HSA online guide – electrical waterbath stunning of poultry

This is the downloadable/printable PDF version of the HSA online guide to electrical waterbath stunning of poultry. As such, some of the video clips are missing. The online version (including video clips) can be accessed from www.hsa.org.uk

Contents:

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Introduction

This HSA online guide to electrical waterbath stunning of poultry is intended to provide information for personnel working within the poultry industry and particularly for persons who perform various hands-on tasks with live birds as part of the poultry slaughter process.

The online guide provides background information on the slaughter method, to help the viewer to understand the technology and to perform their job competently and safely. The online guide explains how to optimise bird welfare during pre-slaughter handling, the theory and the practice of using electrical waterbaths to stun birds and how to effectively bleed birds once they are stunned.

This HSA online guide is also suitable for those with a general interest in humane slaughter, who are new to the topic and who wish to gain an understanding of poultry welfare at the time of slaughter when using electrical waterbaths, eg students of veterinary medicine and animal-related subjects.

If you work within the poultry slaughter industry at a supervisory or management level (eg Animal Welfare Officers, Official Veterinarians, persons who train people for proficiency qualifications or for Certificates of Competence in animal welfare at slaughter and maintenance engineers of slaughter equipment), then you may prefer to read the HSA **Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry'**, which contains more technical, detailed information on setting-up electrical waterbath stunners and the types, and design features, of accessory equipment that can be installed to improve bird welfare. The guidance notes also contain examples of standard operating procedures, information on animal welfare policies and animal welfare training, useful contacts, referenced publications and a glossary of electrical waterbath terminology.

Nevertheless, the HSA Guidance Notes No.7 are also suitable for anyone with an interest in furthering their understanding of electrical waterbath stunning beyond what this online guide provides.

The HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' can be downloaded free-of-charge and is also available in French (**également disponible en français**).

Important points about this online guide

This online guide is intended for all persons around the world who may need to humanely slaughter animals.

In conjunction with reading the principles of operation described in this online guide, viewers are responsible for consulting the relevant legislation. It is not possible to include in this guide the legal requirements of every country or area.

This guide is intended to instruct operators in the proper and humane use of equipment for handling, stunning and killing animals. In order to do this and to safeguard the welfare of the animals to be killed, it is necessary for the guide to be both thorough and illustrated. As such, the following pages may contain descriptions, images and videos of dead animals or stunned animals in the process of dying. The material is presented in an objective and professional manner but please do not read further if you feel you may be negatively affected by the content.

In developing and publishing such guidance, the Humane Slaughter Association (HSA) may indicate its support for methods which it believes to be humane but does not give endorsement to organisations or to specific products, makes or brands of equipment.

The HSA is not responsible for the content of external websites or publications referenced within this online guide, nor do those external publications necessarily reflect the views of the HSA.

Livestock handling and killing systems are potentially dangerous. You are advised to follow your employer’s recommendations and procedures with particular care. If you are in any doubt as to any aspect of the safe operation of systems for handling, transporting, stunning and killing animals, you should consult your manager and the manufacturer. In no circumstances can the HSA accept any liability for the way in which systems are used, or for any loss, damage, death or injury caused thereby, since this depends on circumstances wholly outside of the HSA's control.

The HSA aims to provide up-to-date and accurate information. If you have suggestions for the content of this online guide please inform the HSA via **info@hsa.org.uk** or telephone or write to the office.

Legislation

Some areas and countries of the world have instated legislation to protect the welfare of animals during slaughter and killing.

For example, in Europe the key legislation is *Council Regulation (EC) No. 1099/2009 on the protection of animals at the time of killing*, which has applied since 1 January 2013.

The major provision of the European regulation is that animals shall be spared any avoidable pain, distress or suffering during their killing and related operations (eg handling, lairage, restraint, stunning and bleeding).

Around the world, there may be variation between the legal requirements of some areas or countries. For example:

- The possibility to implement stricter national rules under Article 26 of EC Regulation 1099/2009 means that member states of the European Union may differ in some aspects of their national legislation protecting animal welfare at the time of killing.
- In the United Kingdom, each of the separate countries (ie England, Northern Ireland, Scotland and Wales) may, through their devolved administrations, implement separate national legislation to deal with aspects of the European law.

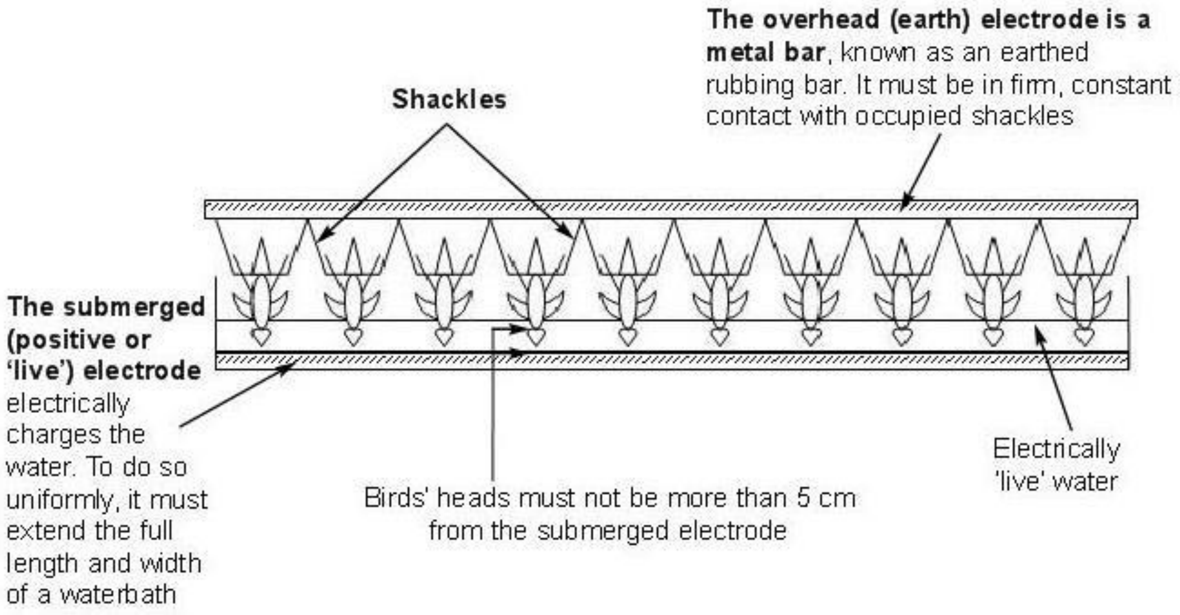
It is therefore critical that viewers of this online guide are aware of all the rules in their country of operation, and any country to which they export products, because it is not feasible to list them all in this guide. Where possible, to assist viewers, some references are made to European law.

Components & principle of function of an electrical waterbath

Every year millions of birds are reared for food for humans and the slaughter of these birds must be carried out in a way that causes no avoidable pain or suffering. Several systems have been developed to facilitate the humane stunning of poultry. The main principle of these methods is to stun each bird so that it becomes unconscious and therefore insensible to pain; this condition must persist until the bird is dead.

Large-scale abattoirs stun poultry using either electrical waterbath or controlled atmosphere systems. Electrical waterbaths are the most commonly used commercial stunning method. Birds are unloaded from their transport containers, inverted and hung by both legs, at the shank, onto a moving shackle line which conveys them to an electrical waterbath (Figure 1). An electric potential difference must be generated across the circuit to produce a steady flow of current that overcomes the total resistance, including that of the birds. In a conventional system, the electrode submerged in the water is maintained at a higher electric potential than the earthed rubbing bar. When the head of a bird enters the electrified water, the electrical circuit is completed and the electric potential difference causes the electrons, and therefore the current, to flow from the submerged electrode in the waterbath up through the water and through the head of the bird, through its body and legs, to the metal shackle in which the bird is restrained and finally up into the earthed rubbing bar.

Figure 1. Principle components of a conventional multi-bird electrical waterbath



The aim of electrical stunning is to pass sufficient current through the brain in order to disrupt its normal function and immediately render the animal unconscious (known as electronarcosis) and insensible to pain until death supervenes. The electrical parameters (voltage, current, frequency and waveform) of a waterbath system can be set to either stun or stun-kill the birds. A bird may be electrically stun-killed by applying a current at a frequency and amplitude that causes unconsciousness and simultaneously stimulates cardiac muscle into ventricular fibrillation and causes death by cardiac arrest. Alternatively, a bird can be electrically stunned and then killed by exsanguination (blood loss due to severance of the major blood vessels between the heart and the brain). No matter whether a system is intended to achieve a stun or a stun-kill, as soon as possible after they exit a waterbath, all stunned birds should have their two common carotid arteries severed, preferably by using a ventral neck cut to sever all the major blood vessels ventral to the spine and to enable easy post-cut verification of which blood vessels are severed. Prompt and accurate neck cutting will benefit animal welfare *and* meat quality.

Despite the increasing complexity and highly-automated operation of some stunning and killing equipment, it remains the responsibility of the operator to ensure that every bird is humanely stunned and killed. Humane electrical stunning of animals requires a sound understanding of electrical parameters, their influence on an animal's brain and how to deliver those parameters efficiently. Effective waterbath stunning depends on the control and management of several elements in order to maximise bird welfare. The welfare of poultry is directly affected by many variables including the waveform and frequency of an electric current, the amount (amplitude or magnitude) of current applied to each individual bird, the optimisation of the flow of electrical current through each bird and the time, and quality, of neck cutting.

A note of caution

Different slaughter methods may have different advantages and disadvantages for animal welfare and meat quality. The conventional electrical waterbath is not a preferred stunning method for poultry welfare because:

- there are inherent risks to animal welfare associated with inversion and shackling of conscious birds;
- it is difficult to control the effectiveness of the stun for every individual bird processed, eg to prevent pre-stun shocks, to ensure immediate immersion of the head in the electrified water and to prevent individual birds entirely avoiding the electrified water;
- commercial waterbath systems generally accommodate a number of birds simultaneously and are operated at a constant voltage, which makes it difficult to deliver the correct current amplitude to each bird;
- scientific research has reported that "*...effective stunning [parameters] using the conventional waterbath almost exclusively produces blood splashing [in the meat]...*" (Hindle *et al*, 2010). This may partly be due to the estimate that "*only a small proportion of current applied in a water bath may flow through the brain and the majority may flow through the carcass*", which is likely to pose problems for welfare *and* meat quality (European Food Safety Authority, 2004).

The 2012 EFSA scientific opinion on electrical requirements for waterbath stunning recommended that "*unless the problems...for all existing waterbath stunning methods can be resolved, other stunning methods should be* *used*". Therefore the world requires improved methods of stunning (electrical or otherwise), to guarantee better parameters for animal welfare and a higher quality carcass.

In the meantime, operating conventional electrical waterbath stunners to a high standard is critical for poultry welfare. In line with the HSA aim to provide information on good operational practices, which may reduce the risk of potential animal welfare problems, this online guide includes advice that prioritises animal welfare, based as much as possible on scientific evidence.

[At the time of publication of this document, the alternative large-scale slaughter methods for poultry were controlled atmosphere systems (CAS). CAS may not be perfect for animal welfare but does offer significant advantages for poultry welfare (and staff health and safety) compared to electrical waterbaths, by avoiding the need for abattoir staff to directly handle, invert and shackle conscious birds and every bird is stunned by a well-run CAS system. To read more about CAS systems, please view HSA publications at www.hsa.org.uk]

References:
EFSA 2004 Scientific Opinion on the welfare aspects of stunning and killing methods. www.efsa.europa.eu/en/topics/topic/animalwelfare

EFSA 2012 Scientific Opinion on the electrical requirements for waterbath stunning equipment applicable for poultry. DOI: 10.2903/j.efsa.2012.2757

Hindle *et al* 2010 *Poultry Science* 89: 401–412

Pre-slaughter handling & restraint

To slaughter birds humanely and effectively, they must be presented to the stunning and killing equipment in the correct manner. The heads of all the birds should be positioned so that the waterbath and neck cutting equipment are applied easily, accurately and for the appropriate duration of time. Restraint facilitates this by restricting a bird's movement. Shackles are the method of restraint used with conventional electrical waterbaths and wet plate whole-body electrical stunners for poultry.

The shackling environment

The shackling area should be well-ventilated, dry and as draught- and dust-free as possible. Noise and any other possible sources of disturbance to live birds must be minimised. In particular, loud, sudden, abrupt noises may unsettle and panic birds; so metal gates should be baffled, radios should not be excessively loud and personnel should avoid shouting (especially whilst handling birds).

Shackling staff should be rotated to other duties at regular intervals to prevent operator fatigue and/or diminished concentration which may hamper their ability to safeguard bird welfare.

When the time comes to shackle a particular batch of birds, their transport container(s) should be re-located from the lairage so they are as close as possible to the shackle line. Containers should be arranged so shacklers can easily reach into them, retrieve a bird and shackle it, without being forced to adopt awkward postures. Containers can be elevated so shacklers do not have to bend to reach birds. Consideration should be given to the number of birds, the typical weight of a bird and the distance it must be lifted and carried by the operators, from a container to the shackle hang-on point.

A container should only be opened as much as is necessary for each person to remove one bird at a time; this limits the opportunities for birds, particularly agile and/or nervous types, to escape. If birds escape from containers or their shackles, they must be immediately retrieved using good practice catching techniques. Birds must not be allowed to wander around an abattoir because this may put them at risk of injury by vehicles. Shackling stations can be caged to prevent escaped birds from roaming into the lairage. Netting can be suspended above the shackling area to contain any escaped individuals of species that can fly (eg guinea fowl). Net threads should be thick and the mesh size should not be too large or too small, to avoid a situation where a bird becomes entangled in the net and needs to be cut free. It may also be useful to have a hand-held catching net in the shackling station to quickly retrieve any bird that proves difficult to capture by hand.

"*Animals shall not be shackled if they are too small for the waterbath stunner or if shackling is likely to induce or increase the pain suffered.*" European Council (EC) Regulation No. 1099/2009

Some poultry are susceptible to gait abnormalities due to rapid growth rate, developmental deformities and infectious causes. In addition, catching poultry on-farm for transport to slaughter may result in new injuries, particularly if birds are caught, lifted and carried by a single leg and carried in one hand with other birds. At the abattoir, it is important that shacklers monitor the birds they unload and do not shackle any injured, diseased or relatively small (eg runting syndrome) individuals. Instead, such birds should be killed using a humane back-up stunning device (eg mechanical percussive (captive-bolt) stunner), which must always be nearby and available to the operators for immediate use. Companies may wish to consider adopting a system for personnel to record how many sick, injured or dead birds arrive at the unloading point. An animal welfare officer (AWO) should review the records.

If any apparently unconscious or apparently dead birds are discovered in containers at the time of unloading, operators should first confirm whether the bird is unconscious or dead. (Warm birds may be alive but unconscious and they should be assessed for indicators of life (breathing, corneal reflex). Cold-stressed birds can sometimes be cold-to-the-touch and stiff but may still be conscious and/or alive. Their breathing is likely to be of a very slow rhythm; checking whether they display a positive corneal reflex is likely to be a good method of assessing their condition.) If a bird is unconscious and it cannot be processed for consumption, personnel should dislocate the bird's neck to ensure it dies, before disposing of the bird. Similarly, if a bird appears to be dead (cold) but if there is uncertainty as to whether it is actually dead, personnel should dislocate the bird's neck to ensure it is dead, before disposing of the bird.

Note: the law regarding licensing and certification, in connection with the possession and use of captive-bolt equipment, may vary between countries and even within. Users of captive-bolt equipment must be familiar with the statutory requirements relating to their particular situations.

Handling for shackling

It is important that personnel responsible for unloading and shackling birds are trained to competently protect the welfare of each bird they handle.

Animals may be stressed by humans handling them, particularly if the animals are unfamiliar or inexperienced with such contact and/or with a handling process. Birds may already be under some stress following the on-farm catching procedure and subsequent transport.

At the abattoir, exposure to any additional stressors should be avoided or minimised in order to reduce bird activity, protect them from physical injury and to keep any animal communication of potential stress to an absolute minimum. This can be achieved by limiting the amount of handling and ensuring the handling procedures do not arouse panic in the birds. Personnel must work in a manner which reduces risk of injury to themselves and to the bird, and which minimises any fear a bird may experience. For example, Table 1 lists actions shacklers should 'aim to' achieve and actions to 'avoid'. Rough handling can result in distress, alarm vocalisations, increased bird activity, bruises, broken bones and dislocated joints, all of which influence the ultimate quality of the carcass.

Although it is not preferred for animal welfare, if birds are unloaded *en masse* and conveyed to a shackling point, the conveyor systems must be constructed so as to prevent any part of a bird becoming trapped and there must be no obstructions that birds might collide with during carriage. Conveyors must allow birds to maintain their balance, ie birds should be able to maintain an upright posture during carriage, without flapping. To achieve this, conveyors must be kept at shallow angles, have non-slip surfaces and move in a smooth manner, without jolting.

Table 1. Shackling poultry.

Aim to:	Avoid:
secure any latches that hold open container doors, so doors cannot drop down onto birds during unloading. Faulty latches or doors that do not remain open must be immediately repaired or replaced.	tipping conscious poultry out of containers; tipping may induce additional stress, fear, flapping and potential for injury (eg red wing tips as a result of flapping and birds may scratch one another with their toenails during, and after, the fall as they try to regain stability and an upright posture.
using both hands, lift one bird at-a-time from a container and shackle it immediately.	roughly or unnecessarily moving birds around containers to position them for lifting.
handle birds calmly and quietly; gently reach under, or around the sides of, a bird to locate its legs in one movement.	knocking any part of a bird against objects, eg transport containers.
once both legs are held, slowly and gently lift up the legs, whilst gently lowering the bird onto its breast. This should reduce any swinging motion and minimise the risk of leg or pelvic injuries (particularly important with heavy birds).	a) pulling a bird across a transport container floor; it may flap (risk of wing, pelvic or leg injuries) and if the container floor is perforated or damaged, toe or breast injuries (and associated carcass damage) may result, respectively; b) lifting a bird off a supporting surface (eg transport container floor) until both legs are held. (Otherwise the bird may swing through the air and may flap.)
a) after lifting by both legs, gently insert each leg into a separate slot of the shackle (with the bird's weight evenly distributed between both legs); b) gently lower the bird's breast against the breast contact strip.	a) lifting, carrying or shackling a bird by one leg, the head, tail or wing(s); b) allowing a shackled bird to 'fall' against the breast contact strip; it may stimulate flapping; c) trapping a bird's toes between its leg and the shackle.

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The shackle line

The shackles should be well-maintained and wetted immediately prior to shackling a bird.

"***Shackles shall be wet before live birds are shackled and exposed to the current. Birds shall be hung by both legs.***" European Council (EC) Regulation No. 1099/2009

"***The size and shape of the metal shackles shall be appropriate to the size of the legs of poultry to be slaughtered so that electrical contact can be secured without causing pain.***" EC Regulation 1099/2009*

*abattoirs with relevant equipment that was in use prior to 1 January 2013 have until 8 December 2019 to comply with Article 14(1) and Annex II of Regulation 1099/2009, including the requirement above. (Abattoirs, layouts or equipment constructed after 1 January 2013 must apply the requirements immediately.)

Shackles have the potential to compress the tissues of the shank, including the innervated periosteum (connective tissue containing nerves and surrounding the bones) and the tarsometatarsal bone, which is potentially painful for a conscious animal and may cause damage (Figure 2). Therefore abattoirs must use shackles that have the correct size (gauge) slot for the birds' legs. Larger, heavier birds are likely to have legs with a larger diameter/circumference (eg male broiler chickens). Shackles with tapering slots are preferable to parallel-slot shackles. If an abattoir processes different species, types, sexes or sizes of bird, then shackles with multiple slots of varying tapering gauges should be installed, to allow birds to be shackled according to their size, thereby limiting (to a degree) leg compression.

Shacklers must not use excessive force when loading a bird into a shackle, because this may cause further compression of the legs. It can be difficult to determine the sex of some types of birds (eg broiler chickens), especially when shackling them at fast line speeds. In such circumstances, and if abattoirs use multi-slot/gauge shackles, it may be appropriate to slaughter males and females separately so shacklers can be instructed, in advance, which shackle slot to use. For example, males can be shackled in the larger slot and females in the smaller slot. However, shacklers should be encouraged to use their initiative also and, as appropriate, shackle a large female or a small male bird in a larger or smaller slot, respectively. Although a shackle should not cause compression injuries or pain, the fit should be sufficiently firm to prevent excessive movement or escape and to allow for good electrical contact for stunning.

Shackling imposes a greater load on birds' legs as bird weight increases. For this reason, heavy birds (eg exceeding 15 kg live weight) should not be shackled for waterbath stunning but should instead be slaughtered using an alternative humane restraint, stunning and killing method (eg restraint cone and captive-bolt followed by exsanguination).

Figure 2. Shackling damage (bruising indicated by arrows) to the shanks of chickens. Bruises are a sign of poor animal welfare.

The duration for which each bird may be shackled

Involuntary inversion appears to cause poultry stress. It is not their default stance and birds do not have diaphragms, so inversion may feel uncomfortable if the viscera compress the heart and lungs. For this reason, and because shackling conscious birds may be painful, it is necessary to minimise the duration that birds are inverted and restrained on a shackle line. Whilst it may sometimes be necessary to allow a short time for birds to reduce their activity and settle down on a shackle line (so they enter the waterbath calmly and smoothly, reducing the risk of pre-stun shocks), the suspension time should always be as short as possible. For example, EFSA (2004) and the OIE (2014) recommended a maximum shackling time of one minute but EFSA (2004) reported 12 or 20 seconds may be sufficient time for chickens and turkeys respectively, to settle on a shackle line.

Maximum durations that conscious birds can remain suspended in shackles before waterbath stunning, according to EC Regulation 1099/2009*:

- **Two minutes for ducks, geese and turkeys**
- **One minute for all other species of poultry**

*abattoirs with relevant equipment that was in use prior to 1 January 2013 have until 8 December 2019 to comply with Article 14(1) and Annex II of Regulation 1099/2009, including the requirement above. (Abattoirs, layouts or equipment constructed after 1 January 2013 must apply the requirements immediately.)

Shackle line design

Shackle lines must be designed to minimise disturbance of suspended birds. Ideally, all sections of a shackle line conveying conscious birds must be straight (ie no corners) and without inclines, whether ascents or descents. A shackled bird must be kept clear of any obstructions that might cause panic, struggling, pain or injury, including when a bird's neck and wings are fully outstretched and if it flaps. Obstructions may include neighbouring birds; if a flapping bird hits its neighbour(s) with its wings, the neighbour(s) may also be disturbed and begin flapping. Shackle lines must be constructed and maintained so they do not jolt birds because this is likely to stimulate flapping. Shackle line speeds must be of a pace that does not cause the birds to struggle. Fast line speeds may cause birds to notice inclines, to swing round any corners (if corners still exist on some shackle lines) and to lose contact with the breast contact strip, initiating wing flapping. The line speed must also be appropriate for each operator to safely, comfortably, gently and effectively shackle and thereafter, whenever necessary, tend to a bird on the shackle line (eg back-up stun/kill it or remove it from the shackle), without undue haste.

At a given line speed, there must be a sufficient number of shacklers so that each has sufficient time to identify, separate and kill (or immediately pass to another appropriate person to kill) any birds that are unfit to undergo the routine slaughter method. All operators responsible for poultry welfare must always be able to visually monitor shackled birds, but it is better if a shackle line is not in such close proximity to operators (or to thoroughfares for other personnel) that their routine working movements disturb shackled birds.

The controls of all processing equipment should be immediately accessible, should the need arise to stop the shackle line in an emergency. For example, multiple emergency-stop buttons or a pull-cord spanning the entire length of a shackle line (from the shackling station to the scald-tank) will allow personnel to immediately stop the line and raise the alarm. Personnel should be encouraged to activate these emergency-stop systems if they foresee or witness an emergency (eg a live bird entering a scald-tank or plucker). Correspondingly, the whole length of a shackle line from the hang-on point furthest from the waterbath, to the point of entry into the scald-tank must be readily accessible to abattoir personnel, should any bird need immediate attention.

If a line stops and conscious birds are likely to be suspended for longer than the recommended or legal maximum duration, they should be immediately stunned and killed, in their shackles, using a humane back-up method. It is preferred, for bird welfare, to stun and kill birds in their shackles, to avoid the additional handling (which may compound any stress) and the potential discomfort (eg recompression of the legs) if birds are either unshackled and then killed using a back-up method, or if they are unshackled, recrated and later reshackled (on potentially damaged legs) for waterbath stunning, once the system restarts.

Methods of reducing bird activity on a shackle line

Ideally there should be no flapping on a shackle line, or as little as possible; however, lack of flapping does not necessarily indicate a bird is unstressed.

Handling, inversion, the act of shackling and tight shackles may induce stress, pain and flapping, which may lead to dislocations (particularly of the wings), fractures and muscle haemorrhages. Struggling may adversely affect meat quality by producing a build-up of lactic acid in the muscle, resulting in a low muscle pH, which reduces the water-holding capacity of the meat. So, in addition to its welfare importance, there is a financial incentive in encouraging birds to limit their activity as much as possible.

Breast contact strips

Breast contact strips are commonly used to reduce the incidence of wing flapping. A breast contact strip should extend below each bird’s head (Figure 3) and the strip must be in constant and full contact with every bird’s breast along the entire length of the line, from the furthest point for shackling, until a bird enters the electrified water. This is easier to achieve if the shackle line is straight but if it is not, the strip must also extend around any bends. The contact strip should be made of one solid piece of non-conductive material, to avoid feathers becoming trapped in joins between sections of material (which may cause discomfort or hold back the body, relative to the legs and shackle, which may cause the bird to swing sideways when released). The material should be rigid to ensure heavier birds do not distort the strip which may prevent lighter-weight birds making effective contact. Contact strips should be sufficiently tall and adjustable so their height and angle can be suited to every type of bird slaughtered at the abattoir. Slightly angling a contact strip may create greater contact with birds' chests, which may be particularly important for small birds or for flighty birds that tend to pull their chests away from the strip whilst flapping. If they are to work effectively, breast contact strips must be repaired or replaced if the surface of the material begins to wear or become uneven (eg buckle).

Figure 3. Broiler chickens on a shackle line with a breast contact strip.

Shackling techniques that may reduce wing flapping

Flapping may tend to occur when birds are loaded into the shackles and for a short time thereafter. To prevent this, immediately after the shackling action, a shackler should routinely either run their hands down a bird's body or briefly hold onto the bird's legs - care must be taken not to scratch or squeeze a bird, or its legs, during this process in case it exacerbates any disturbance. If a bird shows potential signs of distress, such as excessive wing flapping or excessive vocalising, it should be tended to immediately, eg an operator's hand should be gently placed on the bird's breast, or the bird should be gently held against the breast contact strip, whilst allowing it to move with the advancing shackle line (otherwise, when the handler lets go, the bird may swing sideways and cause it to resume flapping). If this does not stop the struggling, the bird should be stunned and killed immediately using a humane back-up method, preferably before it is removed from the shackle. The shackle and the shackle line should be examined for possible causes of the disturbance.

Bird types and varying activity levels

Different types of birds can differ in their activity levels whilst on a shackle line, eg slow-growing chickens may have a shorter latency to more intense struggling compared to fast-growing and heavy lines of chicken; and heavy-line chickens may be less active than fast-growing chickens. Anecdotally, broiler chickens are typically shackled close together to prevent wing flapping at the point of shackling. Geese may bite nearby personnel or neighbouring shackled birds.

Some bird types, and particularly those that tend to be active on a shackle line, may benefit from being adequately spaced out (eg if the shackle pitch cannot be spaced further then there should be an appropriate number of unoccupied shackles in between occupied shackles). This may limit opportunities for physical aggression as well as prevent struggling birds from beating their wings against other individuals, hopefully reducing transmission of disturbance. If certain types of birds cannot be shackled without causing distress and/or high levels of continuous activity, then alternative methods of restraint and stunning may be necessary.

Breast support conveyors

A breast support conveyor can be constructed underneath, and advance in time with, a standard shackle line (Figure 4). The conveyor supports some of the weight of the birds, thereby removing some of the pressure on their legs in the shackles. A conveyor may also keep the birds relatively upright. Compared with a conventional shackle line, this may result in reduced struggling at hang-on, more efficient entries to the electrified water and a lower incidence of wing damage. It is critical that the shackle line is straight because birds traversing corners on a conveyor may display increased disturbance and struggling, compared to birds on a conventional shackle line.

Whilst a breast support conveyor may be advantageous for all types of birds, it may be particularly useful for heavy birds. Even when using a breast support conveyor, shacklers are likely to be easily fatigued by shackling large birds so shacklers must be regularly rested to ensure they are physically and mentally able to afford the birds the necessary gentle care during handling.

Conveyors must be constructed of suitable plastic which will not trap birds' feathers, skin or other body parts. When breast support conveyors are used, operators must monitor birds and, when necessary, adjust the system or reposition individual birds. For example, the speed of a conveyor must be adjustable so it can match the speed of the shackle line. The height of a conveyor must be adjustable so the distance between the conveyor and the shackles allows birds to lie in comfortable positions. Operators must immediately tend to any birds that adopt awkward postures that lead to struggling or discomfort. Any healthy birds which are gasping or gulping in an unusual, strained manner must be assessed to determine why – they may be lying too far forward on their chest and require repositioning. The use of breast support conveyors, and supporting research, are in their infancy. Therefore installation of such devices must be carefully considered and continuously monitored to ensure welfare is not impaired in any way and that birds cannot escape the shackles.

Figure 4. Broiler chickens and turkeys atop a breast support conveyor. Once each bird is shackled and sitting appropriately upon the conveyor, the shackler should fold the birds' wings into the natural closed position, to reduce the risk of pre-stun shocks.

Pre-stun shocks at the entrance to a waterbath

A bird's head must *always* be the first part of its body to enter the electrified water. Any possibility for a part of a bird to come into contact with electrified water *before the head is immersed*, may result in a severely painful pre-stun electric shock.

Birds might be suffering from pre-stun shocks if, at the same point(s) on a shackle line, birds tend to suddenly exhibit abrupt behaviours that might indicate distress, eg flapping and/or high-pitch vocalisations. Also, if birds display more than one contraction on entry to the water, this may indicate interrupted application of the initial current flow.

Pre-stun shocks typically trigger an escape response in birds and therefore can cause them to flap vigorously and to lift up their heads, and sometimes their bodies, above the surface of the electrified water. As a result, birds may not be stunned immediately and may not receive an electric current for the minimum recommended duration; or they may not be stunned at all if they pass through the waterbath without making contact with the electrified water. Vigorous flapping may increase the likelihood of additional pre-stun shocks to the wings and the situation can therefore be cyclical. If neighbouring birds are hit by flapping wings they may be disturbed and begin flapping too.

Flapping birds may damage themselves, particularly if, in the panic, they beat their wings and hit their heads against the side panels of a waterbath. As well as being detrimental to bird welfare, pre-stun shocks are associated with damage to the carcass, eg red wing tips; haemorrhages in the wing, major fillets (dorsal and ventral aspects) and minor fillets (dorsal aspect); and broken pectoral bones.

Risk factors for pre-stun shocks:

- A bird's wings are prone to receiving pre-stun shocks, particularly when the bird holds them open. In this position the carpometacarpus may be especially close to the water.
- The large wingspan of geese and turkeys puts them at particular risk of pre-stun shocks because their wings often hang below their head.
- Agitated, struggling birds may hold their wings open and some flap; as such the wings may be more likely to make contact with the electrified water.
- Sometimes birds' legs and/or feet contact the earthed rubbing bar (eg when a shackle line descends just before the entrance to a waterbath). If the entry ramp is not electrically isolated or if electrified water overflows the entrance, such birds may receive pre-stun shocks.
- Pre-stun shocks may occur if a shackle line descends too gradually, as birds enter a waterbath. For example, when a bird's beak touches the water current will begin to flow and the skeletal muscle in the body will contract, causing the bird to become rigid and typically arch its back (reflex dorsiflexion). This rigidity may effectively lift up the bird, including its head. If, within one second of the initial contact, the beak momentarily loses contact with the water, the bird may receive a pre-stun shock. Thereafter, even if the bird's head regains contact with the water and becomes fully submerged, the earlier pre-stun shock may still have caused suffering.

If pre-stun shocks are suspected to occur, personnel must notify the AWO &/or veterinarian and there must be an investigation to identify the extent of the problem and the necessary corrective action, which may require redesigning the entrance to the waterbath, or perhaps the entire shackle line.

Actions that may minimise the risk of birds experiencing pre-stun shocks

To prevent pre-stun shocks, current flow to/through a bird must only be possible when the shackle is in contact with the earthed rubbing bar and, simultaneously, the bird's head is in full contact with the electrified water in the waterbath.

Anecdotally, some birds that do not flap may fold their wings into the closed position (Figure 5a,b) and hold them against the sides of their body, naturally keeping the wings away from the electrified water and also avoiding contact with neighbouring birds. Such a bird may also hold its neck and head down in a vertical line, which may allow the head to enter the water smoothly. Personnel should strive to ensure handling and shackling is of the highest quality because it may encourage this behaviour in birds.

A steeply-inclined, smooth ramp ascending over the entrance to the waterbath (Figure 6) may reduce the number of birds experiencing pre-stun shocks. An entry ramp should begin below the level of the birds' wings, to prevent wings from becoming caught on the edge of the ramp. A ramp should extend over the water a short distance and must briefly hold birds back at the top of the ramp (Figure 5a,b), so they gently, but rapidly, swing off the edge and their heads swing straight into the water in one smooth motion. The height and angle of a ramp must be adjustable so it can suit the shackle line and the size of bird being processed.

Care must be taken to ensure birds do not receive pre-stun shocks from the entry ramp itself, by electrically isolating the ramp from the rest of the waterbath. This can be achieved by ensuring there is no physical contact between the ramp and the waterbath and by ensuring the ramp does not have a flow of [electrically 'live'] water running onto it from the waterbath.

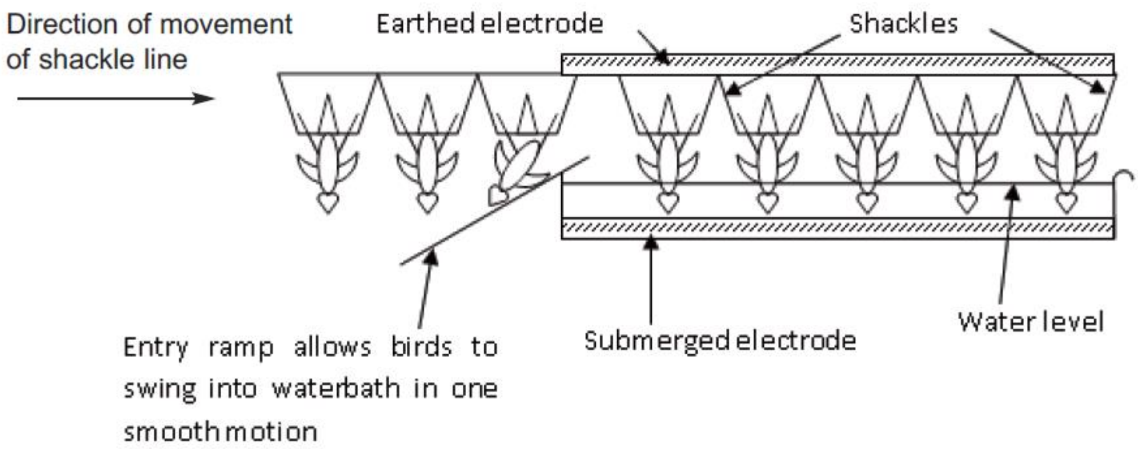
Examples of different types of entry ramps can be found in the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry'.

Figure 5a). A broiler chicken approaching a waterbath stunner. b) As the bird makes contact with the entry ramp its body is held back, facilitating thereafter a swift swing into the electrified water. The bird's wings are closed, reducing the risk of pre-stun shocks.

a) 

b) 

Figure 6. Use of an angled entry ramp to reduce pre-stun shocks.



Birds must be monitored as they move over an entry ramp. For example:

- If a shackle line descends as it passes over a ramp, then a large, heavy bird's head and neck can become trapped between its body and the ramp, whilst the leading wing dips into the electrified water. For this reason, ideally, a shackle line should remain horizontal (or should not descend too much) at the entrance to a waterbath, to enable the entry ramp to work.
- Whilst the legs continue advancing at the pre-set speed of the shackle line, when the birds' bodies contact the ramp their movement over it typically slows and their bodies, necks or shackles may overlap. Birds must be monitored to ensure they are not vigorously struggling, smothering one another, or that toes or feet do not become caught if the shackles cross over one another.
- As a bird enters a waterbath, its shackle must not overlap another shackle (whether occupied or unoccupied) because the bird's shackle will not be in direct contact with the earthed rubbing bar and may compromise the flow of current for each bird.
- Small birds must not be shackled because they may fail to contact the entry ramp, not swing into the water and thereafter may continue to avoid the electrified water. Birds that are of an inappropriate size for effective stunning in a particular waterbath must be slaughtered using an alternative humane stunning method (eg the back-up device).

Summary: reducing the incidence of wing flapping in conscious birds on a shackle line and reducing the occurrence of pre-stun shocks

- Construct a straight shackle line from the first shackling point to the waterbath.
- Avoid constructing bends and inclines in a shackle line.
- Minimise the length of a shackle line to: a) avoid a need to increase the line speed, in order to reduce the time that conscious birds are suspended; b) reduce the number of conscious birds requiring attention during a line breakdown.
- Unload, retrieve escapees and shackle birds calmly, gently and quietly.
- Shackle birds in correctly-fitting and appropriately-shaped shackles; if shackles are too tight they may cause pressure/pain which may provoke wing flapping.
- Replace any damaged or heavily-scaled shackles.
- Use appropriate line speeds to prevent swinging of birds.
- Ensure the line moves smoothly without jolting/jerking.
- Maintain a low light intensity, or use low-intensity blue lighting.
- Avoid passing the shackle line through areas of sudden bright light.
- Prevent temporary loss of visual contact between neighbouring birds.
- Minimise ambient noise (including the rattling of shackles).

- Prevent sudden and excessive movement of air (wind tunnel effect - draughts may disturb birds).
- Ensure shackles and the earthed rubbing bar do not trap and pinch birds' toes or interdigital webbing since this may be painful and cause flapping.
- Use equipment that touches the birds' breasts, eg a breast contact strip or a breast support conveyor. Ensure breast contact is constantly maintained from the start of shackling through to the stunner.
- An entry ramp must be designed and positioned to allow a gentle but rapid flick of a bird's head into the water. Entry ramps also keep wings above the waterline and assist in preventing pre-stun shocks.
- Prevent any overflow of water from the entrance to the stunner; set up a drainage system at the exit of the waterbath.
- If electrified water does overflow from the entrance, install a non-conductive overlay atop the entry ramp, to electrically isolate the entry ramp.
- Ensure the water level in a waterbath is set according to flock size, to allow immediate submersion of the head of the smallest bird.
- A shackle line that descends at the entrance to a waterbath is a traditional design that lowers birds' heads into the water. These dipping lines are typically only suitable at fast line speeds (otherwise the slow entry into the water gives conscious birds an opportunity to resist immersion). Large birds like turkeys and geese may also be at greater risk of pre-stun shocks to their wings on slow-moving dipped shackle lines.
- Ideally a shackle line should not descend at the entrance to a waterbath, when used in conjunction with an entry ramp.

Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

Electricity - voltage, current and resistance

In order to achieve effective electrical stunning, it is helpful to understand the basic principles of electricity.

Ohm's Law defines the relationship between voltage, resistance and current and states that the current is directly proportional to the applied voltage and inversely proportional to the resistance of the circuit. Therefore, to increase the amount of current flowing through a circuit, the voltage must be increased, or the resistance decreased.

Ohm's Law: **Current (I) = Voltage (V) ÷ Resistance (R)**

Voltage is the electromotive force (emf) or electrical pressure that forces the flow of current and is measured in Volts (V). Voltage may also be referred to as the electric potential difference between electrodes. It is necessary to maintain a voltage that is sufficient to produce a current strong enough to ensure that every bird is stunned.

Current (I) is the rate of flow of electric charge through a conductive object and is measured in Amperes (A). The current is the most important parameter in terms of ensuring effective stunning; hence why recommended electrical parameters focus on the current and not the voltage. For example, voltage may vary across different circuits with the same current.

Electrical **resistance** (R) is a measure of an object's capacity to impede the flow of current and is measured in Ohms (Ω). Resistance may also be described as impedance, particularly when referring to an object's resistance to alternating currents. The overall resistance of an object depends on several properties including the length, cross-sectional area and the resistivity of the material that forms the object. The resistance of an object is proportional to its length and inversely proportional to its cross-sectional area. Different materials have different resistances; metals are strong electrical conductors with a low resistance, whereas ceramics, plastics or glass do not conduct electricity well and therefore have a high resistance and are classed as insulators. Whilst it is possible to manufacture the electrodes and the shackles from materials with a relatively high conductance and low resistance, it is not possible to drastically alter the biological resistivity of the birds, although the resistance of living tissue can be reduced by increasing the voltage applied.

An animal is formed of various tissues including skin, muscle and bone which vary in their resistance to electricity. The arrangement of these tissues in the body ultimately determines the path along which the current flows. With time, a voltage progressively overcomes (to a degree) the resistance of the tissue(s) it is passing through, providing a higher current to the tissue. However, electricity is likely to flow along the path of least resistance within an object. Therefore, an applied current is more likely to travel through the lower-resistivity tissues of skeletal (breast) muscle and cardiac muscle than through the more resistive skull bone. It is possible that the brain may only receive a very small proportion of the total current applied to the body, but this may depend on whether a bird's eye(s) are in physical contact with the electrified water (ie submerged) or the electrified wet plate (read the section 'Maintaining an uninterrupted electrical circuit and optimising current flow'). Therefore, it is absolutely critical that the minimum recommended currents are delivered, to increase the likelihood that enough current actually penetrates the skull, enters the brain and triggers unconsciousness.

An individual bird's resistance is highly variable relative to other birds of the same type, as well as between strains, breeds and species (Table 2). Resistance may depend on factors such as age, size (but not necessarily live weight), sex, feather coverage, thickness of the skin and leg scales (degree of keratinization), whether an animal's skin and/or plumage is wet, muscle and fat composition of the torso, an animal's state of hydration and the thickness and density of the skull and tarsometatarsal (shank) bones. For example, it was suggested that the greater amount of abdominal body fat, the lower moisture content of body tissues and the thinner legs are the reason why female broiler chickens have a greater electrical resistance than males, despite being almost the same age and weighing less. Females therefore require higher voltages than males, in order to produce the same current amplitude necessary for effective stunning. Similarly, the fat and moisture content of female turkeys and the diameter and surface properties of their legs was suggested as a reason why they have a greater resistance compared to male turkeys.

Table 2. Electrical resistances of poultry. ♂ = male, ♀ = female. The resistances are based on a 50 Hz sine AC. This table is a guide to the approximate resistances of poultry; because resistance varies with many factors, these values are not guaranteed. Note: mention of foie gras does not imply the HSA agrees with this practice.

Bird type	Average resistance Ω	Range of resistance Ω	Live weight kg Average (range)
Broiler chicken	1000 - 1600 Ω ♂: 900+ ♀: 1200+	800 - 3900	2.5 kg (1.7 - 3.5)
Egg-laying chicken	2500 - 2900 Ω	800 - 7000	1.9 kg (1.3 - 2.4)
Turkey ♀	2100 - 2300 Ω	Up to 5700	5 - 10 kg
♂	1200 - 1600 Ω		8 - 25 kg
Guinea fowl	2900 Ω		1.2 - 2.3 kg
Duck	1600 - 1800 Ω	900 - 2800	2 - 3.8 kg
Male mule (Pekin x Barbary/Muscovy)	2600 Ω	2100 - 3300	4.2 kg (6.5 kg for foie gras)
Goose	1900 Ω	Up to 4100	4.3 - 6.7 kg
French Landes for foie gras	2700 Ω		possibly 8.5 kg

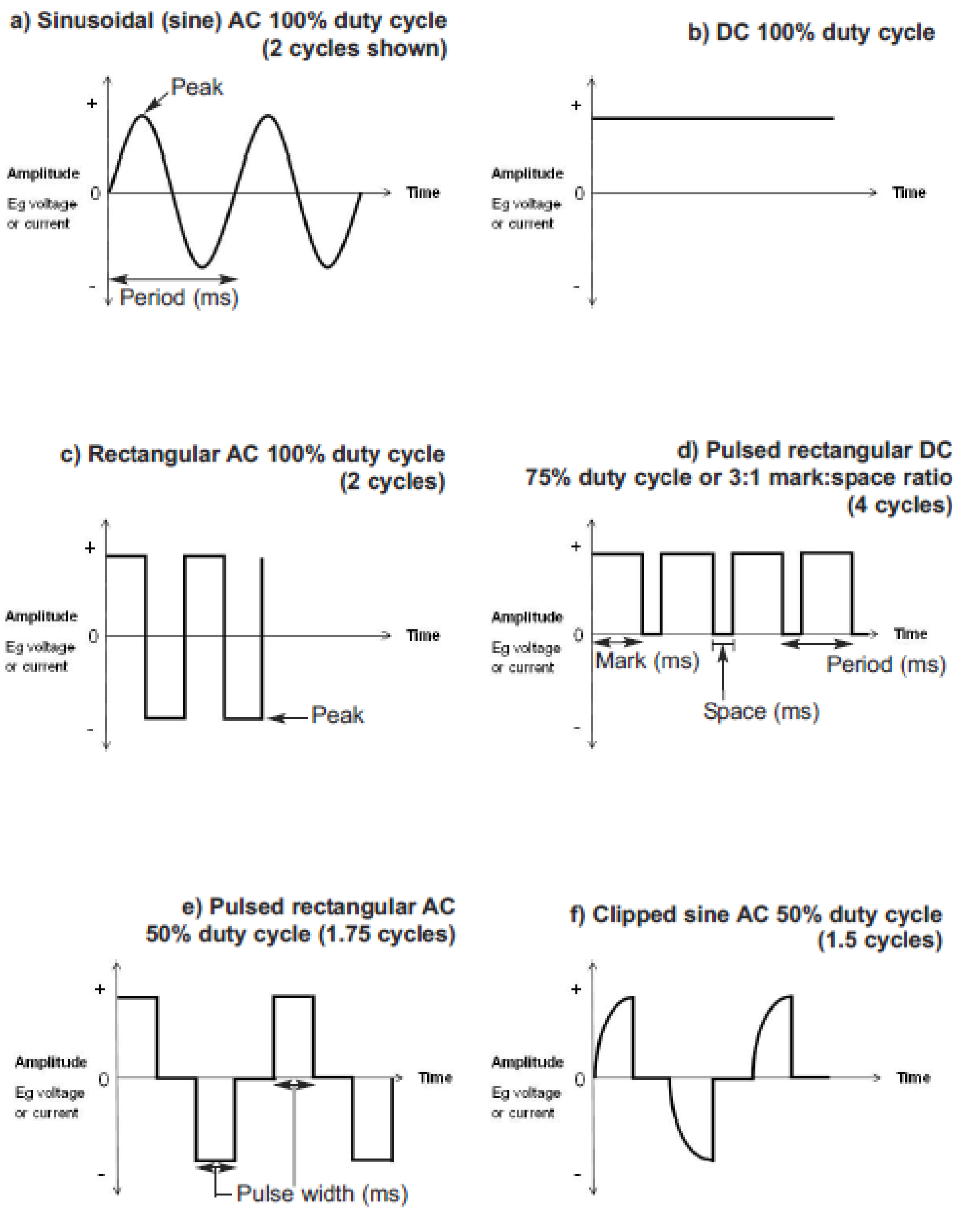
Waveform

The waveform describes the shape of one cycle of the voltage or current. Current can be generated as an alternating current (AC), where the direction of the current flow alternates around zero with positive and negative direction (bipolar; Figure 7a,c,e,f). Alternatively, a direct current (DC) flows in only one direction (unipolar), either the positive or the negative (Figure 7b,d). DC currents are typically pulsed (pDC), meaning the current is turned off (zero amplitude) for a proportion of the cycle time. The resulting waveform can be expressed by the mark:space ratio (where the mark is the time the current is 'on' and the space is the time the current is 'off', ie at zero). An alternative description of this is the duty cycle, where the duration of the mark is expressed as a percentage of the duration of the cycle time.

The way an AC or DC current flows can be examined over time to reveal the shape/form of the wave. For example, waves can be smooth undulating curves (sinusoidal or sine), square or rectangular, sawtooth or triangular. Current can also be modified to produce different waveforms. For example, AC waves can be rectified to different degrees (eg half or fully) to produce DC waves (eg pulsed or constant, respectively). Or a wave can be clipped to produce various different shapes. A variety of waveforms (including some of those shown in Figure 7) have been used in electrical waterbath stunners, mainly to attempt to reduce carcass damage or to improve the efficacy of the electrical pulse. However, so far, scientific research indicates that carcass quality is not necessarily improved when waveforms are altered and a sine AC appears to produce the most effective stuns for animal welfare.

Figure 7. A selection of AC and DC waveforms. Time is typically described in milliseconds (ms).

(Note: this figure is for descriptive purposes only, to enable understanding of electrical terminology; the waveforms shown are not necessarily appropriate for humane electrical stunning of animals.)

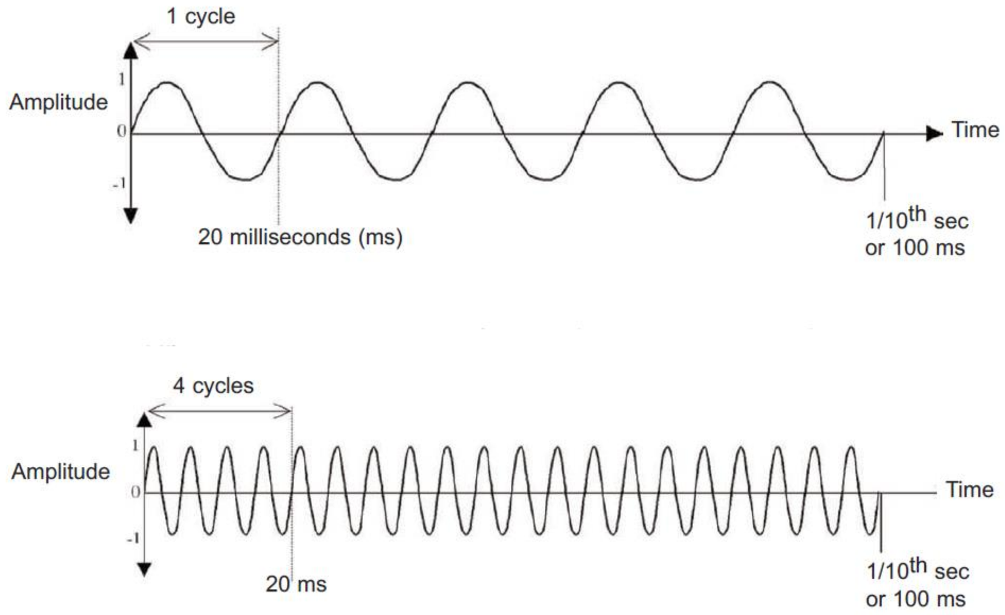


Frequency

The frequency of a current is the number of repetitions of one complete cycle of the waveform per second and it is measured in hertz (Hz). For example, 'standard' mains electricity in Europe is characterised by a sinusoidal waveform with a frequency of 50 Hz, ie it repeats 50 times per second (Figure 8a). If there are 50 cycles every second, that means one full cycle is completed in 20 milliseconds; this duration is known as the period of the current. Waveforms that repeat one full cycle a greater number of times per second will have a higher frequency, eg the current in Figure 8b has a frequency four times greater than the current in Figure 8a.

Figure 8. Top: a sinusoidal 50 Hz wave. 5 cycles in 1/10th sec = 50 cycles per second.

Bottom: a sinusoidal 200 Hz wave. 20 cycles in 1/10th sec = 200 cycles per second.



Descriptive units of current and voltage

There are various ways of reporting the amount (amplitude or magnitude) of a current or voltage.

For example, peak amplitude is the height of a wave from zero to either the highest positive point, or the lowest negative point. However, it is useful to report current amplitude as an average. At a 50% duty cycle (1:1 mark:space ratio) a pDC waveform will have an average current that is always half of the peak current. For different duty cycles, the average and peak current can be calculated.

For AC, if the proportion of time the wave spends above zero is equivalent to the time spent below zero, the mathematical average will be zero and meaningless. Instead, the 'root mean square' (RMS), or 'effective', current can describe an AC wave.

Abattoir personnel must always report the appropriate descriptive units when recording the electrical parameters used in a stunner (eg 'RMS' for AC, 'average' for pDC and the constant amplitude value for DC).

Summary of electrical terminology

- **Current** (I) = the flow of electricity through an object. Always specify the units used, eg **mA RMS** for AC; mA average for pDC; mA for DC.
- **Voltage** (V) = the driving force (electrical pressure). Always specify the units used, eg **V RMS**. (Remember: even if the required current amplitude is identical for different bird types (eg broiler and egg-laying chickens), the voltage required to achieve this current may differ between the bird types due to their different resistances.)
- **Waveform** = the shape of one complete cycle of electrical current. Must include the polarity (ie whether AC or DC) and the shape (eg sine, rectangular, the proportion of any clippings of the wave).
- **Frequency** = the number of complete cycles per second.
- **Period** = the amount of time taken to complete one cycle of the waveform.
- **Pulse width** = the amount of time for which the current flows (ie the 'on' time) within a single period.
- **Duty cycle** = the pulse width, expressed as a percentage of the period.

The above parameters should be specified in Standard Operating Procedures (SOPs) for each waterbath stunner on-site (including for each phase of multi-phase stunners) and for each type of bird processed.

Examples of SOPs for electrical waterbath stunning and back-up stunning of poultry can be found in the HSA Guidance Notes No.7 on 'Electrical waterbath stunning of poultry'.

Constant voltage versus constant current

The commercial electrical waterbath systems presently in use, operate using a constant voltage. Constant voltage stunners are designed to apply an equal voltage to each bird passing through a waterbath, whether it accommodates a single bird or multiple birds.

The minimum total current required for a waterbath will be the maximum number of birds that can simultaneously be in the water, multiplied by the minimum required current per bird, eg Figure 9A. However, this is, at best, an estimate because it assumes all birds have equal resistances, which, in reality, they do not.

When a pre-determined, constant voltage is applied to a group of birds, each bird's different level of resistance will cause it to receive an associated different current amplitude (Figure 9B). This means a bird with a lower-than-average resistance may receive more current than the operator intends and therefore may be stunned (but may also experience more damage to the carcass); whilst a bird with a higher-than-average resistance might receive less current than the operator intends and may not be adequately stunned. Therefore, attempting to deliver to every bird, the minimum recommended current per bird, using a multi-bird constant voltage stunner, is extremely difficult.

A more preferable electrical stunning system for animal welfare *and* meat quality will operate using a constant current. The challenge of the natural, multi-factorial variation in individual birds' resistance, and across the range of available electrical parameters, is met by automatic variation in the applied voltage, to ultimately produce a very similar current amplitude for each bird, ie sufficient current for bird welfare but not too much current for meat quality, eg Figure 9D. Unfortunately, whilst constant current systems have been used since the 1990s for scientific research, no large-scale commercial waterbath systems are yet available to industry.

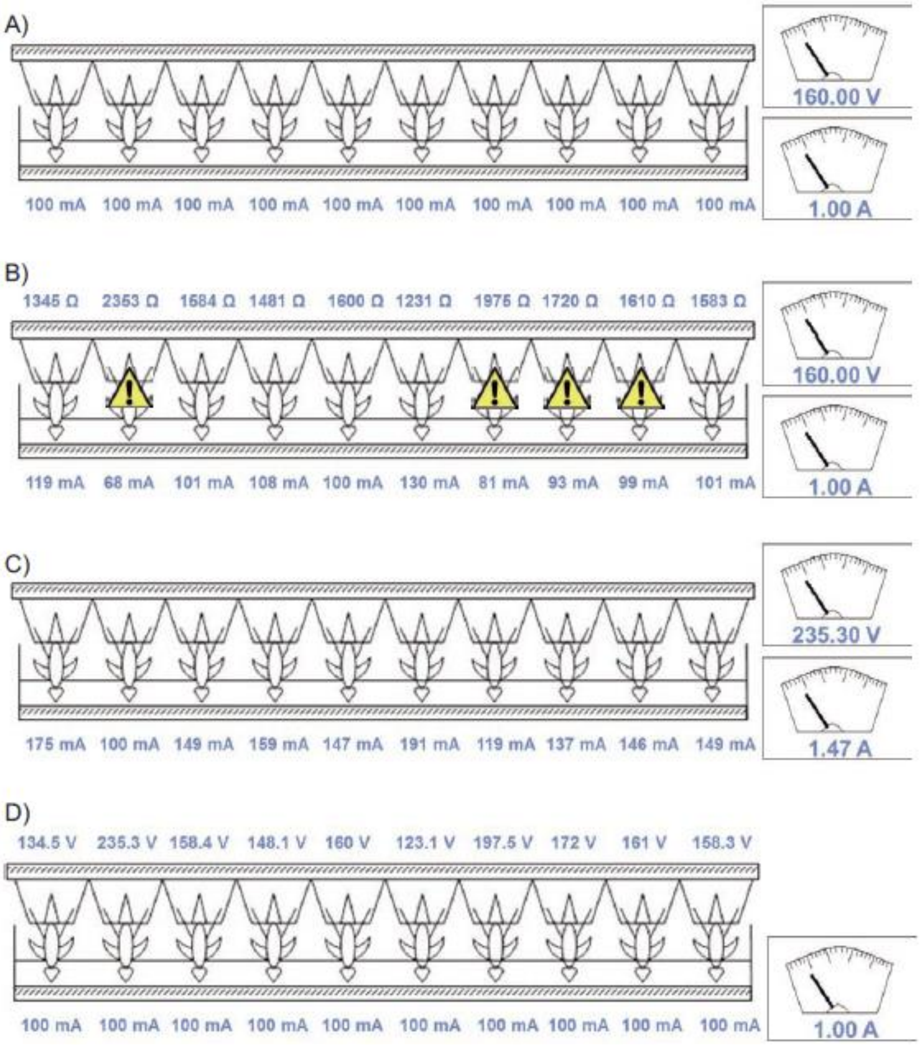
Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

Figure 9. An example of how constant voltage and constant current systems work and the current and voltage used to attempt to supply each bird with a prescribed current of 100 mA. A voltmeter and ammeter are displayed on the right and the parameters per bird are shown above and/or underneath each bird. A) If it is assumed that all birds have an average resistance of 1600 Ω.

B) In reality, each bird may have a different resistance which causes them to each receive a different current amplitude in a constant voltage system. The warning triangles indicate birds that receive less than 100 mA and, as a result, may not be effectively stunned.

C) To combat this animal welfare problem, the voltage of a constant voltage stunner should be increased to ensure all birds receive at least 100 mA.

D) Alternatively, a constant current stunner can alter, as necessary, the voltage applied to each bird, in order to deliver the same prescribed current to each bird.



(Note: all figures are examples; the voltages shown should not be assumed to be the necessary voltage to achieve these current amplitudes in practice. For guidance on appropriate parameters, read the section 'Parameters for stunning'.)

Maintaining an uninterrupted electrical circuit and optimising current flow

A conventional electrical waterbath stunner allows current to flow between two electrodes, from the submerged electrode to the earthed rubbing bar.

Electricity will only flow through a closed electrical circuit. Therefore, all electrical contacts within a circuit must be continuously, physically maintained, ie the bird's head with the electrode/electrified water, the bird's legs with the shackle and the shackle with the earthed rubbing bar.

Even when all objects within an electrical circuit are physically connected, the flow of current between them can be compromised by the inherent characteristics and the quality of the electrical contact(s). If a waterbath has inadequate electrical contact, the problem cannot be solved by simply increasing the voltage supplied, because this may not necessarily improve stunning and may instead affect meat quality and increase the risk to human health and safety.

It is possible to reduce the resistance of a circuit, at the points of electrical contact. Indeed, this is an essential basic procedure in the operation of any electrical system.

Any damaged (eg rusted, distorted or broken) equipment (including the submerged electrode, shackles and the earthed rubbing bar) may not conduct the current properly and must be replaced.

The live electrode-water-bird interface

Water depth

A waterbath must be capable of precise vertical adjustment. A hydraulic lifting system may be required to quickly raise or lower a waterbath whilst it is filled with water. If a large proportion of birds avoid the electrified water it is likely the waterbath height, and perhaps also the water level, need adjusting. The height of a waterbath and the depth of the water within it must be regularly monitored by abattoir personnel and be adjusted, as necessary, to allow full submersion of the head, including the eyes and cranium (the part of the skull encasing the brain), of all birds in the batch. In ducks, when only the beak and crop are immersed, disruption of normal brain function is typically less profound and this may be due to the brain receiving a lower proportion of the current that is passing through the whole bird. Unfortunately it may be difficult to achieve complete submersion of the heads of waterfowl (the heads appear to involuntarily float at the water's surface). Therefore it may be important to install a device that submerges the cranium of each duck or goose, eg a neck extender - although these may have limited success.

Birds may be submerged up to the rostral edge of each wing (ie shoulder level: Figure 1), if this ensures immersion of the head of the smallest bird in the batch being processed. In Europe, birds must be immersed up to the base of the wings (EC Regulation 1099/2009). However, care should be taken if birds are immersed deeper than the shoulders, because there may be a risk of current bypassing the head and brain and birds may not be rendered unconscious, although this is yet to be scientifically investigated.

If a shackle line is moving at a fast speed with a large number of birds per minute, such that the water is pulled from the entrance of the waterbath towards the exit, causing birds' heads to not be fully submerged at the start of stunning, then the water level should be raised to counter this effect and ensure complete submersion of the heads for the entire length of the waterbath.

Wet plate electrical stunning systems

Some electrical, whole-body stunning systems for poultry do not operate with a deep 'bath' of electrified water. Instead, they may operate with a shallow bath of water and/or simply run water over a live electrode (hence 'wet plate'), with which the birds' heads make direct contact (typically the sides of their heads are dragged over the electrode as the shackle line advances). In most cases, the principles that apply to waterbaths also apply to wet plate systems, eg maintaining good electrical contact, including the ability to adjust the height of the stunner to ensure the birds' heads make full contact with the electrode.

Wet plate systems have been found to offer inconsistent contact and may put birds at risk of pre-stun shocks. Therefore if they are used, operators must ensure every bird's head makes full, continuous contact with the live electrode in the appropriate manner and before any other body part touches the electrode. Despite offering direct physical contact between a bird's head and the electrode, wet plate systems appear unable to overcome the aforementioned variation in resistance between sexes of broiler chickens.

Directing the current through the brain

Electrodes must be placed so the target organ (brain) lies between them. There must not be any opportunity for current to bypass the brain and travel instead through other (eg less resistive) body tissues. For example, if a bird's head remains above the electrified water or does not contact the electrified wet plate, but its chest is the first point of contact with the water or the plate electrode, then the chest will still complete the electrical circuit and current flow may be evident from the immediate cessation of movement in the bird and a rigid posture. However, it is possible the brain is not in the pathway of current flow and there is a significant risk the bird may experience electroimmobilisation and merely be paralysed whilst remaining conscious and capable of suffering extreme pain and distress. This is a possibility in all species, but is a particular risk for some species which have a tendency to swan-neck on a shackle line (Figure 10). Despite this risk, it is possible for a bird's entry into electrified water to be swift and effective if an entry ramp is used; but flocks must be monitored to ensure this is the case. If it is not, neck extenders can also be used with long-necked species, to guide the heads completely under the electrified water almost immediately, although these may have limited success. The installation of neck extenders must be carefully planned so they do not obscure viewing for the assessment of the immediacy of stunning and the absence of pre-stun shocks. Once installed, neck extenders must be monitored to ensure all birds' heads are indeed pushed below the neck extender (and not trapped above it, which may cause pre-stun shocks to the wings or chest and electroimmobilisation). For further details on neck extenders please read the HSA Guidance Notes No.7 on 'Electrical waterbath stunning of poultry'.

Figure 10. A swan-necking duck on a shackle line. Compared to the other ducks, with their necks and heads hanging down, the duck second from the right has curled up its neck so the chest is below the head. If its chest makes contact with the electrified water before the head, there is a risk the duck may experience current flow without loss of consciousness because the brain is unlikely to be in the path of current flow. This will be inhumane.

The submerged electrode

To maximise the current amplitude received by the birds, the submerged electrode must always be as close as possible to the birds' brains, both horizontally and vertically (Figure 1). In terms of the horizontal, the submerged electrode must extend across the entire length and width of the bottom of the waterbath. In terms of the vertical distance, it is ideal if birds' heads touch the live electrode, as long as the heads are also simultaneously and completely submerged under the electrified water. The live electrode should always be within 5 cm of the beaks of the birds to ensure their whole heads are exposed to a sufficient current.

Water conductivity

At concentrations of even 0.1% weight/volume, food-grade salt can be added to the water and should dramatically increase conductivity. Although adding higher concentrations of salt may further reduce resistance, the effect is marginal beyond 1% and the voltage required is unlikely to decrease much further. So adding salt, even in large concentrations, may not improve a system that is inappropriately set-up, nor can it compensate for using a voltage that is insufficient to deliver a minimum recommended current per bird. Further, 20 – 30 minutes after adding salt to fresh water, the gain in conductivity may be lost.

Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

Maintaining a single current pathway in each bird

In the interests of animal welfare and meat quality, try to limit the risk of the formation of current pathways between adjacent shackled birds. Such alternative electrical pathways may cause additional variation in the current each bird receives. Therefore, birds should be shackled with sufficient space between one another so they do not touch.

Obstructions to birds' passage through a waterbath

Birds must be able to pass through a waterbath without impacting against, or being hindered by, any obstacles. For example:

- Make sure the submerged electrode is not of a size or shape, or in a position, that obstructs birds' heads from swinging swiftly into the water, or from being fully submerged.
- The width of a waterbath must comfortably accommodate all the types of birds it is used for, so their heads cannot become trapped against the side panels (Figure 11), which can prevent the head from entering the water.
- If any bird escapes from its shackle and is stood in the waterbath, then, depending on its position in the waterbath, it may prevent other shackled birds from being immediately stunned. The escaped bird may a) alter the current flow through shackled birds and b) may be at risk of receiving electric shocks via contact with shackled birds as they pass. The escaped bird must be removed as soon as safely possible. The shackling of conscious birds must immediately cease and the shackle line must stop. Birds which have already begun passage through the waterbath must immediately receive a neck cut, if they are stunned. The electrical supply can then be switched off and the escaped bird carefully retrieved. The escaped bird must be immediately stunned and killed with a humane back-up method; it must not be reshackled.

Figure 11. A broiler chicken's head is trapped against a side panel of a waterbath. The bird will experience current flow because its body is in-contact with the electrified water; however it may not be rendered unconscious and insensible to pain because its head (and therefore brain) are not in the water. The waterbath side panels are too close together and must be moved apart to prevent this situation occurring.

The leg-shackle-earth interface

Shackle maintenance

The contact points between a bird's legs and the shackle is likely to contribute the most resistance within each electrical circuit. Therefore birds must not be shackled with any items around their legs (eg straw) that might further increase resistance.

If the total current passing through a constant voltage waterbath begins to drop as stunning progresses throughout the day, it is possible that feathers, grease and dirt are building up on the shackles, causing resistance to increase. To prevent this, shackles must be regularly cleaned throughout the day. Ideally, just before the shackles return to the live-bird shackling station, the shackles must pass through a wet cleaning system to remove feathers, dirt and any severed feet retained in the shackle. If the cleaning system fails to effectively remove severed feet, shackling staff must remove them manually before loading a conscious bird into that shackle; otherwise the quality of the stun is likely to be compromised. If shacklers continually have to remove severed feet, then the cleaning system should be repaired, or replaced with a more effective model.

Shackle washing serves an additional purpose. Although the birds' legs are touching the shackles, wide variation in resistance still occurs. Shackles must always be dripping wet when birds are hung into them because the water should help to form a better contact between the leg and the metal, reducing the variation in resistance and therefore may improve the immediacy of stunning.

If empty shackles are wetted prior to birds being loaded into them, spraying occupied shackles with water at the leg-shackle interface, just prior to birds entering the waterbath is unlikely to have a significant effect on resistance and is therefore not necessary. If occupied shackles are sprayed with water at the leg-shackle interface, just prior to the entrance to the waterbath, then it is critical that sprays do not: a) disturb birds on the shackle line, especially as they enter the waterbath (eg the spray should not get water in birds' eyes); b) cause birds to receive pre-stun electrical shocks; or c) wet birds' plumage and bodies too much because this may create a shunt and current may flow over the exterior of the head and body instead of through the brain and heart. It is important to use saline water for all these purposes because this increases conductivity, relative to clean water.

The accumulation of a type of scale on shackles (Figure 12), most likely an electrolytic build-up of biological material such as grease/fat from the birds' legs, can sometimes dramatically increase the resistance within a circuit and can make the difference between effective and ineffective stuns. Therefore, as well as being cleaned with water and wire brushes, the shackles (and any other scale-susceptible equipment, eg electrodes) must be cleaned with an acid at least once a week to help prevent the build-up of scale. Monitoring equipment for scale is critical and a shackle must be immediately replaced if it cannot be descaled sufficiently.

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Figure 12. Brown scale on a leg-shackle contact point. Scale must be removed from all contact points if stunning is to be effective. Image: Paul Berry Technical Ltd.

High-voltage electrical parameters are advantageous for poultry welfare at slaughter (read the section 'The effect of electricity on an animal'). If high-voltage electrical parameters are used, with time, carbon can build up on the shackles, resulting in poor conductivity between the legs and the shackle. The shackles must therefore be regularly cleaned in an acid bath to restore normal electrical contact.

Continuous contact between the shackles and the earth bar

The second electrode, ie the earthed rubbing bar, must be in firm and constant contact with each metal shackle in which a bird is restrained, for the entire duration that each bird's head is in contact with the electrified water or wet plate. This includes when the shackles move rapidly, ie when birds swing off an entry ramp into the water, or during disturbance (eg if birds flap as they enter the water they can pull their shackle, and the shackles of other birds, away from the earthed rubbing bar). Similarly, make sure occupied shackles do not overlap onto occupied or unoccupied shackles, because this may reduce or alter the flow of current through a bird. If a shackle does not have continuous contact with the earthed rubbing bar, a bird will receive an intermittent flow of current which is also likely to be below the required minimum amplitude. Such poor current flow is unlikely to effectively stun a bird, particularly if it occurs at the entrance to a waterbath, in which case it may simply cause pre-stun shocks in an otherwise-conscious animal. Repeated applications of electricity may also have an adverse effect on carcass quality.

To ensure physical contact is continuously maintained between the shackles and the earthed rubbing bar, the bar should push against the shackles and gravity and the weight of the birds will keep the shackles against the earthed rubbing bar. Two earthed rubbing bars, in very close proximity, can trap the shackles between them, prevent shackles overlapping and ensure each shackle is always in contact with at least one bar. The earthed rubbing bar(s) and the shackles must be monitored for signs of wear at their respective pressure points and must be replaced when contact is no longer effectively made.

Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' for additional detail and illustrations of how to secure continuous contact between the shackles and the earth bar.

Summary - optimising current flow

Critical control points of electrical contact in a waterbath system:

- Earthed rubbing bar interface with shackle
- Shackle interface with a bird's legs
- Bird head interface with water/electrode

Maintaining good quality electrical contacts and controlling resistance in a waterbath system:

- Install the earthed rubbing bar so it is pushing against all occupied shackles.
- Use a pair of earthed rubbing bars to secure and maintain constant contact with the shackles as birds enter, and whilst they are in, the electrified water.
- Ensure shackles are free from dirt, straw, feathers, severed feet and scale.
- Pre-wet empty shackles with a saline water spray immediately before the start of the shackling station.
- Ensure a firm fit between each leg and the shackle. Regularly monitor leg position in shackles to ensure it is optimum. If a significant proportion of birds is improperly shackled (eg have only one leg shackled), the gauge of the shackle slot may be inappropriate or the line speed may be too fast for the shacklers to work effectively, in which case the line speed should be reduced.
- If a fine saline solution is briefly sprayed onto the interface between the birds' legs and the shackles immediately before the birds enter the electrified water, make sure the spray is targeted only at the interface between each bird's legs and its shackle and that the spray is not soaking the birds' bodies and plumage.
- Keep the birds' bodies as clean and dry as possible, to enable current to flow through the brain and body interior as much as possible.
- Space birds far enough apart on the shackle line to prevent bodily contact, including if the wings flap or are held open. This may reduce bird disturbance, carcass damage and prevent the formation of lateral current pathways between birds during application of electricity.
- Ensure each bird's whole head is immediately and completely submerged in the electrified water (and preferably touching the electrode) and that it remains so until the bird is withdrawn from the waterbath for bleeding.
- As the stunned birds exit the stunner, the shackle line should lift their entire bodies (including heads) clear of the end panel, to prevent contact. Although repeat application of current at the waterbath exit may not necessarily pose a welfare problem in unconscious birds, any current 'spikes' may damage the carcass.

Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

The effect of electricity on an animal

Brain activity

Whilst electricity is applied across an animal's whole body, the body will typically be rigid and still.

If the current passes through the animal's brain and if the parameters are appropriate for stunning, the brain is expected to show a certain type of electrical activity which, in a laboratory, can be viewed using an electroencephalogram (EEG). In Europe, EC Regulation 1099/2009 allows electrical waterbaths to be used for stunning poultry, provided the exposure of the entire body to a current generates a generalised epileptic form on the EEG. This duration of epileptic plus quiescent brain activity must last for at least 45 – 60 seconds, to allow enough time for death to occur by whichever chosen means.

If the EEG does not become epileptiform and quiescent, and for a sufficient duration, then a bird cannot be classed as effectively stunned because it may either never become unconscious or it may recover consciousness too soon, before death can occur. Similarly, if operational parameters cannot achieve unconsciousness immediately, they are unsuitable for bird welfare, even if a longer application time can result in an eventual loss of consciousness, because the bird may experience pain and distress during induction of unconsciousness.

There are interactions between the effects of the various electrical parameters that might be used to attempt to stun birds. Different combinations of parameters determine whether epileptiform activity is expressed and the degree of suppression of the EEG (ie whether a bird immediately becomes, and remains, unconscious for long enough). The electrical parameters that appear to be better at generating epileptiform and quiescent EEGs are generally high amplitude, low frequency, sinusoidal (sine) AC currents. In terms of animal welfare, high frequencies are unlikely to perform as well as low frequency currents. (In addition, the higher currents required at higher frequencies tend to still be associated with defects in carcass quality.) None of the DC parameter combinations researched so far have produced unconsciousness (as assessed by EEG) in 100% of birds.

Paralysis or electroimmobilisation

Unfortunately, paralysis or electroimmobilisation may physically resemble effective electrical stunning because muscle function is inhibited, and physical reflexes are suppressed, by the current (particularly if the current passed through the whole body, as indeed it would in a waterbath or wet plate stunner). Therefore it may be difficult to identify, using animal behaviour alone, a paralysed, conscious animal from a stunned, unconscious animal. Therefore abattoirs should follow evidence-based recommendations for animal welfare from the scientific community, when deciding how and which electrical parameters to apply to an animal, for the purpose of stunning and successfully rendering it unconscious until death supervenes.

Will the stun also kill the bird?

The mode of current application and the electrical parameters used, can determine whether an animal will die (stun-killed) whilst unconscious, or if it has the potential to recover consciousness after the prolonged, effective stun has run its course.

Electronarcosis is a temporary, fully-reversible state. Normal brain function is disrupted for a short time only and, unless killed by another method, the animal will regain consciousness, usually within one minute. (Note: even if there is the potential for an animal to regain consciousness, this must not be allowed to actually happen (to ensure the animal's welfare remains protected). Immediately after stunning, a killing method (eg neck cutting) must be applied to ensure the birds die (eg of blood loss) before there is any possibility of them recovering consciousness.) Restricting a stunning current's pathway so that it travels through only the head (brain) of an animal (eg by using head-only electrical stunning equipment), is far less likely to result in a stun-kill (ie death by electricity) than when the stunning current is also allowed to pass through the animal's body.

A stun-kill can occur if a current passes through the heart of an animal. The muscle of the heart is more sensitive to certain, relatively low frequencies, eg 50 Hz. If a low-frequency current of a large-enough amplitude passes through cardiac muscle, an unco-ordinated condition known as cardiac ventricular fibrillation is likely to occur. The ventricles (ventral chambers) of the heart cease to beat rhythmically and instead contract rapidly and irregularly. Cardiac ventricular fibrillation (CVF) reduces cardiac output, relative to normal levels, and, without correction (eg defibrillation), CVF typically leads to cardiac arrest, which is irreversible, and the heart stops pumping blood round the circulatory system. This rapidly prevents oxygenated blood from reaching the brain (ischaemia), thereby killing the brain cells and preventing recovery of consciousness. Electrical stunning systems that apply current across the entire body, can be operated using electrical parameters that should reliably cause the majority of birds to die from a cardiac arrest. When attempting to stun-kill a bird with electricity, it is still necessary to use appropriate electrical parameters that will cause immediate unconsciousness, prior to, or simultaneous with, the occurrence of death. It is possible that insufficient current amplitude, or other inappropriate electrical parameters, can cause death without associated unconsciousness. Application of electricity in a manner that does not induce unconsciousness (eg if current bypasses the brain or if insufficient current is provided to the brain) cannot be considered humane, even if the animal dies as a result. Compared to using stun-only electrical parameters plus neck cutting, using stun-kill parameters is advantageous for animal welfare because it starts the process of dying at the same time as stunning. This reduces the risk of animals regaining consciousness before, or as, they receive a neck cut and bleed out, particularly if the neck cut is delayed and/or inaccurately performed. Death by electricity therefore acts as a 'safety net' for ensuring birds cannot recover if, occasionally, neck cutting is inaccurate and results in inadequate bleeding.

Immediate, accurate neck cutting is still important!

For any bird that does not die as a result of waterbath stunning, effective neck cutting remains critical. Therefore all poultry slaughtered using electrical waterbath or wet plate stunners, at all electrical parameters, should have both carotid arteries and both jugular veins severed, as standard routine practice. This may also assist with bleeding the carcass as fully and quickly as possible (particularly if the birds have experienced CVF) and may reduce the amount of blood retained in the carcass during further processing.

Parameters for stunning

When a stunning method is applied correctly, the stunning parameters should achieve an effective stun in 100% of individuals. Even a very small percentage of failed stuns will account for a large number of individual birds potentially suffering because poultry are slaughtered in vast numbers around the world.

Individual birds can be effectively stunned in waterbaths using a broad range of amplitudes of current, but the difficulty is ascertaining which parameters reliably achieve effective stunning in 100% of birds. EFSA (2012) could not identify any parameter combinations that, in all tests, resulted in 100% of birds being effectively stunned.

It does not appear possible to specify one current amplitude, for all frequencies and waveforms, that will ensure 100% effective stunning. Abattoirs should be aware that, to achieve an equivalent effect on a bird’s brain activity, different waveforms may require greater amplitudes of current.

In Europe, waterbaths must operate using electrical parameters specified by EC Regulation 1099/2009 (Table 3). However it should be noted that sine AC frequencies of 600 Hz or more, at 200 mA per bird, have failed to induce epilepsy and/or a sufficient duration of quiescent EEG in 100% of broiler chickens tested. Application of 100 - 200 mA per chicken, using frequencies higher than 200 Hz sine AC sometimes failed to induce sustained quiescent EEGs, especially at, and above, 800 Hz. Therefore, in the interests of bird welfare, it may be preferable to use frequencies of 50 - 200 Hz, maximum, for chickens and perhaps even for turkeys. Based on available research using EEG analysis of unconsciousness, the HSA suggests abattoirs consider using the additional measures in Table 4.

Table 3. Minimum current amplitudes per bird for electrical waterbath stunning, as required since January 2013 by European Council Regulation 1099/2009.

Frequency (Hz)	Chickens (mA)	Turkeys (mA)	Ducks & geese (mA)	Quails (mA)
< 200	100	250	130	45
From 200 to 400	150	400	Not permitted	Not permitted
From 400 to 1500	200	400	Not permitted	Not permitted

Table 4. Additional suggestions for good practice electrical parameters.

Waveform & frequency (Hz)	Chickens (mA)	Ducks (mA)
Sine AC 50 - 199 Hz	100 RMS	
Sine AC 200 Hz	150 RMS	
Sine AC 400 Hz	200 RMS	
Square AC 50 Hz		170 RMS*

* it is possible that ducks and geese may require a greater current amplitude for sine and square wave frequencies up to 200 Hz but scientific evidence is lacking (Hindle *et al*, 2009).

Hindle et al (2009) Electrical waterbath stunning of poultry Rapport 200: an evaluation of the present situation in Dutch slaughterhouses and alternative electrical stunning methods. Animal Science Group, Wageningen UR.

Guinea fowl

There are no published recommended currents for inducing unconsciousness in 100% of guinea fowl. As a precaution, until scientific evidence becomes available, the HSA suggests that the minimum current amplitude might be at least 100 mA RMS per guinea fowl, at 50 Hz sine AC. Although the birds are relatively light in weight and have naked heads, they are older than some other species at the time of slaughter and so their skulls and thin legs may have developed a relatively high resistance to electricity.

Duration of application of electricity

To increase the likelihood of an effective stun and a prolonged duration of unconsciousness, each bird must be immersed in the electrified water for a sufficient time. The length of a waterbath and the line speed directly affect the duration that a bird is exposed to a current. The fastest line speed used by an abattoir must still be capable of administering the recommended minimum duration of current application. Recommendations include:

- At least four seconds (EC Regulation 1099/2009 and OIE, 2014)
- At least eight seconds when using high frequencies above 100 Hz (Defra, 2007)
- At least 10 seconds when using 50% pDC (Prinz, 2009)

Note: increasing the duration of application of current may only have a marginal effect on the efficacy of stunning and it cannot compensate for inadequate electrical parameters.

The electrical parameters intended for stunning each bird type should be recorded in the abattoir's standard operating procedures (SOPs) and periodically reviewed and altered as necessary. All personnel responsible for assessing the effectiveness of stunning and for performing neck cutting must have seen the SOPs and be aware of the basic electrical requirements for each bird type (e.g. waveform, frequency, minimum required total current to the waterbath).

Parameters for stun-killing

If abattoirs wish to induce a stun-kill in as close as possible to 100% of birds, Table 5 suggests parameters, based on scientific research. At high frequencies (above 100 Hz), and/or if using certain modified waveforms, it is unlikely that the majority of birds will undergo cardiac arrest. Therefore low frequencies must be used. As well as choosing the correct frequency, the current amplitude must also be appropriate for inducing CVF. Usually, increasing the proportion of birds that experience a stun-kill requires an increase in the current amplitude, to a value beyond that necessary for effective [but recoverable] electronarcosis. For example, at 50 Hz sine AC, 105 mA RMS and 148 mA RMS may produce CVF in approximately 90% and 99% of broiler chickens, respectively.

Within a given set of electrical parameters, the incidence of CVF may vary between species, types, sexes and even batches of birds. For example, compared to lighter-weight turkeys (ie females), heavy, male turkeys may be less susceptible to CVF because their greater mass of skeletal (breast) muscle may reduce the amount of current that can reach the heart.

Table 5. Electrical parameters that may induce CVF in approximately 100% of birds. An application time of at least 10 seconds is likely to be suitable. The current amplitudes required for waterbath stunning by EC Regulation 1099/2009, induced CVF in 100% of turkeys and quail, when applied at 50 Hz sine AC.

Note: if, for reasons of disease control, operators plan to kill poultry using a waterbath and will not bleed the birds after stunning (to limit spillage of potentially-infected bodily fluids), then, to increase the probability that all birds will die, the current amplitudes must far exceed those in this table. For example, at least 400 mA RMS per bird may be appropriate (broiler and egg-laying chickens: Gerritzen *et al*, 2006; turkeys, ducks: M. Gerritzen pers. comm. 2014).

Bird type	Minimum current amplitude (mA)	Waveform	Comments eg based on ...
Chicken	170* RMS	Sine AC 50 Hz	highest amplitude survived
	120+ RMS	Square AC 50 Hz	* 170 mA may be suitable
Guinea fowl	86 RMS	Sine AC 50 Hz	
Duck	255+ RMS	Sine AC 50 Hz	
	235+ RMS	Square AC 50 Hz	
Goose	225+ RMS	Sine AC 50 Hz	

Monitoring stunning parameters

Once the ideal parameters are selected and programmed into a waterbath system, it is necessary to regularly and routinely check the equipment is consistently achieving these aims, using the control panel of the stunner and additional monitoring equipment. Operators must ensure that the minimum value of the range of current amplitudes estimated or measured, is at least the recommended or legally-required minimum current amplitude per bird.

EC Regulation 1099/2009* requires waterbaths to "***be fitted with a device which displays and records the details of the electrical key parameters used. These records shall be kept for at least one year***".

*abattoirs with relevant equipment that was in use prior to 1 January 2013 have until 8 December 2019 to comply with Article 14(1) and Annex II of Regulation 1099/2009, including the requirement above. (Abattoirs, layouts or equipment constructed after 1 January 2013 must apply the requirements immediately.)

Stunner control panel

The frequency and the amplitudes of the total current and voltage passing through a waterbath must be clearly displayed by a large frequency meter, ammeter and voltmeter respectively. Meters must be positioned so they are visible to personnel, including the slaughterperson(s) responsible for checking effective stunning and for neck cutting, so they can clearly see whether sufficient current is passing through the waterbath, without leaving their post or having to turn around. For accuracy, meters should ideally be digital and display all parameters to two decimal places. The units should be clearly indicated, eg Hz or kHz, A or mA. Voltmeters and ammeters must also be capable of displaying correct voltages and currents in RMS, average and peak units, for all waveforms the system can supply; the control panel must automatically indicate which unit is in-use at any given time.

For each different bird type slaughtered, checks of the parameters should be performed at least once per batch, and certainly if the parameters are altered by the operator between batches. This is particularly critical for constant voltage, multi-bird waterbaths, which must be carefully adjusted to attempt to obtain the correct current amplitude per bird. For example, when operating a constant voltage stunner, the actual voltage required may in fact be greater than was estimated. Therefore, at the start of slaughtering each batch of birds, the ammeter must be consulted and the voltage adjusted, as necessary, until the ammeter meets the estimated target. Regular monitoring of the ammeter is key to determining the typical total resistance for each stunner and each type of bird processed; operators can consequently adjust their voltages, as appropriate.

It is important that operators are aware what an ammeter reading refers to. Most ammeters record the total current flowing through the entire waterbath system (not through each individual bird). An estimate of the current supplied to each bird can be manually calculated by dividing the total current by the number of birds within the water at any given time. However, this method will not provide an accurate estimate of the current per bird because a) the number of birds in the water at a given time varies with moving shackle lines and shackling practices, and b) there may be variation in the total resistance of each branch of the circuit (eg the waterbath equipment, each individual bird and the quality of the electrical contact).

In an open circuit (ie with no birds in the electrified water), the ammeter of the stunner control panel should read 0 A. If the ammeter reads a value greater than zero, either the ammeter needs recalibrating, or current is being lost somewhere within the circuit. In each case, birds are at risk of receiving a lower-amplitude current than intended. An electrician must, if necessary, adjust the control panel ammeter and/or identify if, and where, the loss of current occurs and prevent it (eg by replacing corroded electrodes or connections).

Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

Additional monitoring equipment

In-line, stand-alone meters, or remote stun monitors (Figure 13), calculate the estimated current per bird more objectively and can also confirm the stunner control panel meters are accurate. Remote stun monitors can record the waveform, frequency, peak and RMS voltage and current. The device is essentially a resistor that simulates the resistance of a bird. A stun monitor can be shackled in place of a bird and passed through a waterbath either on its own or with live birds in other shackles (the latter scenario will reflect normal processing). The stun monitor records and displays the current amplitude flowing through it and the duration of application.

Figure 13. A remote stun monitor. This equipment simulates the resistance of a live bird and provides an estimate of current amplitude received per bird. Image: AGL Consultancy Ltd.

When estimating the current amplitude per bird using either the stunner control panel display or a remote stun monitor, there is a degree of error involved because of the assumed value of resistance. Therefore operators are strongly encouraged to also use, at regular intervals, a device that can measure [during normal processing] the actual bird's resistance and the actual current amplitude passing through that bird (Figure 14).

Figure 14. A stunner evaluation device. This equipment measures the actual parameters passing through a live bird. Images: Paul Berry Technical Ltd.

Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

Indicators of the effectiveness of stunning

A waterbath stunner should not be used until a person is available to ascertain whether it has been effective in stunning the birds. Immediately after application of an electric current, and before neck cutting, animals must be checked to ensure they are unconscious. When a bird has not been effectively stunned first-time, that person must stun and kill any such birds without delay. Depending on the electrical parameters used, even in a system thought to stun-kill the majority of birds, some may have retained a normal heart rhythm. Consequently, the design of the equipment, its layout and the line speed must allow adequate checks for effective stunning, whilst ensuring these factors do not significantly delay the application of neck cutting.

Assessing the effectiveness of stunning is a very important part of the entire slaughter process. Operators must be trained to identify signs of ineffective stunning and must understand the appropriate action necessary, to immediately protect birds from avoidable suffering. Ineffectively stunned birds must not be re-shackled for waterbath stunning a second time. Instead, a humane back-up stunner should be applied immediately, eg a captive-bolt device designed for poultry.

Assessment using a single animal behaviour may be misleading. Multiple reflexes and behaviours must be assessed in order to reach a reliable conclusion. Ideally, at any time after application of an electric current, birds should not display behaviours that might be associated with consciousness (eg rhythmic breathing).

Practicalities of assessment

It is preferable to assess a bird for the effectiveness of stunning, prior to neck cutting. If a bird is examined only after neck cutting, then:

- If the bird’s spinal cord is damaged by the cut, it may not be possible to properly assess its state of consciousness.
- Potentially, an automated neck cutter may occasionally cut a conscious bird, eg one that avoided the electrified water. This will most likely cause severe pain and suffering and is unacceptable.

Birds can be assessed for effective stunning in-situ in two ways. Whilst a single bird travels along a section of a shackle line, an assessor can follow it and perform a series of checks for indications of the effectiveness of stunning. Alternatively, or in addition, an assessor can stand still at a single point along a shackle line and perform certain checks on consecutive birds that pass by; however, at fast line speeds this typically only allows time to perform one type of assessment per bird and it may be difficult to assess whether a bird is rhythmically breathing.

Key indicators - rhythmic breathing and eye reflexes

Recovery of spontaneous breathing is considered to be the earliest indication of recovery of consciousness. The presence of rhythmic breathing indicates an animal is alive, but not necessarily conscious, but it remains a useful assessment tool because if a bird is breathing, then it has the potential to recover consciousness. EFSA suggests the presence of regular gagging (a brainstem reflex of forced/laboured breathing through the mouth) may gradually lead to resumption of rhythmic breathing, so any bird displaying gagging behaviour should continue to be observed and action taken if necessary. A humane back-up stunning method should be immediately applied to any breathing birds.

Death can be ascertained by testing for the absence of a nictitating membrane (third eyelid) reflex or by testing for the absence of a corneal reflex, as shown in Figure 15B. Although a positive reflex indicates a bird is alive, it does not necessarily indicate that the bird is conscious. However, the proportion of birds displaying eye reflexes (eg nictitating membrane reflex and palpebral reflex), either at certain times or over a specified time, can be useful for monitoring the effectiveness of an electrical stunning system. For example, a stun may be ineffective if the corneal reflex can be repeatedly elicited immediately after a bird exits the electrified water, or if a large proportion of birds display a positive reflex, or if, as the time increases since exiting the water, there is an increase in the proportion of tested birds displaying a positive reflex.

Indications that a bird has not been stunned or that it may be recovering from a stun (ineffective stunning):

- Presence/return of rhythmic breathing - examine a bird's abdomen (Figure 15Ai) for evenly-spaced rise-and-fall movements indicating inspiration and expiration. (Do not confuse with localised, rhythmic contractions specifically of the cloaca (Figure 15Aii).)
- Presence of a corneal reflex (Figure 15Bv) or a nictitating membrane reflex (Figure 15Bi-iv), particularly if a positive result is highly repeatable.
- Presence of a palpebral, or blink, reflex (the upper and lower eyelids meet to close the eye (Figure 15Bv) when the corner of the eye nearest the beak (medial/inner palpebral commissure/canthus) is gently touched).
- Presence of a pupillary light reflex (the pupil constricts in response to a bright light shone close to the eye).
- Presence of regular spontaneous eye blinking (ie blinking without human stimulation), particularly if the frequency increases with time. (Not to be confused with very rapid blinking that may terminate abruptly after a few seconds in a bird that is not breathing. These may be muscular fibrillations of the eyelid, not an indicator of recovery.)
- Presence/return of muscle tone, eg a bird regains voluntary control of its neck and head. (Note: some electrical parameters may cause an involuntarily arched neck, which can be an indicator of effective stunning (Figure 15Aiii). The difference can be ascertained by placing a hand under the bird's upper neck and head, and gently and repeatedly lifting them; if the bird holds its head away from the hand, or if the neck feels tense, it is likely to be recovering. Alternatively, an assessor can grasp the head of a shackled bird and gently pull it downwards; if the bird recoils it is probably conscious.)
- Presence of voluntarily-controlled vocalisations.

Indications that a bird may be effectively stunned (but not killed):

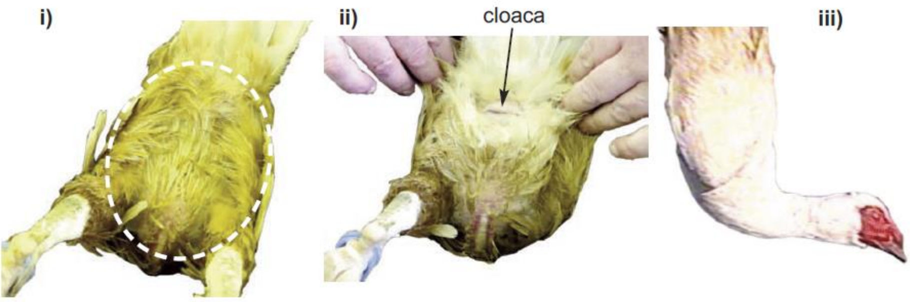
- No rhythmic breathing (examine the bird's abdomen).
- Absence of a corneal reflex or absence of a nictitating membrane reflex (note: the presence of these reflexes indicates a bird is alive but not necessarily that it is conscious - additional checks for consciousness should be performed immediately).
- Absence of spontaneous eye blinking of the nictitating membrane or outer eyelids (may suggest a deep level of unconsciousness).
- A lack of intrinsic (voluntary) control of muscles, eg a relaxed jaw with no muscular tension controlling movement of the beak; a relaxed neck with no self-controlled movement of the head.
- Constant rapid body tremors.
- Wings held tightly against body.

Indications that a bird may be dying, or has died, as a result of the electrical stun:

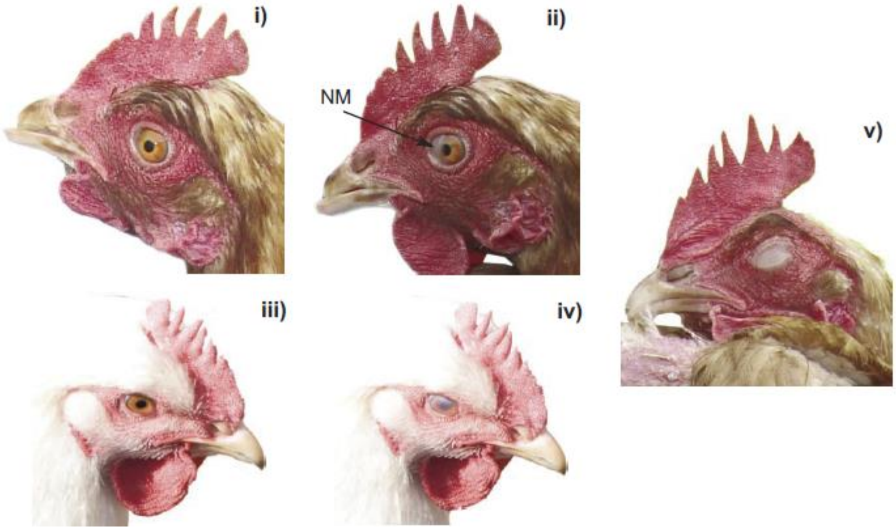
- No return of rhythmic breathing; no gagging.
- Absence of a corneal reflex and absence of a nictitating membrane reflex.
- Absence of spontaneous eye blinking.
- Pupils dilated and centrally-fixed.
- Relaxed, limp body with no pulse, no muscle tone, no movement; wings drooping.

Figure 15. Assessing poultry behaviour to determine the effectiveness of stunning.

A) Rhythmic breathing and neck tension. i) chicken restrained in an inverted position, with the observer looking down upon it. The whole abdomen (encircled), should be examined for rhythmic rise-and-fall movements that might indicate respiration and therefore recovery; ii) with the feathers parted, the cloaca (vent) is visible. The cloaca may rhythmically contract inwards and outwards on its own, without abdominal respiration, and is not thought to be a sign of recovery; iii) after electrical stunning, this inverted duck is displaying an involuntarily arched neck, held parallel to the ground, with the head hanging down vertically; this may be an indicator of effective stunning.



B) Eye reflexes. If a bird is alive when its cornea (the surface of the eyeball) is gently touched, either the upper and lower eyelids will move to touch one another, to close the eye (a positive corneal reflex - image v); or the nictitating membrane will rapidly move across and over the cornea, to cover it briefly, before retracting back out-of-sight (a positive nictitating membrane reflex). Images i-iv) show the nictitating membrane reflex in conscious birds; it will look the same when a bird is assessed in an abattoir. i) & iii) The egg-laying and broiler chickens' nictitating membranes are currently hidden from view; ii) the hen's nictitating membrane (NM) has commenced passage across the eye; iv) the broiler's nictitating membrane has passed across the entire surface of the eye, giving it a 'cloudy' appearance.



Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

Bleeding

Neck cutting is the final step of the slaughter process. Its purpose is to bring about bleeding and the death of a stunned bird.

Even if the intention is to use electrical parameters that will cause the majority of birds to die in a waterbath, it may be unlikely that 100% of birds will experience cardiac arrest, particularly if using current amplitudes lower than those in Table 5 and/or if using a constant voltage stunner. Consequently, any surviving birds are reliant on a follow-up killing method (ie neck cutting) being performed thoroughly and quickly, to prevent recovery of consciousness. Therefore, birds should not be passed through an electrical waterbath unless they can be immediately checked for effective stunning and then immediately bled. Only after a bird has been checked and confirmed to be effectively stunned, should its neck be cut.

The blood loss must be rapid and profuse in order to achieve a quick death. Ideally, the cut must sever all the major blood vessels in the neck of a bird, particularly those that supply oxygenated blood to the brain, the most important of which are the two common carotid arteries. By preventing oxygenated blood from reaching the brain, ischaemia will set in and the brain cells will die, preventing recovery of consciousness. Ideally, slaughterpersons should also sever the two jugular veins, even though they carry deoxygenated blood away from the brain.

Time to irreversible unconsciousness and time to brain death

There must be insufficient time for recovery of consciousness, before permanent loss of brain function due to lack of oxygen. Following electrical stunning of broiler chickens, severing both common carotid arteries and both jugular veins will achieve a quiescent EEG (a sign of continuing effective stunning) within approximately 15 – 30 seconds. This is quicker than after severing only one carotid artery and one jugular vein, which in some cases can take 1 – 2 minutes to achieve a quiescent EEG, particularly as the frequency of the current increases. Compared to severing only one carotid artery and one jugular vein, severing both carotid arteries and both jugular veins will also reduce the proportion of birds displaying behavioural indicators of consciousness. (Note: although severance of both carotid arteries is a rapid means of bleeding a bird, it cannot be used to compensate for inappropriate electrical parameters, eg those that do not provide a sufficient duration of unconsciousness.)

In Europe, if waterbaths operate at ≥ 51 Hz, both carotid arteries, or the vessels from which they arise, shall be systematically severed (EC Regulation 1099/2009). Whatever stunning parameters are used, good practice for animal welfare and meat quality is to immediately sever both carotid arteries and both jugular veins as an absolute minimum, in all birds. This policy may reduce the risk of recovery of consciousness for any birds that are temporarily stunned (including because if variation in resistance causes some birds not to receive a high-enough current amplitude to cause death, even if the abattoir intends so).

Please refer to the HSA Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry' if additional detail is required.

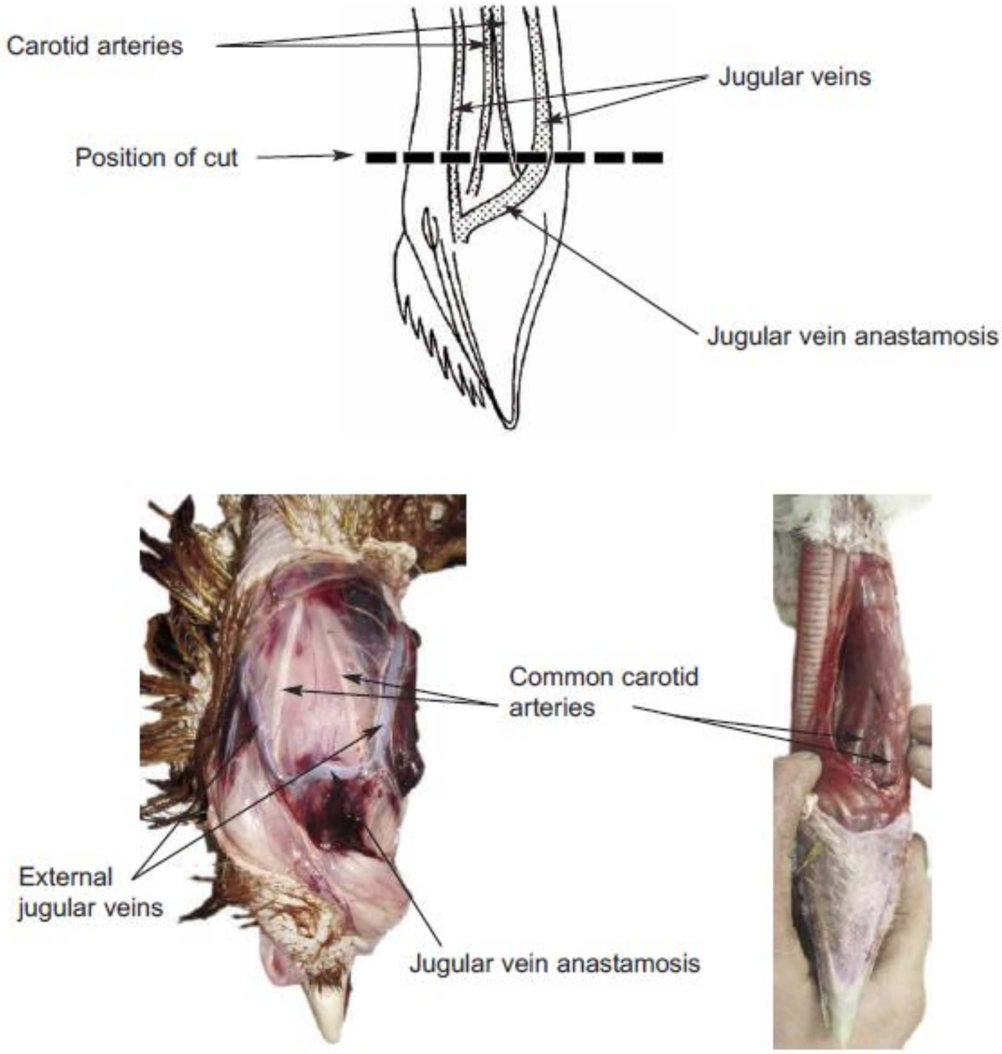
Locating and identifying the carotid arteries and jugular veins

The carotid arteries lie embedded in the muscle of the neck but, depending on the species of poultry, they vary in how close they lie to the cervical vertebrae (the neck bones). In chickens, geese and guinea fowl, near the head, the arteries are typically visible on the surface of the muscle (Figure 16). Whereas in turkeys, the arteries remain hidden underneath the surface of the muscle, even near the bird's head. Ducks have very deeply embedded arteries and these cannot be seen from the surface of intact neck muscle. In all species, the carotid arteries are most easily accessible for cutting from the ventral aspect (underside) of the neck, ie the throat.

Figure 16. Top: schematic of a bird's head and throat, with the ventral (lower) jaw, trachea and oesophagus removed, to show the position of the common carotid arteries and external jugular veins and the ideal location to perform a ventral neck cut to sever all four major blood vessels.

Bottom left: dissected throat of an end-of-lay chicken to show the major blood vessels. The external jugular veins lie just under the skin and have thin walls so blood can be seen within them. The carotid arteries are in the neck muscle and have thick walls so the blood inside cannot be seen. (The oesophagus and trachea cannot be seen because they are pulled round, underneath the bird for the purpose of the photograph.)

Bottom right: dissected throat of a turkey to show the carotid arteries (white tubes) embedded within the neck muscle. The muscle has been cut to expose the arteries. (The jugular veins cannot be seen because the skin is folded underneath the bird for the purpose of the photograph.)



Performing an effective manual neck cut

Abattoirs may decapitate unconscious birds if they wish to be certain both carotid arteries and both jugular veins are severed. Decapitation is the preferred bleeding method if a shackle line becomes inaccessible after neck cutting, because once a bird's brain (head) becomes detached from its body, operators do not need to be concerned for the welfare of the body. After decapitation, immediate mechanical maceration of the head will ensure a rapid brain death.

If decapitation is not the preferred method of bleeding, then operators must perform a deep, transverse cut across the throat, close to the head. This is called a complete ventral neck cut (VNC) (Figure 17a) and is a very successful way to achieve severance of both common carotid arteries and both external jugular veins. Two methods of performing a manual ventral neck cut, depending on how much time is available to the slaughterperson, are described below. Both methods are suitable for any species of poultry, although Method A may be particularly suitable for larger birds such as turkeys (it may make it easier to sever their carotid arteries which lie deep within the neck muscle). Assuming you are the slaughterperson:

Method A:

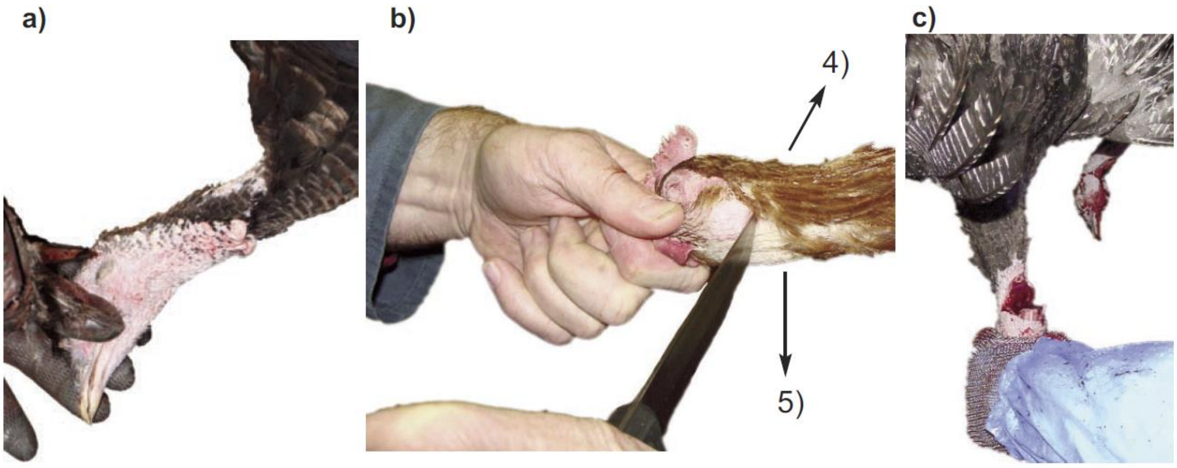
1. Hold the back/top of a bird's head in your palm, with your thumb and fingers positioned either side of the bird's head, over the cheeks (Figure 17a). This allows for a safe, firm grip and enough resistance for the knife to easily penetrate the neck.
2. Turn the bird's head so the side of the head and neck are facing you.
3. With the knife pointing away from you, and with the blade facing the same direction that the bird's throat is facing, position the point of the knife at the junction of the head and neck (ie just below the jaw bone) and slightly towards the ventral side of the middle of the bird's neck so the knife is in between the vertebrae and the trachea (thereby avoiding the vertebrae) (Figure 17b).
4. Then push the knife into the middle of the neck and straight through and out the other side of the neck (as if performing a spear-stick cut) (Figure 17b).
5. Then, with the knife in the same position, pull the blade through the tissues of the throat to open the throat completely (Figure 17b).
6. If you are unsure whether both carotid arteries are severed, you should immediately turn the blade around so it is facing towards the bird and carefully cut back into the wound, up to (but not into) the vertebrae. It is important to manoeuvre the blade to also cut both sides of the throat, to ensure no blood vessels escape the knife.

Method B:

1. Firmly hold the beak and rostral part of the bird's head, ensuring your fingers are not within the trajectory of the knife. It is important to maintain a firm grip, to provide resistance for the knife to work against.

2. With the bird's throat facing you, position the blade on the throat, at the head-neck junction and on one side of the bird's neck.
3. Press the blade onto the throat and, whilst applying pressure, pull the knife across the throat and round to the other side of the bird's neck, in one smooth, uninterrupted action. (Cutting the sides of the throat in this manner (Figure 17c), may allow the knife to 'follow' and cut the muscle and blood vessels, if they are pushed to the side by the movement of the knife.)

Figure 17. How to manually restrain a bird's head and apply a ventral neck cut. Restrain the head using any of the grasps shown. b) relates to Method A: 4) push the knife through the middle of the neck in a straight line so it emerges out the other side; 5) then pull the knife through the tissues of the throat. Whichever of the suggested methods is used, after cutting, the throat should look like that of the bird held in c): the neck muscle and sides of the throat are visibly cut. (Consider wearing suitable personal protective equipment, eg chain mail glove.)



Immediately after performing the neck cut, the slaughterperson must look for two thin 'jets' of blood spraying under high pressure (Figure 18) – this indicates both common carotid arteries have been severed. Slow-flowing or dripping blood immediately after cutting may indicate the jugular veins are cut but the carotid arteries may still be intact so the bird should be cut again. No, or very limited, blood flow after cutting also suggests an ineffective cut, even in small species, eg quail; immediately perform the cut again, until sufficient blood flows.

Figure 18. A stunned turkey that has received a ventral neck cut. The turkey's two common carotid arteries have been successfully severed, as indicated by the upside-down V-shaped pattern of blood flowing from the arteries which are embedded within the neck muscle. The high-pressure arterial flow typically subsides five to 10 seconds after neck cutting. It should be simple for slaughterpersons to self-check their neck cutting efficacy by checking that each bird displays this pattern of high-pressure blood-loss. Limited, or only dripping, blood flow may suggest the carotid arteries remain intact and the cut should be immediately performed again to prevent any possibility of recovery.

Types of neck cut that are likely to have difficulty severing both common carotid arteries:

- Dorsal neck cuts. Unlikely to sever the carotid arteries, which are located on the ventral side of the vertebrae.
- Unilateral cuts to one side of the neck only. Typically only severs one jugular vein and sometimes one carotid artery.
- Spear-stick cuts are made by pushing a thin knife through the middle of the neck and withdrawing the knife through the same wound, without further manipulation of the knife inside the neck. Inconsistently severs both carotid arteries.
- Mouth or beak cuts (known as *per os*); a knife is inserted into the mouth and into the throat where the cut is made, near the base of the skull. Typically only severs the jugular vein anastamosis or one jugular vein.

Automated mechanical neck cutters

Automated mechanical neck cutters (ANCs) can be set-up to deliver a ventral neck cut, but it is essential that every bird is presented to the blade(s) in the correct orientation, otherwise the carotid arteries may be missed. A guide rail system should accurately position a bird's throat against the rotating blade(s) to cut very close to the head-neck junction, and to a sufficient depth to penetrate the muscle and sever both common carotid arteries.

ANCs can have two blades, which can be set up so a bird's neck passes between them; this may produce a bilateral neck cut which is acceptable if both common carotid arteries and both external jugular veins are severed.

ANCs must not be set up to deliver a dorsal neck cut because a) this may miss both common carotid arteries and result in a slow bleed-out, and b) it may damage the spinal cord and prevent further assessment of the effectiveness of stunning. Therefore, ideally, the spinal cord should not be severed. However, the priority is to sever both carotid arteries and if this outcome can only be reliably achieved in conjunction with some damage to the spinal cord, then this is acceptable and the more appropriate choice for animal welfare.

The height of an ANC must be adjustable in order to suit each batch and type of bird processed, so all birds are cut in the correct anatomical position.

Stun-to-cut time

Once confirmed unconscious, birds must have their necks cut immediately and, at the latest, within 15 seconds of stunning at 50 Hz and within 10 seconds of stunning at higher frequencies. If the primary means of neck cutting is manual, every slaughterperson must be positioned within 10 – 15 seconds of the exit from the electrified water (the actual distance will vary with the line speed), including the last slaughterperson in the team.

The line speed must allow employees to work at a pace that ensures a high quality of neck cut. If slaughter personnel cannot routinely sever both carotid arteries and both jugular veins, then there must be a re-evaluation of the system, including whether the line speed is too fast for the number of operators working at this point or if staff need re-training.

If the primary means of neck cutting is an ANC, it must be capable of keeping up with the line speed, so birds are cut as quickly as possible and do not build-up at the entrance to the ANC, and/or bypass it. There must be a manual slaughterperson positioned immediately after the ANC, to cut any stunned birds that either completely miss the ANC or receive an insufficient cut from it. The ANC and the slaughterperson must both be able to perform their cuts within 10 – 15 seconds of the birds exiting the electrified water.

Delayed and/or inadequate neck cutting can cause a slow rate of bleeding and retention of blood in engorged vessels in the wing, breast and thigh muscles, which further processing (eg plucking) may worsen by rupturing those vessels and massaging the blood into the surrounding tissue, creating red wing tips for example. It is therefore important for abattoirs to perform comprehensive neck cuts and to maximise the bleed-out time before further processing.

Monitoring birds as they bleed-out on a shackle line

After a neck cut is administered, if a bird's head remains attached to its body:

- Each bird must be checked for effective neck cutting and bleeding.
- Birds must be checked for continuing unconsciousness until death is confirmed.
- Birds must not be electrically stimulated or further processed in any way (eg plucked or scalded) until death is confirmed.

Following stunning, if a bird displays relatively greater amounts of convulsions (compared to other birds on that slaughterline), it may indicate the bird has not experienced cardiac arrest, and/or that it received a poor quality neck cut (and therefore has sustained a supply of oxygenated blood to nerves and muscles). Such birds must be examined for the quality of neck cutting and the effectiveness of stunning.

Before further processing, birds should be left to bleed for a sufficient time. In addition to achieving death, bleed-out durations of 2.25 – 3 minutes were found to be better for meat quality and produced equivalent bleed-out in birds that experienced cardiac arrest and those that did not.

If a bird appears to be recovering, it must be stunned and killed immediately using a humane back-up method, eg a captive-bolt device designed for poultry. Therefore, shackle lines must be designed to allow personnel to immediately and easily tend to any bird, anywhere on the line, without endangering themselves. For example:

- A shackle line that winds back on itself must be designed in a manner that allows personnel to immediately access birds anywhere on the line.
- Blood-collection troughs must not obstruct a person from removing a bird from a shackle or force the person to make an awkward manoeuvre.

Maintenance of knives & automated mechanical neck cutters

Neck cutting should always be carried out using a sharp clean knife with a blade that is at least 12 cm long. Although a sharp knife might be considered dangerous, correct use of one may allow more precise cuts to be performed more quickly and therefore ensure birds are bled efficiently and safely. Blunt knives may lead to premature cessation of blood flow.

At the start and end of each processing shift, all blades and knives should be inspected for damage and sharpened whenever necessary to ensure consistent, effective and rapid cutting. ANCs must be checked daily by the AWO to ensure the equipment is set correctly and working effectively.

Blades must be cleaned thoroughly to maintain their operational efficiency. A knife cleaning/sharpening station must be positioned immediately adjacent to, or in front of, the position where a slaughterperson stands when cutting birds. This should allow the slaughterperson to clean/sharpen the knife without changing position and to keep track of birds yet to be cut (or checked for effective cutting), giving the slaughterperson more time to catch up.

Humane slaughter checklist

A successful electrical waterbath slaughtering system is dependent on the following:

- Correct set-up of all equipment.
- Regular inspection, testing, calibration and maintenance of all components in the slaughter system, eg regularly clean electrodes and shackles with acid and wire brushes and check that no current flows when birds are not immersed in the electrified water.
- Fully trained, competent and compassionate lairage staff and slaughterpersons.
- Minimising fear, stress, discomfort and pain of birds during handling and shackling.
- Shackles must be dripping wet before birds are hung into them; this should enhance conductivity during stunning and may reduce frictional forces during shackling.
- Shackling birds for as short-a-time as possible.
- Use a breast contact strip or support conveyor that maintains contact with each bird's breast throughout the duration of time the birds are shackled and conscious.
- A shackle line must be straight whilst the birds are conscious.
- Shackled conscious birds should be sufficiently spaced apart to prevent physical contact whilst in the waterbath; this may limit the variation in the current amplitudes received in a constant voltage stunner.
- Encouraging as many birds as possible to adopt an ideal posture for entry to a waterbath. Good entries may be seen in birds that hold their neck extended towards the floor, their head down and their wings folded into the closed position against the body. To assist, shacklers may need to gently fold a bird's wings into the closed position, whether the birds are against a breast contact strip or on a breast support conveyor. With closed wings, birds may be less likely to touch one another in the waterbath.
- Slaughtering birds in batches in which the individuals are as uniform as possible. This should allow more efficient and humane stunning in terms of reduced compression of some birds' legs, better entries to the electrified water and more similar current amplitudes when using a constant voltage stunner.
  - Avoid shackling together birds that are different in size (including length, leg circumference), age or expected body fat and muscle content. For example, slaughter males and females separately.
  - Runts or very small birds must not be shackled for waterbath stunning because they may miss the electrified water and/or miss an automated mechanical neck cutter. They must be slaughtered using an alternative humane stunning method.
- Prevention of pre-stun electrical shocks.

- A waterbath should be of an adequate size (particularly width and depth) for the type of bird being slaughtered. Undersized, or even oversized, individuals must not be shackled for waterbath stunning if their size puts them at risk of ineffective stunning.
- Monitoring the position of birds in the electrified water to increase the likelihood that sufficient current will flow through the target organ(s), ie the brain (and heart in the case of intended stun-killing).
  - The water level in a waterbath must completely cover the entire head of each bird (including the cranium of the smallest bird suspended) and, if necessary (eg in Europe), the neck and up to the rostral edges of the wings (ie shoulders).
- The submerged electrode must span the entire length and width of a stunner and the earthed rubbing bar(s) electrode must span the entire length of a stunner.
- Continuous physical contact between the components of an electrical circuit, throughout the intended duration of current flow, ie from the electrode/water to the bird's head, the bird's legs to the shackle and occupied shackles to the earthed rubbing bar(s). This should allow for receipt of a consistent amplitude of current.
- The good condition of all components that enable current flow. Replace if worn or damaged, or if scale or carbon residues are present and if descaler and acid are ineffective at removing the scale or residues. (Scale and carbon residues can impede current flow, even though there is physical contact.) Keeping resistance as low as possible at all conduction points between the birds and the electrodes may avoid the need to use excessive voltages to reach the required current.
- Selection of equipment capable of delivering electrical parameters appropriate for animal welfare.
  - The latency to deliver the recommended current may vary with the available and applied voltage. Electrical waterbaths must be supplied with an appropriate input voltage, to ensure stipulated currents are reached and birds become unconscious immediately.
  - It is necessary to program a constant voltage stunner to deliver a minimum voltage that is capable of delivering the recommended current to 100% of birds. When under load, the ammeter on the stunner control panel must display a total current that equals, or exceeds, the number of birds simultaneously in the water multiplied by the minimum recommended current per bird. If birds are stunned in mixed-sex batches, abattoirs must use a voltage sufficient to ensure all sexes receive the minimum recommended current amplitude. Alternatively, if necessary and if practical, separately slaughter males and females (eg broiler chickens) in order to provide females with the necessary higher voltage and to limit any damage to the carcasses of males.
  - If, in future, a true constant current stunner becomes available, it is likely to be preferable to use that type of stunner because it should be able to control the delivery of a constant current to each individual bird. This should be irrespective of the number of birds in contact with the water, any differences in resistance attributable to species, breed, strain, sex and age of bird, as well as the electrical waveform, all of which are otherwise difficult to predict and control for.
- Choose electrical parameters that should ensure 100% of birds are immediately stunned and remain so until death occurs.
  - Apply a current that at least meets, or exceeds, the threshold amplitude recommended to induce generalised epileptiform activity followed by a quiescent EEG.
  - Sine AC may provide a more effective stun than other AC and pDC waveforms.
- Monitoring equipment to ensure it actually delivers electrical parameters as appropriate for the welfare of each type of bird. Use the waterbath control panel ammeter and remote stun monitors to check that current is

applied for a sufficient duration, not exceeding the recommended maximum frequency or using less than the recommended minimum amplitude of current.

- Installation of slaughter systems in a layout that allows personnel to safely and easily assess and access birds at any point on a shackle line, from shackling to entry to a scald tank. If access is denied because personnel are obstructed by features of the system or other equipment, eg if fast line speeds or the height of a shackle line effectively puts the birds out of reach, then the system should be redesigned. Use equipment that enables operators to access birds quickly in emergencies.
- Construction of shackle lines in a layout that enables birds to be checked for effective stunning before their necks are cut.
- Recognition of an ineffective stun.
- Birds must not be passed through a waterbath until a slaughterperson or ANC is ready and waiting to cut the birds.
- Accurate, consistent severing of at least both common carotid arteries and both external jugular veins, as soon as possible and within 10 seconds of high frequency stunning and 15 seconds of 'standard' frequency (eg 50 Hz) stunning.
  - For all species, it is necessary to cut into the neck muscle, to sever the carotids.
  - A ventral neck cut is an effective means of reliably severing both carotid arteries and therefore for bleeding birds as much, and as quickly, as possible, thereby protecting their welfare and benefitting meat quality.
  - Sufficient time for a bird to bleed out (incomplete bleeding may lead to downgrading of breast fillets and red wing tips).
- Recognition of an ineffective neck cut. If an operator is unsure if the carotid arteries are cut, they must cut the bird again.
- Rehearsed contingency plans. For example, if power to a waterbath fails:
  - The shackle line must automatically stop to prevent conscious birds' heads being immersed in non-electrified water.
  - Birds that have already received an electric current and are unconscious must receive a ventral neck cut immediately, to prevent recovery.
  - Birds that received an electric current and are showing signs of recovery must be re-stunned using a back-up method and then bled.
- Immediate availability of a sufficient number of humane back-up stunning devices.
- Clear standard operating procedures. For example, if there is any indication that restraint, stunning or killing equipment is not operating effectively, slaughter must cease until the system is checked and any faults are corrected. An electrician or electrical engineer must be on-site and on-call during slaughter, in order to respond quickly and effectively to equipment failures.
- All personnel taking remedial action and/or immediately informing an AWO and the veterinarian, of any sick, injured or ineffectively stunned or ineffectively cut birds.

For more detailed information (including general maintenance of equipment, standard operating procedures, animal welfare policies and training, useful contacts and publications and a glossary of electrical waterbath terminology) suitable for Animal Welfare Officers, Official Veterinarians and abattoir management, please view the HSA **Guidance Notes No.7 on 'Electrical Waterbath Stunning of Poultry'**, which can be downloaded free-of-charge and is also available in French (**également disponible en français**).

Aide-mémoire pour un abattage respectueux

l'ensemble du dispositif soit examiné et les défaillances corrigées. Un électricien ou ingénieur électricien de garde doit être présent sur le site pendant l'abattage, afin d'être en mesure de réagir promptement et efficacement à toute défaillance du matériel.

Figure 33. Un bain d'eau aux panneaux latéraux coulissants dans le sens vertical, afin de permettre l'accès du personnel aux volailles en cas d'urgence. L'image de gauche montre le bain d'eau en cours d'utilisation, panneaux fermés, et l'image de droite donne à voir le même dispositif avec les panneaux ouverts. Photos : Marel Stork Poultry Processing.