



SUMMARY

This paper is divided into two parts. The first part considers how captive bolt stunning should be performed in cattle. The second part gives practical recommendations on how to apply and assess electrical stunning in sheep, pigs and calves. Some of the carcass quality problems associated with particular stunning methods are outlined, along with ways of reducing their severity.

CAPTIVE BOLT STUNNING

The Principles of Penetrating Captive Bolt Stunning

Cattle are stunned by the energy that the bolt imparts to the head. The main factors determining the energy delivered by the bolt are its velocity and its diameter. The penetration of the bolt into the brain does not cause unconsciousness on its own; it is the energy delivered to the animal's head that is all important. The captive bolt does not immediately kill the animal. The heart can carry on beating for many minutes after the stun, although it will eventually stop.

Causes of Ineffective Operation of Stunning Guns

Insufficient air pressure in pneumatically fired guns, underpowered cartridges for the size of animal and poor maintenance of the gun all contribute to reduced velocity and bad stunning. For guns powered by cartridges, the size of the expansion chamber for the exploding gases is critical in determining the velocity of the bolt (Figure 1). The smaller the chamber size, the greater the potential velocity of the bolt. If a gun is corroded or contains a build up of carbon, the bolt will not seat back properly, and the expansion chamber will be enlarged. The power of the gun will be correspondingly reduced.

If the tip of the bolt is protruding from the muzzle more than the usual distance then the gun needs cleaning. Instructions on how to clean a particular make of gun should have been supplied when the gun was purchased. Contact the supplier if the cleaning instructions cannot be found, or if specific cleaning tools are necessary for your particular make and model of gun.

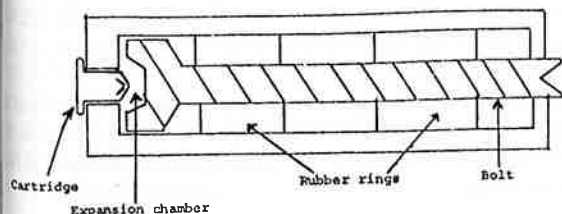


Figure 1. Cut away diagram of bolt end of a stunner, showing the expansion chamber, bolt and rubber compression rings.

Shooting Position

Research and practical experience have shown that the shooting position on the animal's head is important. The front of the animal's brain is situated along an imaginary line drawn between the rear margin of its eyes. Ideally the shot should be at the crossover point between two lines, each drawn between one of the eyes and the base of the horn on the opposite side of the head. This is called the frontal position, and there is an increased likelihood of poor stunning with any shot that is placed more than 2 cm from this point.

It is possible to stun an animal effectively by penetrating its brain from behind the head (the poll position). However, the chances of a good stun are reduced and so it is not generally recommended. If the poll position is used, it is essential that the

bolt is directed forward towards the brain and not downward into the spinal cord.

In order to shoot in the frontal position, the slaughterman must be able to stand alongside or in front of the animal's head. The design and layout of the stunning pen and slaughterman's platform are important in this respect. Restraining the head of the animal offers many advantages for applying an accurate stun, but, when it is used, the animal should be stunned as soon as the head is held. Do not leave a conscious animal locked in the head restrainer.

Stun-stick Duration

Theoretically, it is not necessary to stick an animal that has been stunned with a penetrating captive bolt stunner. However, there are many practical reasons why an animal should be stuck after stunning. As a general guideline, it is best to stick within two minutes of stunning.

PERCUSSION STUNNING (Mushroom-headed guns)

The Principle of Percussion Stunning

The exact way in which a blow to the head causes unconsciousness is not known. However, it is believed that the acceleration of the head at impact is critical. The velocity of the percussion bolt must be sufficient to produce this acceleration of the head of the animal. Thus, as with penetrating bolt stunning, the velocity is important in determining stunning effectiveness. Only the frontal position should be used with these guns.

Because of the possibility of recovery of consciousness following a percussion stun, it is desirable that the stun to stick interval be less than 30 seconds.

New Developments

There is a new type of non-penetrating percussion stunner on the market which replaces the Cash Knocker. It is called the Cash Magnum Knocker, and it is generally more effective than the previous Knocker. When correctly applied, it can be as effective as a penetrating captive bolt stunner.

ASSESSING THE EFFECTIVENESS OF A CAPTIVE BOLT STUN

When an animal is properly stunned, it immediately collapses to the floor with its hind legs flexed into the body. The forelegs may also be drawn in, but they straighten after a short period of time. The muscles of the body are contracted and the back is usually arched. If the body is relaxed, or if the animal makes kicking or paddling movements immediately after stunning, or if it shows signs of trying to stand up, it has not been stunned properly. Some kicking may set in after the initial muscle contraction phase. This is not a bad sign from the humane point of view, provided the animal has gone through the contracted (tonic) phase.

The animal should not show regular rhythmic breathing movements after it has been stunned. These are best observed by looking at the animal's flank, and if they occur, the animal should be reshot. However, one should be careful to distinguish between normal rhythmic breathing and gagging where the animal makes erratic inspiratory gasps. Gagging indicates a dying brain.

Touching the eyes or eyelashes should not produce any response, the eyes should have a fixed and glazed appearance, and they should not be rolled down into the head. Good stunning also produces relaxation of the jaw muscles. This can be tested

either by prising the jaws apart by hand or by watching for the tongue to hang out of the mouth when the carcass is hoisted.

In summary, the major indicators of an effective captive bolt stun are:-

- the animal must collapse immediately
- it must not attempt to get up
- rhythmic breathing must stop
- the eye must have a glazed appearance.

SAFETY ASPECTS

Most guns are fitted with synthetic rubber rings around the bolt. These stop the bolt after its maximum extension and return it to the breach. They should be replaced at regular intervals (usually every 4,000 shots). If this is forgotten, there is a danger that the bolt will eventually shear. When this happens the gun is potentially dangerous to all staff working in the area.

Special care is required with contact firing guns. These have to be struck against the animal's head in order to get them to fire. If they are dropped on the floor or struck against the stunning box wall, the whole gun can become a dangerous missile.

Carcass kicking is a hazard when slaughtering large stock. Unfortunately, hindleg kicking can occur when brain function is depressed, so it happens even when animals are well stunned. The best way of getting around the problem is to shackle and hoist soon after stunning, whilst the hindlegs are still doubled up into the body (in flexion).

DO'S AND DON'TS

Do: - shoot in the frontal position

- use a gun and cartridge which is recommended for the size of animal (or, if using a pneumatic stunner, use the recommended air pressure).
- check the animal is stunned before proceeding to the next one.
- keep a spare loaded gun near the stunning pen in case of a poor stun.
- clean, check and maintain the parts of the stunner daily.

Don't: - continue with your existing stunner if it consistently results in repeat shooting.

ELECTRICAL STUNNING

Recommendations

Research has produced recommendations on the current and voltage necessary to produce epileptic activity in the brains of sheep, calves and pigs. It is widely accepted that animals will be unconscious during the epilepsy, and so applying these standards in abattoirs should ensure that the animals are effectively stunned.

Head Only (Reversible) Stunning

The minimum current and voltage required to produce epilepsy in 98 per cent of lambs, calves and pigs are shown in Table 1. These values were obtained using scissor-type stunning tongs applied for 3 seconds. They are recommended as minimum values for use in commercial abattoirs. However, the estimate for lambs is based on a breed which does not have a very woolly head. For woolly headed animals and adult sheep it is better to use higher voltages (200V or more) in order to achieve 0.5 amp. It is possible that when lower currents and voltages than those shown in Table 1 are applied for longer than 3 sec that the animal will be adequately stunned, but further research is required to clarify this point.

Table 1. Minimum current and voltage required to stun 98% of lambs, calves and pigs when using scissor-type head only tongs

Species	Minimum recommended current (amp)	Approximate voltage (volt)
Lamb	0.5	160
Calf	1.0	115
Pig	1.3	240

The currents listed in Table 1 will not kill an animal, they will only stun it. It is important to ensure a rapid death and so avoid resumption of consciousness, and this is best achieved by sticking promptly. As a general guideline sheep and pigs should be stuck within 15 seconds of stunning, and calves should be stuck within 10 seconds. A practical advantage of sticking as soon as this is that the animal's body will still be in the rigid (tonic) phase after the stun, and so it can be stuck before it starts kicking. It is also important to stick accurately. With gash (ear to ear) sticking, both common carotid arteries must always be cut. With thoracic (chest) sticking the aorta or brachiocephalic trunk must be severed.

Cardiac Arrest Stunning Methods

When this method is correctly applied it will stop the animal's heart and hence kill it. From the humane point of view it becomes less important to stick soon after stunning, but one must stick within 2 minutes in order to achieve a good bleed out.

The electrodes must be applied so that they span both the brain and the heart. The front electrodes must not be placed on the neck. Ideally they should be in line with the rear margin of the eyes. The rear electrode should be placed on the back at about the last two ribs. If the distance between the electrodes is too short, then the heart will not be spanned and cardiac arrest will not occur at stunning. Head to leg and head to brisket electrode arrangements can also be used to achieve a cardiac arrest stun. The electrodes and the application sites must be wetted to ensure good electrical contact particularly in sheep, and to avoid skin burns.

Cardiac arrest stunning causes the death of the animal at the time it is stunned and so there is little likelihood of it regaining consciousness. There are some commercial advantages from stopping the heart. For instance the expression of blood splash and bruises that are inflicted near to stunning can be reduced. In addition it will provide a quieter carcass that shows less kicking and is easier to handle.

The currents and voltages that will produce epilepsy and a cardiac arrest with head to back stunning are shown in Table 2. When these currents are used the electrodes should be applied for 3 or more seconds.

Table 2. Current and voltage required to stun lambs and pigs and induce a cardiac arrest when using head to back electrodes

Species	Recommended current (amp)	Approximate voltage (volt)
Lamb	1.0	375
Pig	1.3 (minimum)	250 (minimum)

ASSESSING THE EFFECTIVENESS OF A STUN

There are two approaches to assessing the effectiveness of electrical stunning. First the animal's physical behaviour can be examined from stunning through to the time it bleeds out. However, only a limited amount of information can be obtained from this. The second approach, which is equally if not more important, is to test the efficiency of the electrical stunning equipment.

Checking the Stunning Equipment

Ideally tests should be made on the current applied to the animal when it is being stunned. The value should be not less than the appropriate recommendation given in Table 1 or 2. To measure the current an animal receives, an ammeter or current measuring circuit has to be inserted in series with the stunning circuit, and this means that the circuit has to be interrupted in the stunning control box. There are two alternatives to this procedure; (i) if the stunning equipment delivers a current at a constant voltage, the voltage can be measured across a dummy load of between 100 and 400 ohm resistance. The measured voltage under this load must be greater than that shown for the relevant application in Table 1 or 2, (ii) if the stunning equipment operates on a constant current or current limited system the current must be measured in series with a standard resistor of between 100 and 400 ohm. The measured current under this load should be greater than the appropriate current shown in Table 1 or 2. It is important to ensure that the resistor is capable of tolerating the stunning current without burning out and that the circuit is switched off when the resistor is being connected to the stunning electrodes.

Symptoms of an Electric Stun

When a stunning current is applied to an animal it goes rigid. During the rigid (tonic) phase the head becomes raised and the hind legs are flexed into the body. The forelegs may be flexed to begin with and then gradually straighten out during the tonic phase, but the presence of flexion depends on the species and current that are used. Overall rigidity in the animal normally lasts for 10 to 20 seconds and it is best to stick whilst it is in this phase and before the kicking phase sets in. If the animal shows paddling or kicking movements with its legs as soon as the stunning current stops, it is possible that the animal is not properly stunned.

The normal kicking (clonic) phase usually follows on from the tonic phase and lasts for between 15 and 45 seconds.

The presence of a tonic and clonic phase in this sequence is taken to be a sign that the animal has been effectively stunned. There is no point in trying to assess any reflexes during these phases as the animal is convulsing and no meaningful results will be obtained. The clonic phase is usually less pronounced following head to back stunning than with head only stunning.

At the end of the clonic phase a quiet period sets in, by which time the animal will have started to breathe. It is from this point onwards that the animal will start to regain awareness of its surroundings. A simple test that can be carried out in the slaughterhouse is to watch the animals' flanks for normal or rapid rhythmic breathing movements. The movements should be distinguished from gagging where the animals make erratic respiratory gasps. Gagging movements are an indication of a dying brain and they have a lower frequency than normal breathing movements.

INTERRUPTED STUNNING

When stunning electrodes are applied to the animal it must become rigid instantaneously. If it escapes from the electrodes or if the initial contact is insufficient to produce rigidity the animal becomes distressed and struggles which in turn makes it more difficult to apply the electrodes. If a particular electrical stunning method persistently leads to such interrupted stunning, it can be improved in one of the following ways. Either the presentation of the animal to the slaughterman can be improved so that the electrodes are placed more accurately and more firmly, or the equipment can be improved to help it overcome the electrical resistance of the animal and the electrodes.

Every experienced slaughterman will have a preference for the way an animal should be presented for stunning, but a few general tips can be made which may prove useful in evaluating the system:

- It is easier to apply electrodes accurately if the slaughterman does not have to support too much of his weight at the time he makes the application. For example, it is usually easier to apply electrodes downwards instead of horizontally.
- Once the electrodes are positioned it is easier to apply pressure onto the animal if the electrodes are relatively heavy. This applies particularly for the scissor and head to back electrodes.
- It is easier to place electrodes accurately if the animal is restrained instead of free-standing on the floor.
- Head to back electrodes can be applied with greater pressure and accuracy if they are held in both hands.
- The slaughterman should not have to bend his back each time he applies the electrodes, otherwise it becomes tiring and this can lead to inaccurate application.
- The slaughterman should not have to concentrate on keeping his balance when he is applying the tongs.

The electrical resistance between the electrodes and the animal can be reduced in the following ways:

- Wetting the application sites on the animal before the electrodes are applied.
- Wetting the electrodes. This will improve the electrical contact with the animal and help to reduce the build up of carbon on the electrodes.
- Regular decarbonising of dry electrodes, eg. with a powered rotary wire brush situated alongside the stunning position.
- Increasing the effective surface area of the electrodes.

SAFETY ASPECTS

All electrical stunning equipment is potentially dangerous to staff if it is misused. Protection is given in different ways, including:

- Stunning with an isolated circuit, in which current flows preferentially between the two electrodes. Nevertheless if a human comes between both electrodes or touches one electrode whilst he is well earthed he can get a potentially lethal shock. It is essential that the safety procedures recommended by the equipment manufacturers are closely followed.
- Using safety switches or triggers. Never tape the switches down so that the electrodes are permanently live.
- Having a pre-set timer which regulates the duration of stunning current flow. With some makes of equipment the voltage returns to a low level between each stunning episode. The low voltage is used for sensing the resistance of the animal, and once this is detected the stunner switches to the higher stunning voltage and is kept there for a set duration.
- Housing the control box in a separate area which is always kept dry.
- Using spring mounted electrodes which have to be pressed against the animal or an object to allow current flow.

COMMERCIAL PROBLEMS

Electrical stunning in pigs can lead to broken shoulder blades, especially when they are stunned whilst free-standing on the floor. These breaks usually occur when the animal's forelegs make sudden impact with the floor at the start of stunning. This sends a shock wave up the leg and causes a complete fracture at the neck of the shoulder blade. A star-like fracture also occurs at the cup end of the shoulder blade where it butts onto the humerus. The problem can be avoided by lifting the pigs off the floor at stunning, for example by using a V restrainer.

Broken vertebrae can occur in pigs stunned with head to back tongs if the voltage is too high. Present experience suggests that a satisfactory stun with a minimum of fractures is obtained when using 1.3 amp. These fractures are not usually associated with much bleeding if the heart is stopped at stunning since this stops the pump which would otherwise force blood out of the ruptured vessels. In a similar way, inducing a cardiac arrest at stunning will reduce the expression of bruising inflicted either

immediately before stunning or between stunning and sticking.

Cardiac arrest stunning will help to produce a relaxed carcass which is easy to handle. It can however produce pelt burn in sheep if insufficient water is used at the back electrode. Burning of the skin may not be evident in the fresh pelt but it can become noticeable after tanning.

Blood speckle in the fat of the carcass can also be associated with head to back stunning. It can look like a firey rash at the site where the rear electrode was applied, or like a mild wool-pull bruise. The latter can occur anywhere along the side or back of the carcass, and is due to the wool being pulled between the sheep's body and the restrainer as the animal goes into a spasm.

Blood splash can be a problem with head only electrical stunning systems in lambs. There are three ways of reducing its incidence. Either by sticking very quickly after stunning, thus minimising the time available for blood to leak through the ruptured vessels, or by changing to the captive bolt gun or cardiac arrest stunning. In the case of pigs, this problem is best avoided by using a cardiac arrest stunning method.

Cardiac arrest stunning does not lead to poor bleeding in pigs provided they are stuck within 2 minutes. In sheep, the initial bleed out looks poor and the reason for this is that some blood is retained in the larger blood vessels of the chest and abdomen, especially if the carcass is bled horizontally. This blood will leave the carcass when the pluck is removed or it can be encouraged to drain out earlier if the carcass is either tilted or suspended by a hindleg. No extra blood is retained in the meat of the carcass.

In conclusion, correct application of the voltage or currents recommended in this report should provide a humane stun. As with all other stunning methods they are not totally free from certain carcass quality defects, but these can usually be kept at a low level.

