, cracks or misshapen eggs. No eggs should be removed from the setter tray before calculating the weight at transfer time. If an egg has been broken or removed for some mechanical reason, only then should the egg be replaced. The egg used for replacement should be fertile with a viable embryo. If the transfer time is variable, all figures should be calculated back to one transfer time. This process is simple and will ensure accurate data once collected. (See following page for calculations and examples)

The procedure

1. Weigh an empty incubator tray.

2. Next, weigh each incubator tray with eggs before incubation. The eggs used in this calculation should be quality hatching eggs free of any shell quality issues, cracks or misshapen eggs.



3. Finally, each specific incubator tray will be weighed again at transfer to obtain the percentage of moisture loss.

Calculations

The calculation for determining the percentage of egg moisture loss is:

$$\frac{\text{(full incubator tray weight at incubation - full incubator tray weight at transfer)}}{\text{(full tray weight at incubation- empty tray weight)}} \text{ X 100 } = \text{percentage of egg moisture loss}$$

An example calculation:
Full incubator tray weight at incubation 6,250 g
Full incubator tray weight at transfer 5,650 g
Empty incubator tray weight 1,050 g

$$\frac{(6{,}250 \text{ g} - 5{,}650 \text{ g})}{(6{,}250 \text{ g} - 1{,}050 \text{ g})} \text{ x 100 } = \text{ 11.5 \% egg moisture loss at 18.5 days}$$

The moisture loss table (page 1) is based on 18.5 days of incubation. However, if the transfer time is not at 18.5 days (444 hours), all figures should be calculated based on the actual incubation time. This number then can be used to calculate moisture loss at 18.5 days.

The calculation for determining the percentage of egg moisture loss at 18.5 days is:

$$\frac{\text{(Moisture loss at X days (\%))}}{\text{(X days of incubation)}} \text{ x 18.5 } = \text{ percentage of egg moisture loss at 18.5 days}$$

An example calculation:
Full incubator tray weight at incubation 6,250 g
Full incubator tray weight at transfer 5,550 g
Empty incubator tray weight 1,050 g

$$\frac{(6{,}250 \text{ g} - 5{,}550 \text{ g})}{(6{,}250 \text{ g} - 1{,}050 \text{ g})} \text{ x 100 } = \text{ 13.5 \% egg moisture loss at 19 days}$$

$$\frac{\text{13.5 \% moisture loss}}{\text{19 days}} \text{ x 18.5 days } = \text{ 13.1 \% egg moisture loss at 18.5 days}$$

Record and Store Data

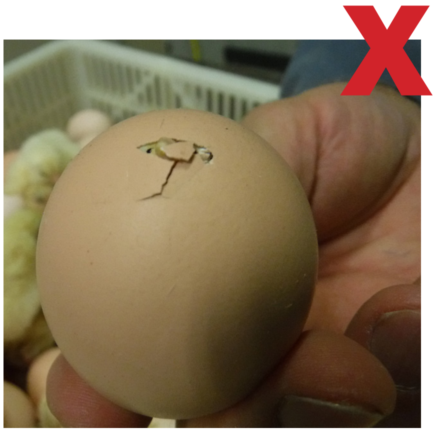
Moisture loss data can be associated by flock, machine, incubation day or breeder flock age. The calculations should be kept in a database or spreadsheet so that the data can be referenced by hatch date, week, month or flock type. The more information that is collected, the more valuable the data becomes. This information can produce trends which allow comparisons to be made from season to season, or year to year.

It is very important to know the moisture loss percentage by breeder age. The eggs from a breeder hen increase in weight and size as the flock ages. This increase in weight and size will dictate the target percentage of moisture loss by breeder flock age.

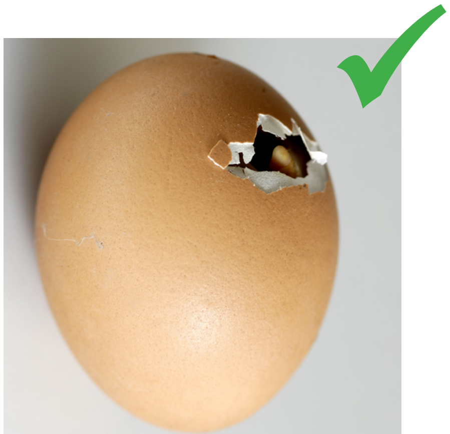
Indicators of moisture loss

Insufficient moisture loss can cause sticky chicks with shell debris stuck to them. This debris is the inner shell of the membrane from the egg. The inner shell membrane will typically remain attached to the eggshell during the pipping process. When inner shell membrane is adhered to the chick, it's a sign of insufficient moisture loss.

The location where the chick externally pips through the eggshell can be an indicator of correct moisture loss. The head of the chick should be level during the pipping process. If the head is inverted or tilted up, this is a sign of insufficient egg moisture loss.



Here, the pip is too high, indicating insufficient moisture loss.



In the photo above, the pip is in the correct location, indicating the correct amount of moisture was lost from the egg.

Indications that the amount of egg moisture loss is incorrect	
Insufficient moisture loss	**Excessive moisture loss**
Air cell too small	Air cell too large
Sticky chicks	Chicks hatching early
Chicks heavier than normal	Chicks lighter than normal
High pips on eggs	Chicks pipping early
Red hocks or abrasions to the beak or nostrils	Embryonic death at 20 days (Internal pip)
Enlarged abdomens	Dehydrated chicks
Chicks with eggshell stuck to them	

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