

Controlled Atmosphere Systems for Broiler Chickens

Controlled atmosphere systems of pre-slaughter stunning include any systems which use gases, including systems which use Low Atmosphere Pressure Stunning (LAPS). All controlled atmosphere systems work by limiting the oxygen available to the animals. The method can either be stun-only or stun-kill, dependent on the concentrations of gases used and length of time for which the animals remain in the gases, however, we recommend only using controlled atmosphere systems for stun-kill, thereby avoiding any risk of recovery before bleeding.

Key Advantages

The use of controlled atmosphere systems (CAS) for the killing of poultry has increased in popularity globally over recent years. In 2013, the Food Standards Agency's Animal Welfare Survey reported that the use of CAS accounted for 71% of poultry throughput in Great Britain¹. The use of CAS varies across the European Union, but it is estimated that 20% of broiler chickens, 7% of laying hens and 24% of turkeys in the EU are now slaughtered using this method². Controlled atmosphere systems are replacing the use of electrical waterbath stunning systems and are generally viewed as a more humane alternative.

In comparison to electrical waterbath stunning, one major welfare advantage of CAS is that the physical handling of birds at the slaughterhouse is eliminated. In most cases, the bird transport containers can be automatically loaded directly into a CAS system without having to remove the birds first. Additionally, some CAS systems use compatible mechanical catching machines, which completely removes the need for any pre-slaughter handling of the chickens from the rearing barn to the time the birds are killed. In electrical waterbath systems, however, the birds have to be manually removed from their transport crates individually and are inverted and hung by their legs on a metal shackle, which conveys them to the waterbath. This is both painful and stressful to the birds.

There are also other significant welfare benefits associated with controlled atmosphere systems. For example, compared to electrical waterbath systems, they can offer a more consistent and reliable induction to unconsciousness and, in the UK, it is a legal requirement that the birds must be killed in the system rather than just stunned.

However, unlike some other methods of stunning poultry, controlled atmosphere systems do not instantaneously render poultry unconscious and insensible to pain and distress. It is therefore of high importance that these systems are designed, operated and managed appropriately to ensure the most humane kill possible is achieved.

Gases Used

There are various designs of controlled atmosphere systems available globally, which have been designed to be used with different gasses or gas mixtures: some use carbon dioxide (CO₂) gas only; some use inert gases, such as argon; and others use a mixture of the two - inert gases and carbon dioxide. Further, most systems have been designed to expose birds to one or more 'stages' or 'steps', whereby each stage/step contains a different concentration of the gas being used: starting at a low concentration and increasing to a higher concentration.

Birds are killed (or rendered irreversibly stunned) in the system because the gases being used do not contain oxygen. Therefore, it is this lack of oxygen that results in unconsciousness and then

the subsequent death of the birds. Depending on the system used, the gas selected, and the concentration of the gas, this process can rapidly and humanely render the birds unconscious and insensible to pain and distress.

Carbon Dioxide

Carbon dioxide is a relatively inexpensive gas. It has an anaesthetic effect on birds and therefore can result in a calmer induction to unconsciousness. Carbon dioxide is also heavier than air*, making it easier to 'manage', and this attribute has been usefully exploited in the design of some controlled atmosphere systems. However, the major disadvantage of carbon dioxide is that it is aversive to chickens and turkeys, with the degree of aversion increasing as the concentration rises: for instance, chickens can start to detect the presence of CO₂ at around 7%; and at 25%, some aversion may be observed. At concentrations of 40% and above, CO₂ is considered to be particularly aversive. For this reason, it is important that the birds are initially exposed to a low concentration of carbon dioxide – up to 30% – until they have lost consciousness. Once the birds are unconscious, they can then be exposed to higher concentrations of the gas until death occurs. Within the European Union, it is a legal requirement that birds have lost consciousness prior to exposure to concentrations above 40% CO₂.

Inert Gases

Inert gas mixtures, such as nitrogen or argon, are relatively more expensive gases. However, birds are unable to detect the presence of these gases and, as such, they are not aversive. These gases can be more challenging to 'manage' as, for example, nitrogen is lighter than air, making it more difficult to contain. To be effective, the gas within the system must be maintained at a level that reduces the available oxygen to below 2%. This can be technically difficult to achieve and maintain in some systems. Although inert gases do not result in aversive behaviour, there still remains some concern around the use of these gases. This is because, after loss of consciousness, birds can perform quite vigorous, uncontrolled wing flapping and body convulsions, which can affect those birds that have not yet lost consciousness. However, despite having the potential to cause some discomfort in this respect, this is likely to be an issue for a short duration only. Therefore, the use of inert gases is recommended over the use of carbon dioxide and mixtures of inert gases with carbon dioxide.

Inert Gases with Carbon Dioxide

Inert gases mixed with carbon dioxide may also be used, e.g. argon and carbon dioxide. Within the European Union it is a legal requirement that the level of carbon dioxide in such mixtures does not exceed 40%, and in the United Kingdom it must legally be no more than 30%. To be effective, the gas mixture within the system must be maintained at a level that reduces the available oxygen to below 2%.

Low Atmosphere Pressure Stunning

Low Atmosphere Pressure Stunning (LAPS) is a different type of controlled atmosphere system that is still in its infancy. LAPS obtained a 'no-objection' ruling by the United States Department of

* Air contains 78% nitrogen weighing 14 grams per mole, 21% oxygen weighing 32 g/mol and 0.9% argon

Agriculture's office of New Technology and is currently being used in one large-scale slaughterhouse in the USA. The method works by gradually removing air (and therefore also oxygen) from a chamber containing the birds. Initial research indicates this is an effective method with fewer signs of aversion than carbon dioxide systems, equivalent to inert gas systems. The European Food Safety Authority (EFSA) published an opinion on LAPS in December 2017, stating that the method meets the requirements for listing as an approved method under Regulation (EC)1099/2009 for the slaughter of broiler chickens³.

Systems Currently in Use

There are three main types of controlled atmosphere systems: tunnels, pits and closed cabinets. In most systems, the chickens remain in their transport crates throughout the killing process. This is considered desirable from a welfare perspective, as it reduces the stressful handling of birds. However, some systems automatically empty the birds from their crates, which causes unnecessary stress.

In tunnels and pits, the systems are pre-filled with gas and the birds enter continuously at one end of the system and are conveyed to the opposite end where they exit. In contrast, in closed cabinet designs, birds are loaded into the system as one 'batch' and remain static within the system. Only once the birds have been loaded within the system is the gas then added. Then, when the birds are dead and the process ends, the gas is fully evacuated, the birds are unloaded, and the subsequent 'batch' of chickens loaded. The fully enclosed design of cabinet systems offers a greater level of control and uniformity over the gas killing process.

There are currently five main manufacturers of large-scale, commercial controlled atmosphere systems: Meyn, Marel, Linco, Anglia Autoflow, and Humane-Aire. The typical operation of the systems they manufacture is described below. However, various factors, such as gas concentrations and dwell times, can be adjusted according to the requirements of the factory where the system has been installed.

Meyn

Meyn manufacture a controlled atmosphere system of the closed cabinet design. The birds remain in their transport module throughout the killing process, i.e. the individual transport crates that sit within a module are not removed. Once the module enters the system, carbon dioxide (CO₂) gas is introduced in stages, with the concentration of CO₂ gradually increasing with each stage. There are five stages in total, which last a total of six minutes: each stage lasts for one minute, except for the final stage which continues for two minutes. Whilst conscious, the birds are exposed to the first two stages whereby the maximum carbon dioxide concentration remains below 30%. Following these two stages, which render the chickens unconscious, the birds are then exposed to the three further stages whereby the concentration of carbon dioxide exceeds 60% during the final stage. A proportion of the birds can be monitored throughout the process via a window at the rear of the system. www.meyn.com

Marel

Marel manufacture two different designs of carbon dioxide-controlled atmosphere systems: a bi-phasic system and a multi-phase system. Both systems are of the tunnel type.

With regards to the bi-phasic system, birds are automatically emptied from their transport crates and transferred to, and through, the system via a number of successive, adjoining conveyor belts. In phase one, birds are exposed to carbon dioxide up to a concentration of 40% for a period long enough to render them unconscious. They then continue into the second phase, whereby the concentration of CO₂ exceeds 40% and the birds are killed. The phase one and phase two tunnels are physically joined to form one tunnel, but the second phase tunnel is positioned beneath that of the first phase tunnel. Because CO₂ is heavier than air, this design helps maintain the correct concentration of CO₂ within the two tunnels (phases), i.e. it helps prevent gas moving from the greater concentration in phase two, positioned below, to the lower concentration in phase one, positioned above. Further, the entrance to phase two has a plastic curtain to help contain the gas.

Marel's multi-phase system is designed as one long tunnel which, unlike the bi-phasic system, is on one level. The tunnel is physically divided internally into five sections (stages) by the installation of plastic curtains. Birds are transported through the system whilst remaining in their transport crates. Each stage exposes the birds to an increasing concentration of CO₂ – starting from 28% (first stage), rising to above 70% (final stage). During the first three stages, oxygen can be added to the CO₂ mix, which is reported to result in a smoother induction to unconsciousness. The total time the birds spend in the system is set to five minutes, whereby birds are exposed to each stage for one minute, but this can be adjusted.

In both systems, birds can be observed as they are conveyed through the tunnels via windows positioned along the sides. www.marel.com

Linco

Linco manufacture a pit-type system. In this design, the birds enter the system within their transport crates. On entering the system, the birds descend to the bottom of the pit in stages. At each stage, the crates stop for a set period of time to expose the birds to a gradually increasing concentration of CO₂. The gas concentration gradient in the pit ranges from about 5% at the top of the pit to greater than 70% near the bottom of the pit. The number of stages the birds are exposed to varies according to bird weight, with heavier birds being exposed to more stages to maintain a constant dwell time and throughput rate. The minimum desired dwell time is six minutes. The chickens can be monitored within the system via a remote controlled infra-red camera that can be moved up and down the pit to monitor the birds at different steps, or follow a group of birds within a crate as they descend. A CO₂ sensor is mounted on the camera enabling the concentration to be monitored at different steps too. www.baader.com

Anglia Autoflow

Anglia Autoflow manufacture two different designs of carbon dioxide gas killing systems: a bi-phasic system and a multi-phase system. Both systems are of the tunnel type, and birds are transported through both whilst remaining in their transport crates.

In the bi-phasic system, in phase one, birds are exposed to carbon dioxide up to a concentration of 40% for a period long enough to render them unconscious. They then continue into the second phase, whereby the concentration of CO₂ exceeds 40% and the birds are killed. The phase one and phase two tunnels are physically joined to form one tunnel, but the phase two tunnel is positioned beneath that of phase one. Because CO₂ is heavier than air, this arrangement helps maintain the correct concentration of CO₂ within the two tunnels (phases),

i.e. it helps prevent gas moving from the greater concentration in phase two, positioned below, to the lower concentration in phase one, positioned above.

Anglia Autoflow's multi-phase system can be designed as one long tunnel or, like the bi-phasic system, can be on two levels. The tunnel is physically divided internally into five sections (stages) by the installation of sliding doors. Birds are transported through the system whilst remaining in their transport crates. Each stage exposes the birds to an increasing concentration of CO₂ – starting from c.25% (first stage), rising to above 50% (final stage). The total time the birds spend in the system is set to five minutes – whereby birds are exposed to each stage for one minute – but this can be adjusted.

Anglia Autoflow also manufacturer a single-phase tunnel system that can be used to kill birds using inert gases only or inert gases mixed with CO₂.

In all systems, birds can be observed as they are conveyed through the tunnels via windows positioned along the sides. The system and crates are also designed to work with an existing mechanical catching machine (Easyload Harvester) that uses finger-shaped projections to collect their birds from the barn floor, which eliminates the need for any handling from the rearing house until the birds are killed at the slaughterhouse. www.aaflo.com

Humane-Aire

Humane-Aire manufactures controlled atmosphere stunning systems specifically for broiler chickens or turkeys. Their five-stage tunnel system for chickens operates by delivering increasing concentrations of CO₂ starting with 20-25% in the first induction phase. The birds remain in the transport crates the entire time in the system and exit the final stage irreversibly stunned. Each stage features a window along the side allowing the birds to be directly viewed. The airflow through the tunnel system also allows for CO₂ to be subsequently reused.

The Humane-Aire CAS system was developed in conjunction with a poultry handling equipment manufacturer (Bright Coop Inc.). Therefore, the system was designed to function with pre-existing transport crates, forklifts, and unloading systems. It can also eliminate any pre-slaughter broiler handling as the crates can be used with an existing mechanical catching machine (Apollo Generation 2 harvester) that uses conveyor belts to lifts the birds from the barn floor. humanaire.com/

Summary Table

	Meyn	Marel		Linco	Anglia Autoflow			Humane-Aire
Gas	CO ₂	Inert or Inert Mixes	CO ₂					
Number of phases	5	2	5	Multiphase	2	5	1	5
Birds in crates?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Observation possible?	Proportion	Direct	Direct	Camera	Direct	Direct	Direct	Direct
System Type	Closed cabinet	Tunnel	Tunnel	Pit	Tunnel	Tunnel	Tunnel	Tunnel

Key Recommendations

Key recommendations for controlled atmosphere systems, beyond the requirements of the EU Regulation:

- Controlled atmosphere systems should not be used for simple stunning. Instead, the birds should remain in the gases until they are killed;
- Use controlled atmosphere systems in which the birds remain within their transport crates, thereby avoiding the need for any live handling at the slaughterhouse;
- Fully enclosed controlled atmosphere systems, which introduce the gas to the birds rather than vice versa, offer a greater level of control and uniformity over the killing process;
- The use of inert gases is preferable to the use of carbon dioxide as inert gases are not aversive;
- When carbon dioxide gas is used, the birds must remain in concentrations less than 30% CO₂ until the birds are rendered unconscious.
- A gradual increase in carbon dioxide concentration results in a smoother transition to unconsciousness than direct exposure to high concentrations of carbon dioxide, therefore multi-phase systems are recommended when carbon dioxide gas is used;
- It should be possible to observe the birds throughout the process, via windows or cameras, so that any issues can be quickly identified and acted upon.

Acknowledgements

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Further Resources

CIWF Food Business Resource: Humane Slaughter: Overview

<https://www.compassioninfoodbusiness.com/media/7427576/humane-slaughter-summary.pdf>

CIWF Food Business Resource: Humane Slaughter: Broiler Chickens

<https://www.compassioninfoodbusiness.com/media/7427577/humane-slaughter-broiler-chickens.pdf>

RSPCA welfare standards for meat chickens; laying hens; and turkeys: 'Gas killing' standards

- <https://science.rspca.org.uk/sciencegroup/faranimals/standards/chickens>
- <https://science.rspca.org.uk/sciencegroup/faranimals/standards/layinghens>
- <https://science.rspca.org.uk/sciencegroup/faranimals/standards/turkeys>

References

¹ Food Standards Agency (2013) Results of the 2013 animal welfare survey in Great Britain. Available online: <https://www.food.gov.uk/sites/default/files/2013-animal-welfare-survey.pdf> Accessed on 06/10/2017

² European Commission (2013) Report from the Commission to the European Parliament and the Council on the various stunning methods for poultry. Available online: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_practice_slaughter_com_2013_915_report_en.pdf Accessed: 01/12/2017

³ European Food Safety Authority (EFSA) (2017) Low atmospheric pressure system for stunning broiler chickens. Available online: <https://www.efsa.europa.eu/en/efsajournal/pub/5056> Accessed: 06/02/2018