Electrical Stunning of Red Meat Animals

This is the downloadable PDF version of the online guide. As such, some of the features are missing, including video footage and web links. The online version may be accessed from **www.hsa.org.uk**

Introduction

Every year, billions of animals are reared for food around the world. In order to be considered humane, the slaughter of these animals must be carried out in a way which causes no unnecessary pain or suffering. A number of systems have been developed to facilitate the humane slaughter or killing of livestock. The main principle of all these methods is to stun the animal so that it becomes unconscious and insensible to pain; this condition should last until the animal is dead.

Electrical stunning, also known as electronarcosis, was initially developed in France and Germany in the late 1920s, for use on cattle, sheep, pigs, calves and horses. This method involves stunning the animals with electricity; death is caused either by bleeding (cutting the major blood vessels between the heart and brain), or by electrocution (by applying an electric current to stop the heart). Even in the early stages of development, experiments were carried out to determine the optimum electrical current needed to stun animals for sufficient time to enable them to be bled without recovering consciousness. In the early 1930s, high-throughput electrical stunning systems were developed in the United States of America. Electrical stunning became more widely established in Europe in the 1950s and is now used around the world.

Modern equipment controls the voltage, frequency, waveform and duration of the electric current delivered to stun the animals. There are systems available which can can also monitor the operation to record and display the electrical parameters with which the animal is stunned. Despite the increasing complexity of electrical stunning equipment, it is still the responsibility of the operator to ensure that every animal is humanely stunned and killed. Poorly maintained or incorrectly used electrical equipment can result in avoidable suffering for the animal, and can also compromise operator safety.

These guidance notes explain the theory, practice and use of electricity to stun and kill animals. They provide essential technical information to abattoir supervisors, veterinary surgeons, meat hygiene inspectors and maintenance engineers; assist management in the selection of equipment; provide operators with background information to help them carry out their job competently and safely; describe faults and conditions that might prevent equipment operating correctly; and explain how to rectify the common problems.

The practical information presented in this guide is intended to be clear and instructive. However, some of the stunning and killing procedures described cannot be very effectively or fully demonstrated except in practice. Anyone aiming to undertake these procedures should also seek practical training with an experienced operator. In many countries (e.g. EU member states) training and certification are required by law.

Important Points About This Guide

This guide is intended to instruct operators in the proper and humane use of electrical stunning equipment for the slaughter and killing of red meat livestock. However, anyone aiming to undertake stunning and slaughter procedures should also seek practical training with an experienced operator. In many countries (e.g. EU member states) training and certification are required by law.

In order to safeguard the welfare of the animals to be killed, it is necessary for the guide to be both thorough and illustrated. As such, some people may find some of the descriptions and graphics upsetting. Please do not read further if you feel you may be negatively affected by the content.

Electrical stunning equipment is potentially lethal. You are advised to read the **Safety** section of these notes with particular care. If you are in any doubt as to any aspect of the safe operation of electrical stunning equipment you should consult the manufacturer. In no circumstances can the Humane Slaughter Association accept any liability for the way in which electrical stunning equipment is used, or for any loss, damage, death or injury caused thereby, since this depends on circumstances wholly outside of the HSA's control.

For information regarding electrical stunning of poultry, the HSA has produced an online guide titled **'Practical Slaughter of Poultry - A Guide for the Smallholder and Small-Scale Producer'** which contains a section on electrical stunning.

The HSA aims to provide up-to-date and accurate information. If you have suggestions for improving any of the material included in this guide please let us know at info@hsa.org.uk or using the contact details provided at the **HSA Website**.

A **Paperback Version Of This Guide** (published 2005) is also available to purchase at a cost of £5 (including postage).

Electricity

The principle of electric stunning is to pass sufficient current through the brain to interrupt its normal activity, so that the animal becomes immediately unconscious and unable to feel pain. When electrodes are applied to the head, the amount of current that flows will depend on the voltage difference between the electrodes, and the electrical resistance of the animal. This section explains some basic electrical principles and how they apply to animals.

Current, Voltage and Resistance

The flow of electricity through an object, such as a wire, is known as the current (I). It is measured in amps (A); if the current is very small then it is described in milli-amps (mA), 1000 mA = 1A. The driving force (electrical pressure) behind the flow of a current is known as the voltage and is measured in volts (V) (Voltage may also be referred to as the potential difference, or electromotive force). The property of a material that limits current flow is known as its resistance (R), the unit of resistance is the ohm (Ω). Resistance to alternating current is more properly called impedance but, in this application, resistance and impedance can be considered to be equivalent.

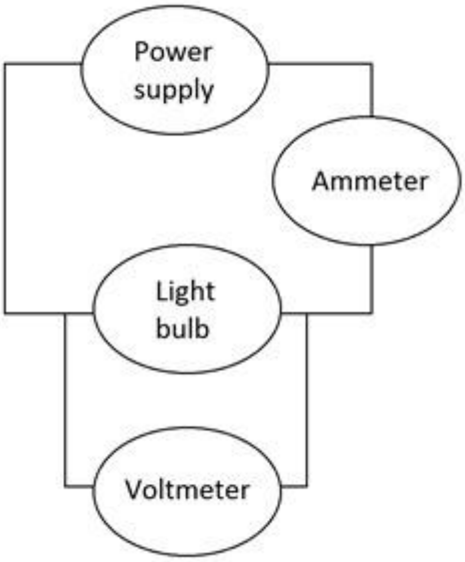
The relationship between current, voltage and resistance is expressed by Ohm's Law. This states that the current flowing in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance of the circuit, provided the temperature remains constant.

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

To increase the current flowing in a circuit, the voltage must be increased, or the resistance decreased.

A simple electrical circuit is depicted in Figure 1a. The flow of electricity through this circuit is further illustrated by analogy to the pressurized water system in Figure 1b.

In the electrical circuit the power supply generates electrical pressure (voltage), equivalent to the pump creating water pressure in the pipe; the current is equivalent to the rate of flow of water; and the light bulb provides the resistance in the same way as the restriction in the water system. The ammeter is equivalent to the flow meter and the voltmeter measures the difference in electrical pressure each side of the restriction in the water system. There will be a drop in voltage due to the energy used up in driving the current through the light bulb, which has a higher resistance than the wire in the circuit. Similarly, the water pressure at (A) will be less than at (B).



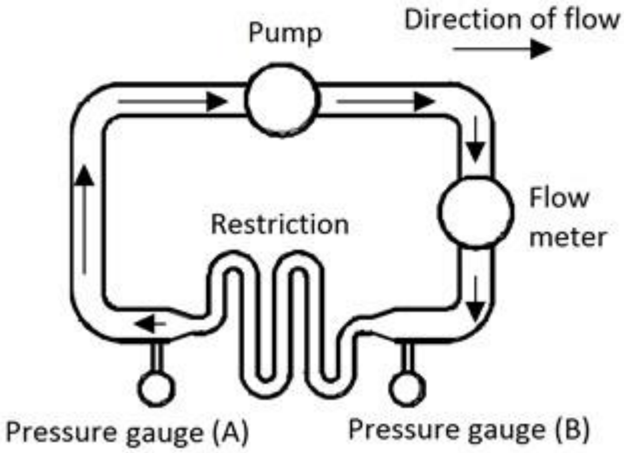


Figure 1a Simple Electric Circuit **Figure 1b** Pressurised Water System

The overall resistance of an object depends on a number of properties including its length, cross-sectional area and the type of material. The longer a conductor, the greater its resistance; for example, a two metre wire has twice the resistance of a one metre wire of similar properties. The larger the cross-section of a conductor, then the lower its resistance: overhead power cables have a much lower resistance than a lamp flex of the same length. Different materials also have different abilities to conduct electricity. Metals conduct very well but materials such as ceramics or glass do not usually conduct electricity at all and are known as insulators.

Animals contain a high proportion of liquid that will conduct electricity well; however skin, fat, bone and hair are poor conductors. Electrical current will take the path of least resistance through animal tissue, with the result that only a small proportion of the measured current will penetrate the brain. Animals with heavy fleeces, thick skin, fat layers or thick skulls will have a high electrical resistance. Table 1 shows how the relationship between current, voltage and resistance differs when stunning sheep of different physical condition. In this example, the minimum current required for an effective stun is one amp.

Table 1 Examples of the application of Ohm's Law when stunning sheep

	Condition of Animal	
	Dry, fat and in full fleece	**Wet, thin and recently sheared**
Voltage applied (V)	200 V	200 V
Resistance across head (R)	1000 Ω	150 Ω
Current (I = V/R)	0.2 A	1.3 A
Result	Ineffective stun	Effective stun

Waveform and Frequency

Current can be generated as either pulsed direct current (DC) (Figure 2a), as from a battery switched on and off, which flows in one direction; or it can be an alternating current (AC) (Figure 2b), from the mains supply or a generator, where the direction of the current flow changes. The waveform of a current describes the shape of one cycle of the current.

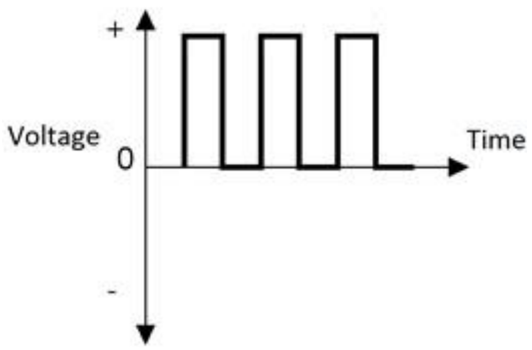


Figure 2a Pulsed direct current (DC) (three cycles)

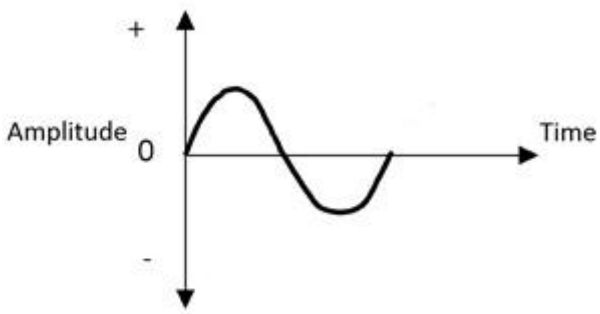


Figure 2b Alternating current (AC) (one cycle)

The frequency of a current is how many times one cycle of the waveform is repeated per second, and is measured in hertz (Hz). Mains electricity has a sine waveform (Figure 2b) and a frequency of 50Hz, i.e. it repeats 50 times per second. Higher frequency waveforms repeat more times per second; e.g. the frequency of the current in Figure 3a is four times the frequency of the current in Figure 3b.

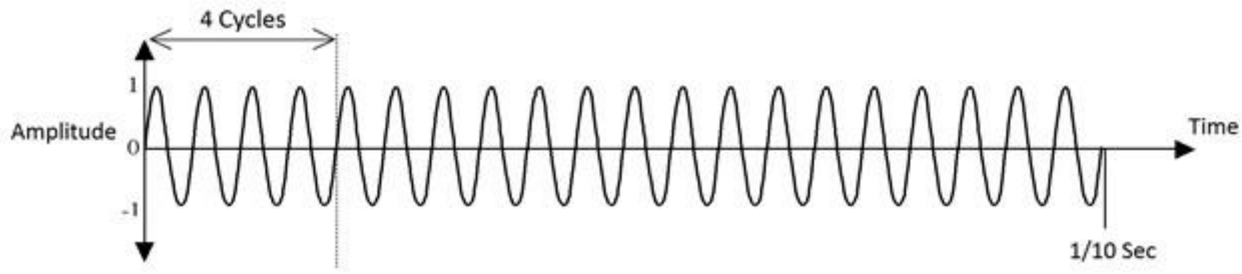


Figure 3a Example of standard 200Hz frequency

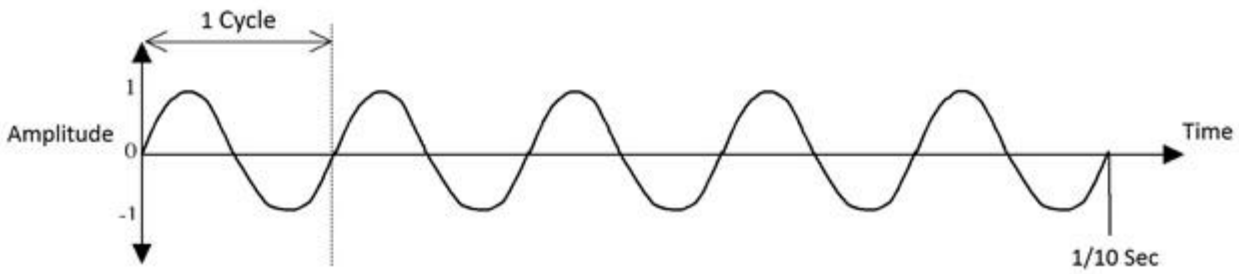
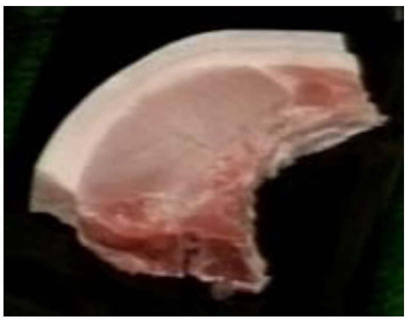


Figure 3b Example of Standard 50Hz Frequency

Meat Quality

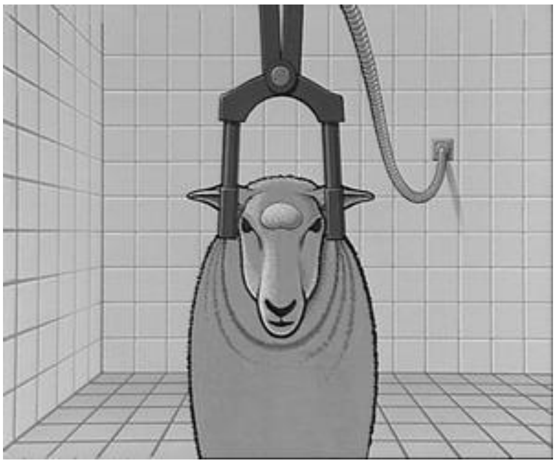
The waveform and frequency of the supply voltage can alter the effect that electric current has on animals. Consequently, electrical stunning is often blamed for meat quality issues leading to carcase downgrading. As a result, adjustments are sometimes made to electrical equipment that could compromise animal welfare.



Most conventional stunners operate with the same 50Hz sine wave as the mains supply (Figure 3b). However, research has demonstrated that direct muscle stimulation is responsible for downgrading conditions. Increasing the frequency of the applied waveform to 1500Hz significantly reduces the level of direct muscle stimulation and manufacturers have now produced equipment which applies high frequency current followed by low frequency current. Research has also shown that, although electrical stimulation of muscles at stunning can lead to blood splash, bruising and broken bones, the occurrence of these conditions also depends on other factors, including: the source, breed and strain of the animal; nutrition; changes in temperature prior to slaughter; pre-slaughter handling; and interrupted contact of stunning electrodes. These may account for the frequency and random nature of the incidence of downgrading between individual animals. All these factors must be thoroughly investigated before making changes to the settings of a stunner.

Any changes to stunner settings which could compromise animal welfare must not be made in an attempt to rectify meat quality problems.

Electrical Stunning



Stunning with electricity is known as electronarcosis, and killing with electricity is known as electrocution. Electronarcosis is a fully reversible procedure, immediately disrupting normal brain function for a short period. Electrocution leads to cardiac arrest, stopping the heart pumping blood around the body and causing rapid death; it is often referred to as a stun-kill. This section describes what happens to an animal during electronarcosis and electrocution, detailing the parameters required to ensure that each stun is immediate and effective.

Electronarcosis

When electrical stunning is carried out effectively, the result is essentially the same as an epileptic seizure in man, known as a grand mal epileptic fit, during which the brain is severely stimulated, the body exhibits tonic/clonic activity, and there is complete loss of consciousness. During the first (tonic) phase, when current flows through the brain, the animal collapses and stops breathing, with the front legs extended rigidly and the hind legs flexed into the body. The second (clonic) phase sees the animal relax and start involuntary kicking of both the fore and hind legs. As the clonic activity subsides, the animal moves into the third (recovery or exhaustion) phase.

It is recognised that while an animal is in the first two phases it is unconscious and, therefore, insensible to pain. However, the onset of the third phase is an indication that the animal is beginning to recover and may be able to experience pain. The first sign that an animal is recovering from the effect of the stun is a return to normal rhythmic breathing. Rhythmic breathing can be determined by watching for the rise and fall of the chest, with evenly spaced breaths. This should not be confused with random gasping (agonal breathing), a result of spasmodic muscle contractions, which can occur when the brain is dying. During these random contractions, air can also be forced from the lungs, causing the animal to make involuntary noises.

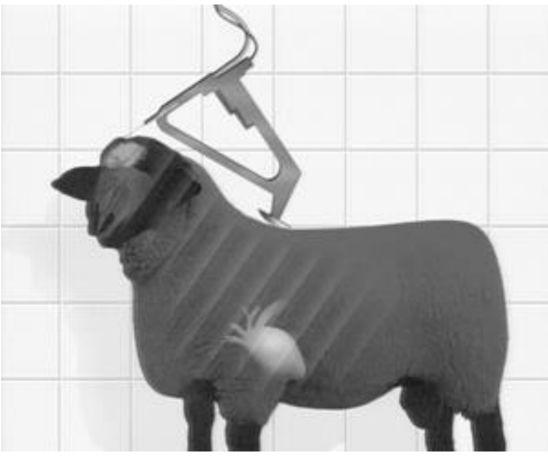
Phase	**Physical symptoms of an epileptic seizure**
Tonic	Animal collapses and becomes rigid No rhythmic breathing Head is raised Forelegs extended and hind legs flexed into the body

Clonic	Gradual relaxation of muscles Paddling or involuntary kicking (can be severe at times) Downward movement of eyeballs Urination and/or defecation
Recovery	Resumption of normal rhythmic breathing Response to painful stimuli Becomes visually aware Attempts to stand

- Lack of obvious tonic activity indicates a poor or ineffective stun.
- The first sign of recovery from an effective stun is a return to normal rhythmic breathing.

Electrocution

The purpose of electrocution is to kill the animal by stopping the heart from pumping blood around the body (referred to as cardiac arrest). If this happens, the brain will be starved of oxygen and will rapidly die. When an appropriate electric current is passed through the heart it goes into a state known as ventricular fibrillation. This means that the heart muscles fibres contract in a rapid, uncoordinated manner instead of in a regular, coordinated way; blood circulation stops and, if this state persists, death will soon occur.



When an animal is electrocuted it becomes rigid with slight body tremors and then gradually relaxes. There should be no further movement. Electrocution is painful, so it is essential that animals are stunned before it is carried out. In practice, this is achieved by using equipment that delivers current initially through the brain, and then through the brain and heart simultaneously.

It cannot be guaranteed that every animal will go into cardiac arrest: if an animal exhibits the signs of a head-only stun, such as clonic paddling movements of the legs, then it should be bled immediately to prevent recovery. Equally, it may be possible for the animal to go into a cardiac arrest without being effectively stunned. The symptoms of this are very difficult to observe as the animal may be paralysed and will die very quickly, but the presence of eye movement or corneal reflex (reaction to touching the surface of the eye) are reasonable indicators. Should this situation occur, the animal must be re-stunned immediately, the equipment checked before further use, and the placement of the electrodes carefully monitored.

Stun Duration

The purpose of stunning an animal is to make it insensible to pain until death is caused by bleeding or cardiac arrest. Therefore, it is important to know the duration of an effective electrical stun. The tonic and clonic phases of a stun have already been described. Table 2 gives the time in seconds that these phases are expected to last (these times relate to the recommended minimum application of stunning currents).

Table 2 Expected duration of phases following head-only electrical stunning

Species	Tonic	Clonic	Recovery
Pigs	10-20 secs	15-45 secs	30-60 secs
Sheep			
Goats			
Cattle	5-20 secs	10-60 secs	45-90 secs
Calves	8-14 secs	8-28 secs	40-70 secs

It is also important to know the duration of unconsciousness when calculating the maximum interval between stunning and bleeding, in order to avoid the risk of animals recovering consciousness before they die from loss of blood. Table 3 lists the average time span in seconds to loss of brain function following various bleeding methods. Where death is not induced by cardiac arrest, all stunned animals must be bled within 15 seconds of stunning. (N.B. These are average times, actual times to loss of brain function may vary from these figures and be greater or less)

Table 3 Mean time to loss of brain function following various bleeding methods

Species	Method	Time (seconds)
Pigs	Chest stick	18
Sheep	Chest stick	4.5
	Both carotid arteries and both jugular veins (full cut)	14
	One carotid artery and one jugular vein (half cut)	70
Cattle	Both carotid arteries and both jugular veins	55
Calves	Chest stick	5
	Both carotid arteries and both jugular veins	17

Not only must animals be bled without delay, but correct procedures must also be followed. The following diagram (Figure 4) shows the variation in times to loss of brain function, as influenced by the timeliness, quality and techniques of sticking. For example, in sheep, if only one carotid artery and one jugular vein are cut (half cut), brain death can take up to 70 seconds (over 50 seconds longer than a full cut). After this length of time the animal will be in the recovery phase and may no longer be insensible to pain. The diagram also shows the increased likelihood of pigs regaining consciousness before dying, if chest sticking is delayed. The section on bleeding describes the correct sticking procedures to ensure that these times are achieved.

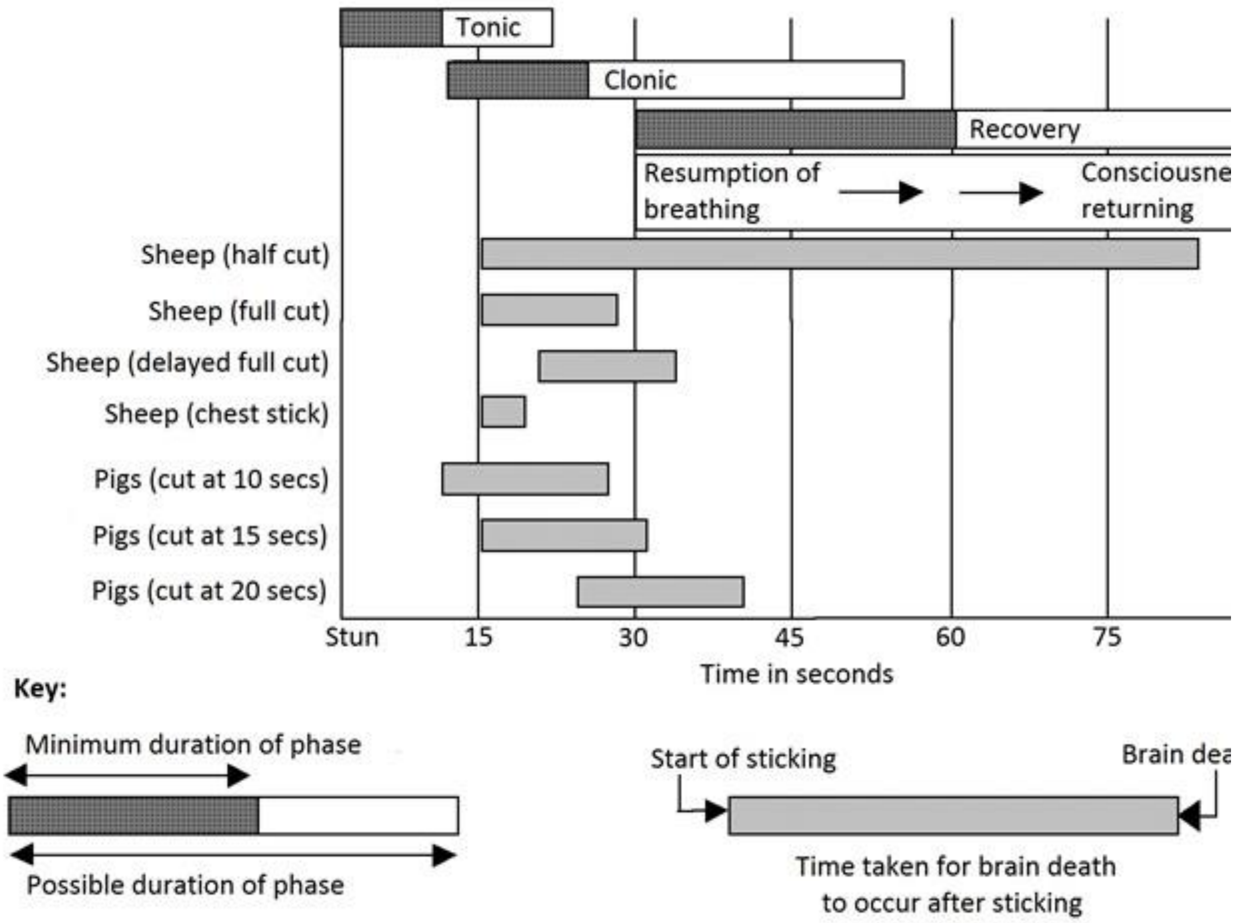


Figure 4 Relationship between the phases of epilepsy and the importance of quick and effective stunning

Currents

In order to stun or kill an animal with electricity, it is necessary to pass sufficient current through the brain, or through the brain and heart respectively. Therefore, accurate electrode placement is of paramount importance. However, assuming correct electrode positioning, it is the magnitude of the current that determines whether the animal is stunned or killed. Table 4 shows the recommended currents, for head-only stunning and head-to-body killing, delivered by a conventional 50Hz sine wave supply voltage.

Table 4 Recommended currents for stunning and killing animals

	Current	
Species	**Stun** (Head-only)	**Kill** (Applied to heart)
Cattle	1.28 A	> 1.51 A
Calves	1.25 A	1.0 A
Sheep/Goats	1.0 A	1.0 A
Lambs/Kids	1.0 A	1.0 A
Pigs	1.3 A	1.3 A

When applied correctly, with electrodes positioned to span the brain, these currents will stun immediately. Within a normal working environment it is recommended that the current should be applied for at least three seconds. If electrocution is being carried out, the frequency of the current should be no greater than 100Hz because, as frequency increases, ventricular fibrillation is less likely to result.

Most modern stunning equipment operates at outputs in excess of 200V, but some automatic equipment, where there is less risk of the operator coming into contact with the electrodes, can run at up to 1000V.

Note: Older electrical stunning systems, with outputs of 150V or less, are not considered to be effective at producing an immediate stun. The HSA recommends that such equipment should be immediately taken out of service and replaced with modern, higher voltage stunning systems with outputs of 200V or more.

Resistance

With either electronarcosis or electrocution, the overall resistance to current flow is due to two factors; the tissues of the body and also the contact between the electrodes and the skin. It is important to keep the resistance as low as possible to maximise the flow of current. It is not possible to alter the resistance of the tissues of an animal, however, it is possible to minimise the contact resistance by applying electrodes in the correct position and maintaining constant pressure during the duration of the stun.

Very often there is a build-up of grease and dirt on the electrodes, especially where localised heating occurs. This build-up has a high electrical resistance and must be regularly removed. Failure to clean electrodes will lead to corrosion, further increasing resistance. Although resistance falls once the current begins to flow, it is the initial resistance that must be overcome to deliver the recommended current in order to produce an immediate stun.

Table 5 shows the typical electrical resistance of animals during stunning. If electrodes are clean and well maintained, and the contact sites have been wetted, then the resistance will be at the lower end of the range. However, if the electrodes are dirty and dry, resistance may be even greater than the ranges in the table.

Table 5 Approximate electrical resistance of animals to stunning current

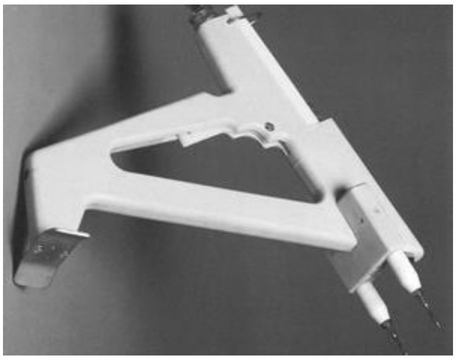
Species	Electrode Position	Resistance (Ohms)
Pigs (approx. 100kg)	Across the head	150-350
Sheep	Across the head, light fleece cover	150-400
	Across the head, heavy fleece cover	150-1000
Cattle	Nose to neck	130-230

Table 6 gives examples of currents that may flow, as calculated by Ohm's Law, and shows whether or not there is enough current to produce an effective stun. It is essential that all electrical stunning equipment displays the voltage and current which flows during each stun cycle. This display must be visible to the operator.

Table 6 Examples of calculating current with Ohm's Law

Species	Voltage (V)	Resistance (Ω)	Current (A)	Effective Stun?
Pig (clean electrodes)	250	150	1.6	Yes
Pig (dirty, worn electrodes)	250	350	0.7	No
Sheep (short, wet fleece)	250	200	1.25	Yes
Sheep (long, dry fleece)	250	1000	0.25	No

Equipment



Electrical stunning and killing equipment falls into three main categories: head-only (stun); head-to-back (stun-kill); and head-to-body (stun-kill). All systems consist of an electrical control box to produce the appropriate supply and a system of electrodes to deliver current to the animal. Head-only and head-to-back systems usually have the electrodes placed manually; head-to-body systems tend to have automatic electrode placement.

Head-Only Stunning

Head-only stunning can be carried out on individual animals within a group in a pen, or on individual animals in a restrainer-conveyor. There are two basic types of head-only tongs: scissor or fork (Figures 5 and 6). The site of application is the same in both cases but the method of restraint may be different. The most widely used are scissor tongs (Figure 5), which can be used in either group stunning pens or restrainer-conveyors. The arms are usually around 75cm long and have a maximum jaw gap of about 30cm; the handles may incorporate a switch. The design of the electrodes varies, but is generally either a parallel array of metal teeth, or a circular cup electrode with one or more central spikes. The electrodes are connected to insulated blocks at the ends of the tongs.

Figure 5 Scissor stunning tongs

Figure 6 Fork stunning tongs

To enable accurate placement and maintain contact, the fork tong (Figure 6) should only be used when stunning animals held in a restrainer. The electrodes are usually longer than those found on scissor tongs, to allow for variation in the size of animals, and are connected to a single handle by insulated arms.

Control equipment must be adequately protected from both physical and water damage. The easiest way to achieve this is to site the control box away from the stunning and sticking area. Provided the cable between the stunning tongs and the stunner control box is of sufficient diameter, there should be no appreciable drop in current level due to increased resistance caused by cable length. The operator must be able to see the meters which display the current and voltage, and be able to hear and see the audible and visible signals to warn if the stun duration falls below the required level. It is important that the operator has unrestricted access to the safety stop controls.

Head-only stunning electrodes should be placed so that they span the brain as directly as possible. Positioning the electrodes anywhere else means that more of the current may flow through lower resistance pathways and not entirely through the brain, thus reducing the effectiveness of the stun. When using scissor-type tongs on sheep and pigs, the recommended tong position is on either side of the head between the eye and ear (Figures 7, 8 and 9). In practice, this position can be difficult to achieve on pigs because of the shape of the head; so an alternative is just below the ears, or diagonally below one ear to above the opposite eye (Figures 10 and 11). When using a fork-type tong the position is the same, between the eye and ear on each side of the head. In both systems, once the electrodes are applied they must be kept in constant contact with the animal to prevent interruption to the stunning current flow, as this can lead to an ineffective stun and can also increase the occurrence of carcase damage.

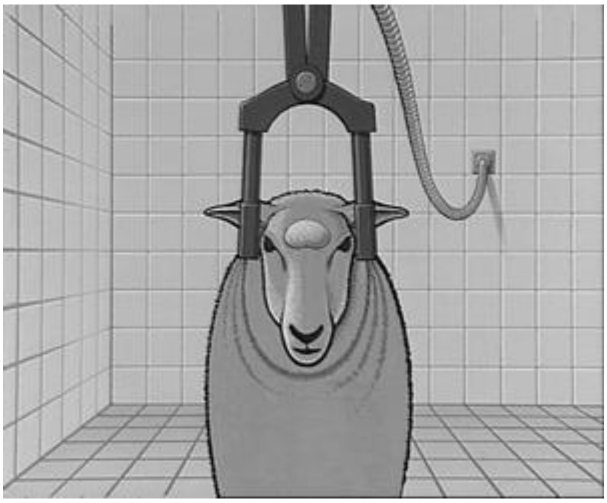


Figure 7 Electrode position for sheep (front view)

Figure 8 Electrode position for sheep (side view)

Figure 9 Electrode position for pigs

Figure 10 Alternative electrode position for pigs

Figure 11 Diagonal electrode position for pigs

Head-to-Back Stun-Kill

Head-to-back stun-killing is carried out by passing a current simultaneously through the brain and through the heart of the animal. In order to achieve this, head-to-back systems have the electrodes fixed in a handpiece (Figure 12), which is applied and operated manually by the slaughterman. To ensure correct positioning of the electrodes and to maintain contact, it must only be carried out on animals held in a restrainer.

The correct positioning of both electrodes is very important in order to ensure that the current flows through both the brain and the heart (Figure 13). With the animal restrained, the rear electrode should be placed firmly in the middle of the back above the heart (Figure 14). The front electrode should then be placed on the head, level with, or forward of the eyes (Figure 15). If a switch is fitted to the handset it should only be pressed once the electrodes are in position. The rear electrode should not be placed too far back, as the front electrode will also be in the wrong place and the animal will not be properly stunned. Electrode handsets that combine a water spray will help to reduce contact resistance and will, therefore, improve current flow. Additionally, they will decrease the likelihood of pelt damage of sheep by reducing the heating effect of the current at the site of the rear electrode.

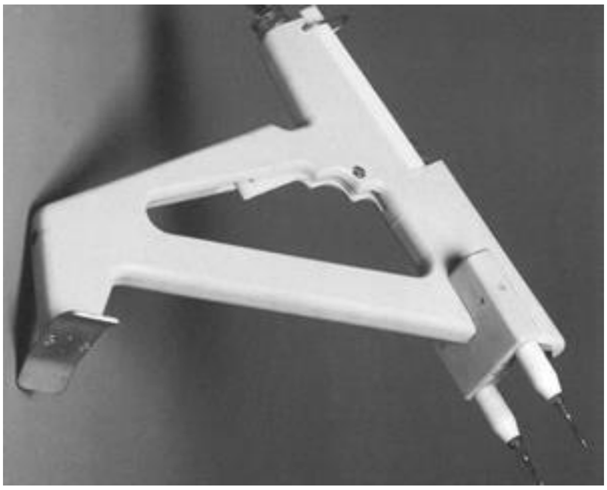


Figure 12 Head-to-back stunner

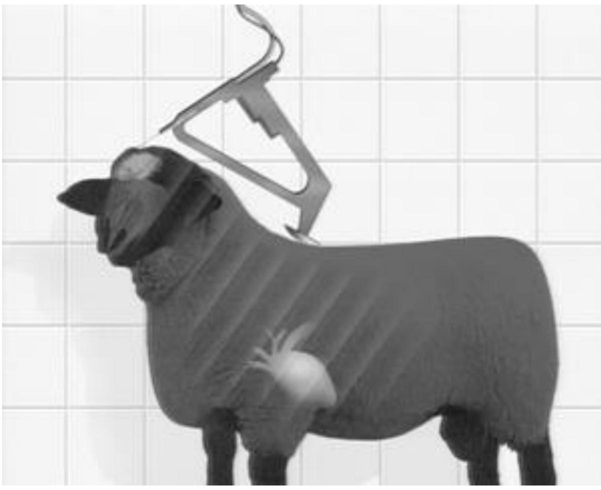


Figure 13 Correct head-to-back electrode position

Figure 14 Correct back electrode positioning

Figure 15 Correct front electrode positioning

Head-to-Body Stun-Kill

The design of equipment for head-to-body stun-killing depends on the species of animal being killed and is generally semi- or fully-automatic. It is important to make sure that the animals are positioned correctly in the machine, in relation to the electrodes, and to make adjustments for different sized animals. Regular checks must make sure that both an effective stun and cardiac arrest are induced. All automatic stun-kill equipment must be set carefully to the manufacturer's instructions and both electrodes and placement sites must be clean.

Equipment for pigs automatically places a pair of electrodes on the head, just below the ears, to stun the animal. A third electrode is then placed on the chest of the animal, to deliver a second current that will fibrillate the heart, and thereby cause the death of the animal.

Electrical stunning of cattle can be achieved using three phases sequentially: a three second head-only phase to stun the animal followed by a 15 second cardiac phase to induce ventricular fibrillation (cardiac arrest) and then a four second spinal discharge phase to reduce clonic convulsions. Equipment for cattle should restrain the animal with a neck yoke, chin lift and rump pusher, in order to position the animal for accurate electrode placement (Figure 16). An electrode will then contact the nose and current will flow from the nose to the neck yoke, stunning the animal. A second electrode will then be placed on the brisket and a further current will flow through the body and stop the heart. The type and magnitude of the current delivered varies, dependant on the equipment used. The third phase, nose-to-rump, which disrupts spinal reflexes, is used so that the animal lies motionless once it is released from the restrainer.

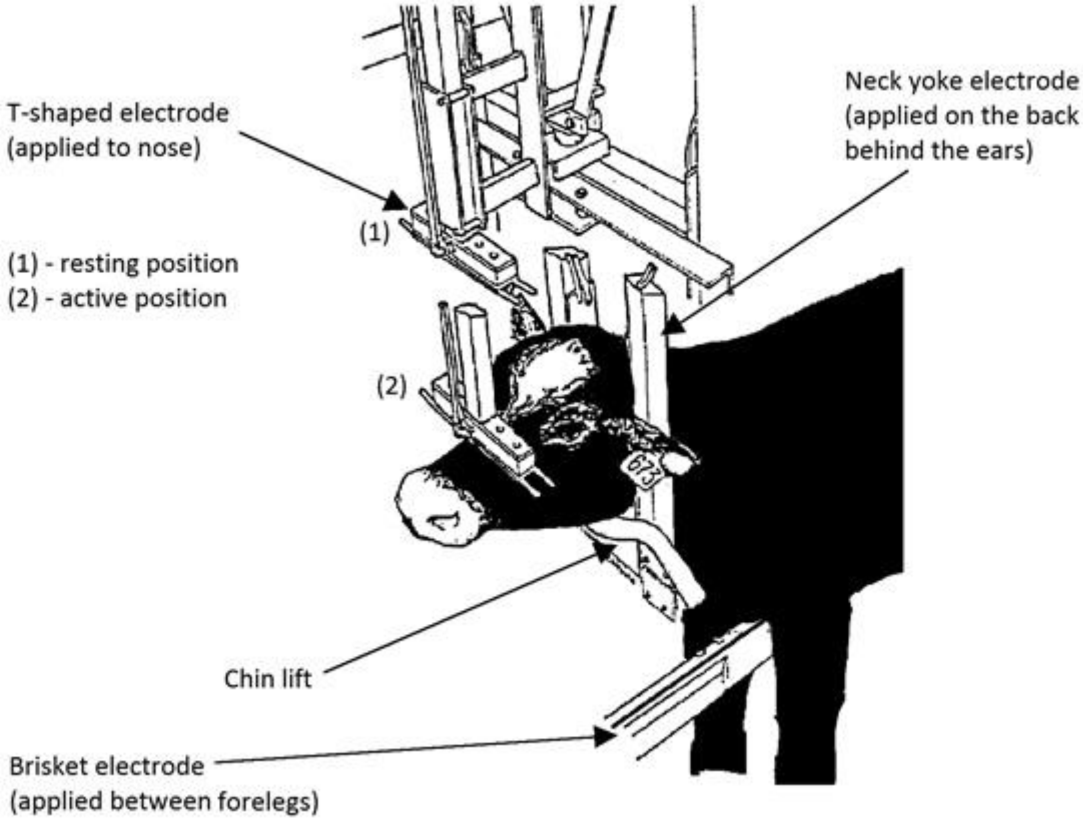
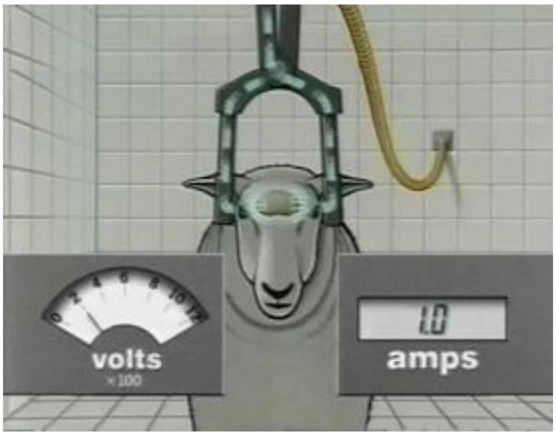


Figure 16 Head-to-body stun-kill cattle equipment

In a commercial environment, the interval between stunning and sticking of cattle can be long (up to 60 seconds where the stunned animal has to be shackled and elevated prior to bleeding). Therefore it is essential that all staff should be able to recognise and differentiate between effective and ineffective electrical stunning with subsequent cardiac arrest. A back-up captive-bolt stunner must always be available.

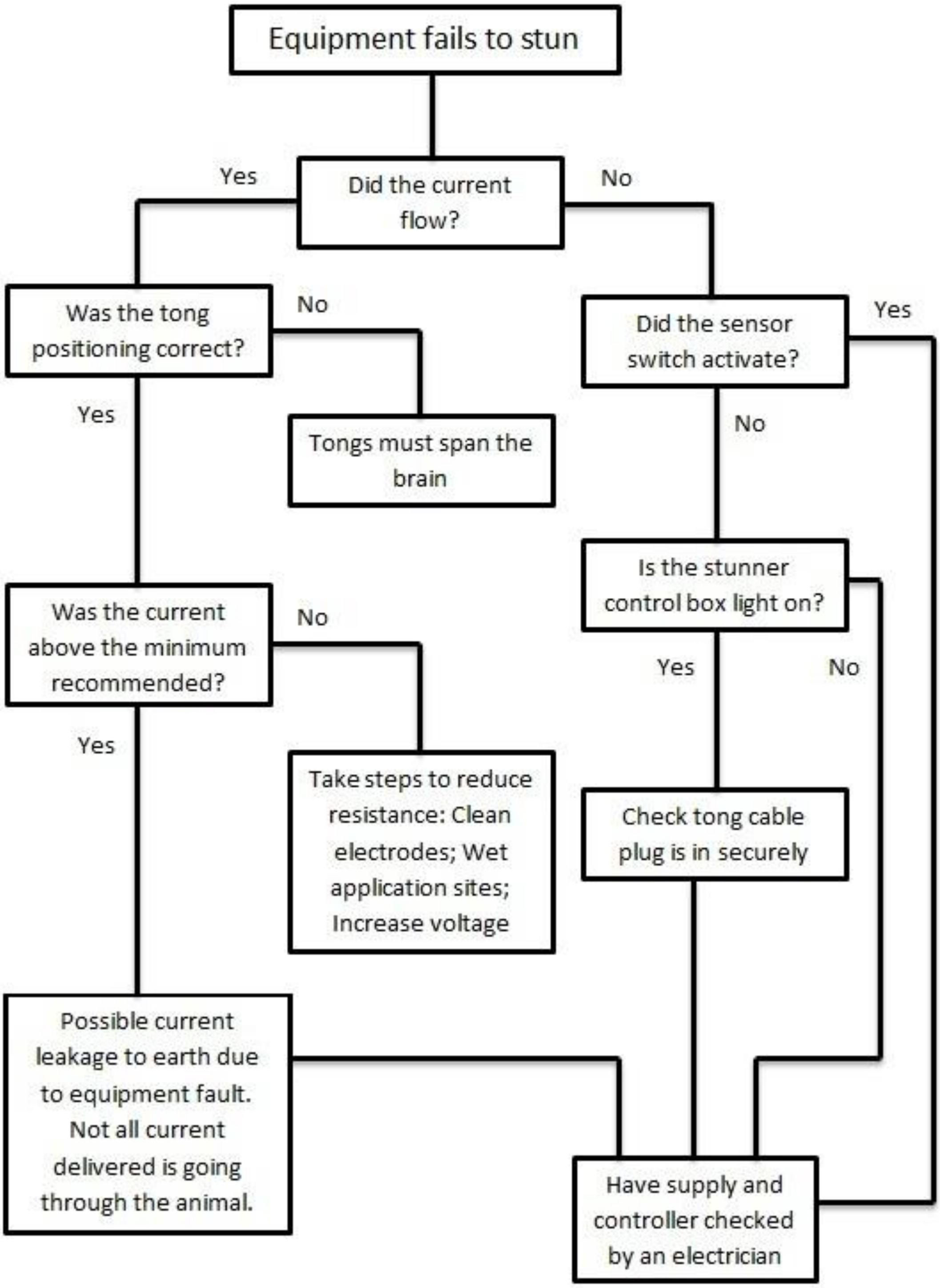
Control Devices and Monitors

Stunning controllers are becoming increasingly sophisticated as more research into the effect of electrical currents on animals is carried out. They range from simple transformers, which deliver a fixed voltage output, to complex electrical systems, which control the voltage, frequency, waveform, and duration of application.



Some systems provide current monitoring, which enables the current profile from each stunning operation to be logged and reviewed. Sensor switches are incorporated into some models to prevent the flow of current if the resistance of an animal's head is above a set level. All electrical stunning equipment must feature meters, which display the current and voltage, and audible and visible signals to warn the operator if the stun duration falls below the required level. These displays can be separate to the control unit, but must be visible to the operator.

Troubleshooting



Restraint

Restrainers are designed to hold individual animals and present them in such a way that the stunner electrodes can be easily and accurately applied. Animals held in a restrainer can be stunned with head-only, head-to-back or head-to-body electrodes. With any type of restrainer, if the electrodes are being applied manually, the operator must be able to stand in a comfortable position. Ideally, placement of electrodes should be from above, rather than from the front, to prevent animals from shying away.

Electrodes are more likely to be poorly positioned if the animals are difficult to reach, resulting in increased frequency of ineffective stunning. The use of a counter-balance with manual stunning tongs will reduce operator fatigue, which can also lead to poor positioning of electrodes. The operator must have easy access to controls that will stop the restrainer and release the animal in the event of a problem. There are two types of restrainer: static, where the animal walks into a box to be restrained; or conveyor, which automatically presents a continuous line of restrained animals to the operator.

Static Restrainers

Static restrainers are normally used for larger animals such as adult pigs or cattle. In order to encourage the animal to walk into the restrainer, the gate and far end should not be solid, so that the animal can see ahead. The restrainer should be well lit to encourage the animal to enter, and the stunner operator should be out of the animal's field of vision. An escape gate, close to the entrance to the restrainer, should be provided to allow the animal to be removed from the approach race in an emergency.

When operated, the restrainer gently grips the animal from either one or both sides, or positions the animal with a combination of a neck yoke, static head restraint and rump pusher. If gates or the crush are operated pneumatically, then the pistons should be vented outside the animal handling and lairage area to reduce startling noises, and be set to prevent excessive pressure on the animals.

Restrainer-Conveyors

Restrainer-conveyors are designed and used for high throughputs, especially for sheep and pigs. They can present animals for head-only, head-to-back or head-to-body stunning.

Restrainer-conveyors fall into two categories: either two belts mounted in a 'V' which grip the animal from both sides and carry it to the point of stunning; or a narrow single conveyor to support the belly of the animal.

Animals should be restricted to a single file before entering the conveyor. The drover must also be able to reach the start of the conveyor, from the side, to encourage animals into it without having to lean over others waiting to enter, or having to push those waiting from behind. In case of an emergency, stop buttons should be within easy reach of both the drover and stunner operator, and a procedure must be in place for removing animals from the conveyor in the event of a breakdown.

If electrodes are placed manually, the speed of the conveyor must be such that the animals are presented to the operator at a rate which allows effective stunning to be carried out. Changes in the required throughput of the plant should not compromise the proper stunning of the animals.

Bleeding

Animals can recover fully from head-only stunning which does not stop the heart. Therefore, animals must be bled within 15 seconds of stunning to ensure rapid death. Even if the intention is to kill the animal by cardiac arrest, it is good practice to bleed immediately in case the cardiac arrest is not effective. Timely bleeding is essential, for both animal welfare and meat quality.

Bleeding involves severing the carotid arteries and the jugular veins, or the vessels from which they arise. It is important that all major blood vessels (Figure 17) are cut cleanly to ensure that blood loss is rapid and profuse. It has been shown that for all red meat species, whatever type of electrical stunning is used, the most effective method of bleeding is the chest-stick, which severs all the major blood vessels close to the heart. This achieves rapid initial blood loss and the shortest time to loss of brain function. Sticking should always be carried out with a sharp knife at least 12cm long.

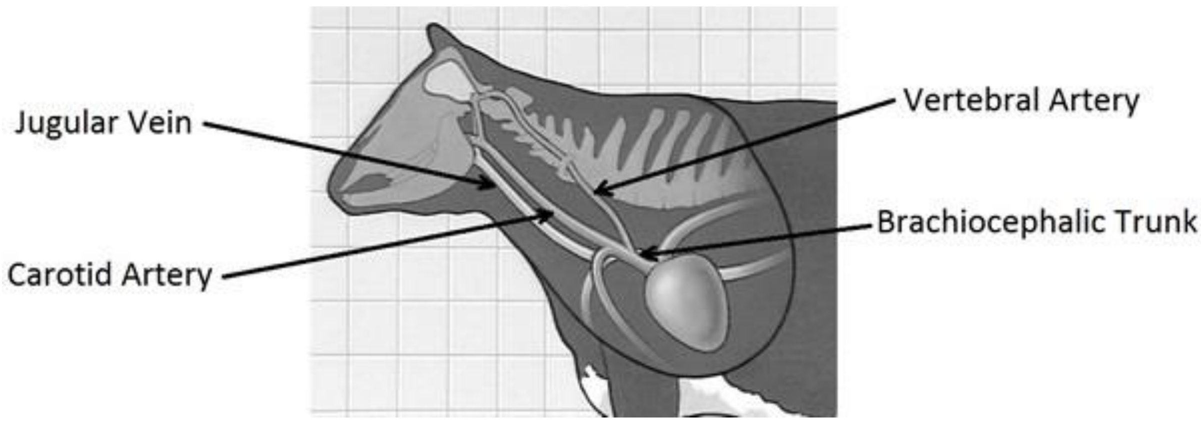


Figure 17 Blood supply in red meat animals

Cattle and Calves

In cattle and calves, blood is supplied to the brain by the major blood vessels of the neck and also by the vertebral artery. The vertebral artery lies close to and above the spinal cord, and will continue to supply blood directly to the brain, even if the major carotid arteries of the neck are cut, provided some cardiac output is maintained.

It is therefore important to stick cattle close to the heart, at the brachiocephalic trunk (see**Figure 17**). Sticking should be carried out by an incision made with a sharp knife in the jugular furrow at the base of the neck, the knife being directed towards the entrance to the chest to sever the major blood vessels close to the heart (Figure 18). In the interest of good hygiene, two knives should be used – the first to open the skin and the second to sever the blood vessels.

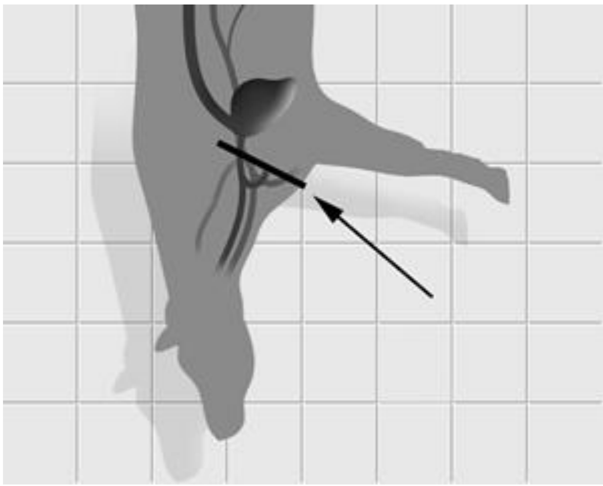


Figure 18 Cattle and calves

Pigs

Pigs should be stuck close to the heart, in a similar position to cattle, to ensure a rapid bleed out. The knife should be inserted into the midline of the neck at the depression in front of the breastbone. The skin should be raised with the point of the knife using light pressure and a lifting movement. When penetration has been made, the knife handle should be lowered, so that the blade is pointing towards the tail of the animal, and pushed upwards to sever all the major blood vessels which arise from the heart (Figure 19). It is important that the length of the incision is adequate to allow rapid blood loss.

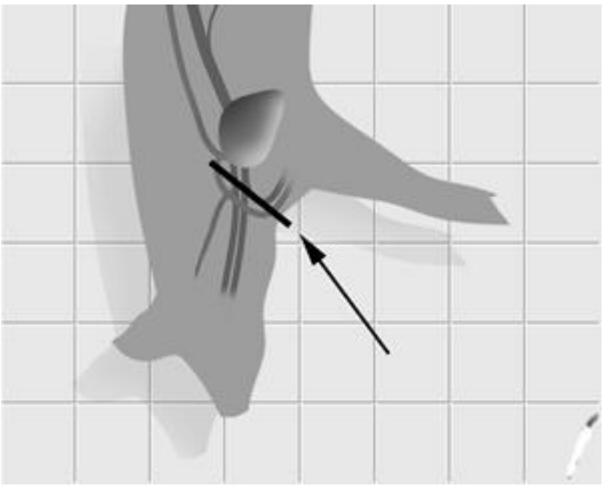


Figure 19 Pigs

Sheep and Goats

For a rapid bleed out, it is recommended that sheep and goats should be stuck close to the heart in a similar manner to pigs (Figure 20, position 1). Alternatively, sticking may be performed by making a deep, transverse cut across the throat close to the head (Figure 20, position 2), to sever the four major blood vessels in the neck (Figure 21). This is only acceptable in sheep and goats because there is no direct blood supply from the vertebral artery to the brain.

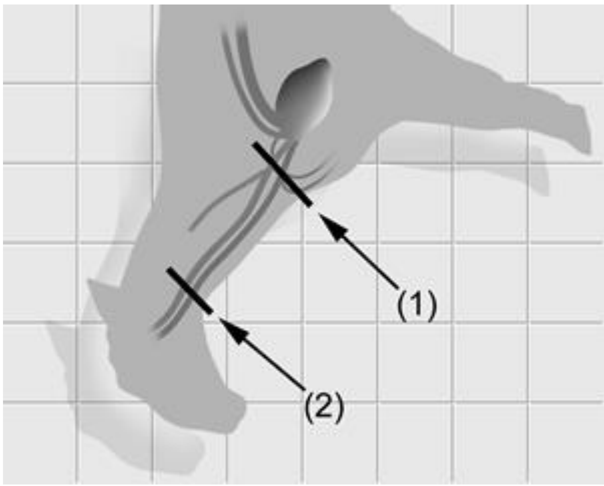


Figure 20 Sheep and goats

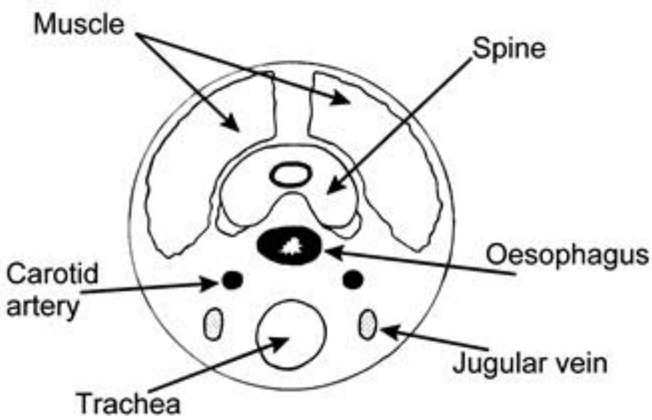


Figure 21 Cross-section of neck

Animals should be bled as soon as possible after stunning, ideally during the tonic phase. At this stage the body is rigid, making sticking easier and safer. When using a transverse cut across the throat, it is essential that both the carotid arteries and both jugular veins are effectively cut.

Safety and Maintenance

In the EU, manufacturers of stunning equipment are required by law to provide instructions for the safe and proper use and maintenance of the equipment; manufacturers' instructions must always be followed.

All electrical stunning equipment is potentially dangerous to staff. The equipment should only be used by properly trained, skilled individuals. Particular care should be taken of the equipment, with regular checks and maintenance carried out by a qualified electrician. All electrical stunning equipment should work by the use of an isolated circuit, in which current flows preferentially between the two electrodes; nevertheless, if a person contacts the electrodes there is a danger of a fatal electric shock.

Safe Operation

- Use safety switches or triggers so that the current only flows when the switch is held down by the operator.
- Do not tape switches down so that the electrodes are permanently live.
- Have a pre-set timer which regulates the duration of the current flow. With some models of equipment the voltage returns to a low level between each stunning episode. This low voltage is used for immediately sensing the resistance between the electrodes and, once detected as within pre-set limits, the stunner switches instantly to the higher stunning voltage which is applied for the pre-set duration.
- House the control box in a separate area which is always kept dry.
- Inform operators, via warning lights, of the state of the equipment, e.g. ready, stun on, stun complete etc.

Cleaning and Storage

- Electrodes should be cleaned regularly to ensure that there is minimal contact resistance. Clean with a wire brush, a powered wire wheel, or place the electrodes in a cleaning station, after every 20-25 animals.
- When not in use, tongs should be stored in a dry environment with the electrodes protected from damage.
- Between stunning operations and/or when filling pens, tongs should be seated on a mounted wall-bracket, or in a cleaning station.

Summary

Head-only Stunning

Inspect and test equipment regularly

Keep a back-up captive-bolt to hand

	
1.3 Amps	1.0 Amps

Stun time not less than **3 seconds**

Phase	Duration	Visible Signs	Action
Tonic	10 to 20 seconds	• Body becomes rigid • No rhythmic breathing • Head raised • Hind legs flexed into body	• Stick during this phase if possible
Clonic	15 to 45 seconds	• Involuntary kicking or paddling • Relaxation	• Stick immediately

Recovery	30 to 60 seconds	• Resumption of normal rhythmic breathing • Responds to painful stimuli • Becomes visually aware • Attempts to stand	• Stun with captive-bolt and stick immediately

Stick within **15 seconds** of stun

Average time to irreversible loss of brain responsiveness after effective sticking	
Pigs: 18 seconds	Sheep: 14 seconds