



# Captive-Bolt Stunning of Livestock

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](http://www.hsa.org.uk)

## Introduction

Around the world, billions of animals are reared for food. It is important that the slaughter of these animals is carried out in a way which causes no avoidable pain or suffering. Over the years this has led to the development of specialist equipment and techniques which kill animals humanely. The captive-bolt stunner was one of the first pieces of equipment to be developed, becoming commercially available in the UK in 1922. Today, having undergone modification and improvement, it remains one of the most versatile pieces of stunning equipment, both within abattoirs and out in the field. It is now used throughout the world, in countries where the principles of humane killing have been widely accepted. Although the captive-bolt is used mainly for stunning cattle, sheep and goats, it is also employed to a lesser extent for pigs, horses and farmed deer. Captive-bolt stunning equipment has also been developed for poultry; information on captive-bolt stunning of poultry can be found in the online guide titled

**'Practical Slaughter of Poultry - A Guide for the Smallholder and Small-Scale Producer'**, produced by the HSA.



The humane killing of livestock with captive-bolt equipment is a two-stage process. First, the animal must be effectively stunned, rendering it immediately insensible to pain. Second, the major blood vessels in the neck or thorax are cut, or pithing is performed. The animal then dies from a lack of oxygen to the brain, caused by loss of blood, or by destruction of the brainstem. It is important to remember that the captive-bolt is a humane stunner and the stun must always be followed immediately by bleeding or pithing. The animal must remain unconscious from the initial stun until death occurs. Whilst it may appear that captive-bolt stunning is a straightforward procedure, great care must be taken in its operation, as both operator error and equipment failure will severely compromise animal welfare.

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These guidance notes explain how captive-bolt stunning works, how the equipment should be used and maintained, and highlights the associated animal welfare implications. They will be of particular value to anyone using, or supervising the use of, captive-bolt equipment.

### **Important Points About This Guide**

**This guide is intended to instruct operators in the proper and humane use of captive-bolt equipment for the slaughter and killing of cattle, pigs, sheep, goats, deer and horses. 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.**

Captive-bolt 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 operation of this type of equipment, you should consult the manufacturer. In no circumstances can the Humane Slaughter Association (HSA) accept any liability for the way in which captive-bolt stunning equipment is used, or any loss, damage, injury or death caused thereby, since this depends on circumstances wholly outside the HSA's control.

For information regarding captive-bolt 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 concussion 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](mailto:info@hsa.org.uk) or using the contact details provided at the [HSA Website](#).

A [Paperback Version Of This Guide](#) (published 2006) is also available to purchase at a cost of £7 (including postage).

## Percussive Stunning

The primary objective of captive-bolt stunning is to induce immediate insensibility by administering a severe blow to the skull of the animal. The animal must then remain unconscious until it dies as a result of bleeding or pithing. The term 'percussive' describes the principal action of the captive-bolt, i.e. the forcible striking of one solid body against another.



The first percussive instrument specifically designed to stun animals was the pole-axe, a crude implement which relied on the strength and skill of the slaughterman to be effective. The subsequent development of the captive-bolt, at the beginning of the last century, mechanised the stunning operation, making it a more humane procedure. The earliest designs of captive-bolt equipment all involved some form of penetration of the skull, as it was believed that the physical damage to the brain was important.

However, it was soon realised that sufficient concussive forces alone would cause insensibility. This led to the development of stunners which deliver a non-penetrative blow to the animal's head. Today, captive-bolt stunning equipment falls into two broad categories: non-penetrative and penetrative. These will be discussed in detail later.

NOTE: Firearms which discharge free projectiles are also percussive in action. But are used to kill rather than stun.

## Physiological Effects of Percussive Stunning

When a sharp, heavy blow is correctly applied to the skull it produces a rapid acceleration of the head, causing the brain to impact against the inside of the skull. There is disruption of normal electrical activity resulting from sudden, massive increase in intra-cranial pressure, followed by an equally sudden drop in pressure. The consequent damage to the nerves and blood vessels causes brain dysfunction and/or destruction, and impaired blood circulation. The duration of insensibility depends on the severity of damage to the nervous tissue and the degree to which the blood supply is reduced. In addition, there may be physical damage to the skull or brain according to the type of stunner used, i.e. penetrative or non-penetrative.

The initial effect on the animal is immediate unconsciousness accompanied by what is known as 'tonic' activity. The animal collapses, stops breathing and becomes rigid, with its head extended and its hind legs flexed towards the abdomen. This period of rigidity normally lasts for 10 to 20 seconds following stunning. The forelegs may be flexed initially and then gradually straighten out. However, this depends on the species and the severity of the blow. This tonic activity is followed by a period of involuntary kicking movements which gradually subside. If an animal immediately shows paddling or kicking movements on collapse, it is almost certain that it has not been effectively stunned and it should be re-stunned immediately.

An effective stun can be defined as one which renders the animal immediately unconscious and insensible to pain. The animal collapses, exhibiting exaggerated tonic activity followed by gradual relaxation and involuntary kicking movements. Once the animal is stunned it must be bled or pithed without delay.

The Physical Signs of an Effective Stun are:

- Animal collapses
- No rhythmic breathing
- Fixed, glazed expression in the eyes
- No corneal reflex
- Relaxed jaw
- Tongue hanging out
- 

## Physics

A knowledge of basic physics helps to understand how a severe blow to an animal's skull will induce immediate unconsciousness. During stunning there is a transfer of kinetic energy (the energy of movement) from the travelling object, i.e. the captive-bolt, to the animal's head and from there directly to its brain.

*Effective percussive stunning is achieved by delivering the maximum amount of energy to the correct part of the animal's brain in the shortest possible time.*

Kinetic energy (KE) is proportional to the mass (m) of the bolt and its velocity (v). this relationship is expressed by the following formula:

$$KE = \frac{1}{2}mv^2$$

An example of the above relationship is shown in Table 1. Kinetic energy is expressed in joules (J), mass is expressed in grams (g) and velocity in metres per second ( $ms^{-1}$ ). In this example the mass of the bolt is 150g and the amount of energy required for an effective stun is 130J.

**Table 1**

|                        | Velocity of bolt      |                         |
|------------------------|-----------------------|-------------------------|
|                        | 50 $ms^{-1}$          | 30 $ms^{-1}$            |
| Mass of bolt           | 150g                  | 150g                    |
| KE = $\frac{1}{2}mv^2$ | 187.5J                | 67.5J.                  |
| <b>Result</b>          | <b>Effective Stun</b> | <b>Ineffective Stun</b> |

It is the velocity of a moving object, rather than the mass, which has the greatest effect on its kinetic energy. If the velocity of the bolt is reduced, its ability to stun an animal effectively will be impaired. Regular and thorough cleaning of captive-bolt equipment is of paramount importance (see pages on [Maintenance](#) and [Troubleshooting](#)).

## Equipment

Captive-bolt stunners are comprised of a steel bolt, with a flange and piston at one end, which is held in the barrel. The piston fits tightly into the breech and the bolt is free to move forwards and backwards within the barrel. On firing, the expansion of gases, produced by the explosion of charge, propels the piston forward (approximately 80mm) and the bolt projects through an aperture in the front of the barrel. The bolt remains captive within the barrel, because the flange at the rear prevents it passing through the hole. The impact of the flange with the front of the barrel is absorbed by either micro-cellular buffers (also known as recuperator sleeves) or a grease collar, according to the type of stunner. There is a wide variety of captive-bolt stunners available (Figure 1).

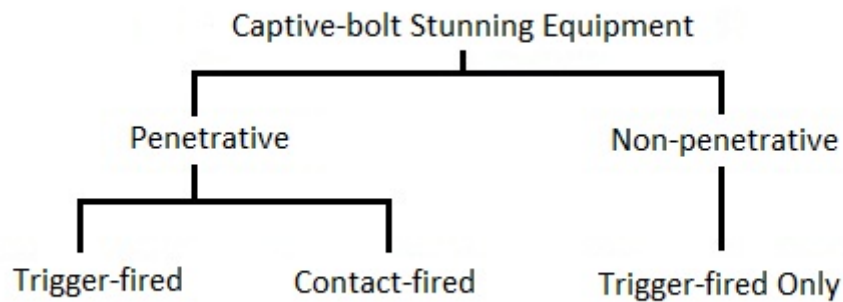


Figure 1 Captive bolt stunning types available

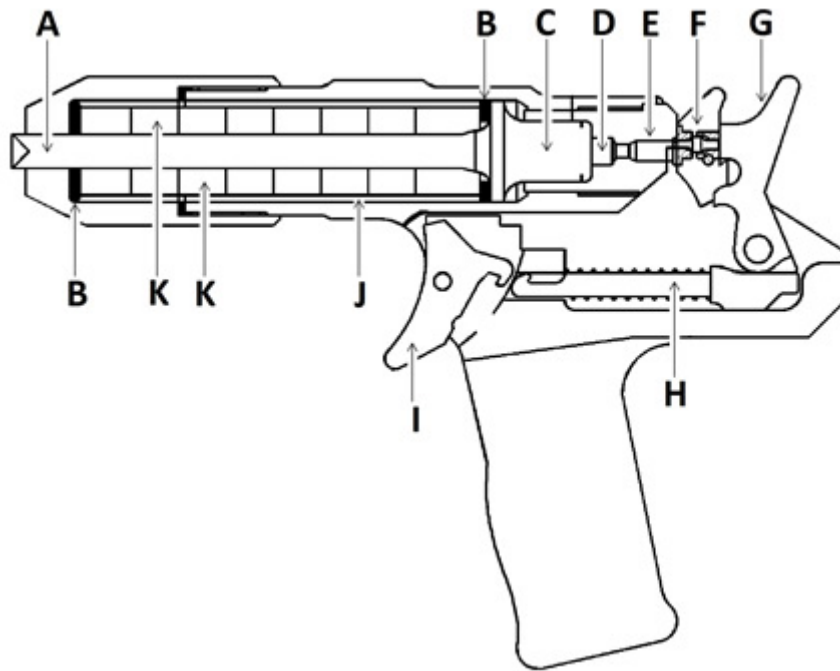
### Mode of Action

Penetrative stunners cause insensibility due to the concussive blow to the skull and the physical damage resulting from the entry of the bolt into the brain.

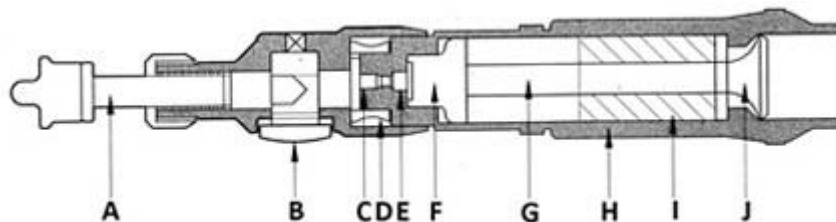
Non-penetrative stunners have a ‘mushroom-headed’ bolt which impacts with the skull but does not enter the brain. This type of stunner causes insensibility due to concussive forces alone. Under EU legislation, non-penetrative stunners are only permitted for use on poultry, rabbits, hares and ruminants less than 10kg liveweight.

### Method of Firing

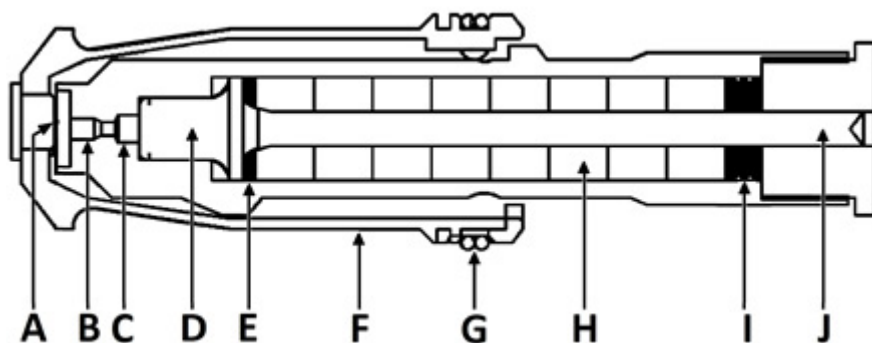
Captive-bolt stunners may be trigger-fired or fired by contact with the animal’s head. Trigger-fired penetrative stunners are the most versatile and can be used on a range of different species in different situations, e.g. in abattoirs, on the farm or in a confined space, such as an aircraft. The trigger mechanism may be a conventional pistol-grip (Figure 2) or a trigger pad on the body of the stunner (Figure 3). Contact-fired captive-bolt stunners (Figure 4) are only suitable for stunning cattle which are restrained in a stunning box; they are not suitable for use outside the abattoir on animals which are not restrained.



**Figure 2: Penetrative, trigger-fired captive-bolt stunner** Key: Bolt (A), Stop washers (B), Flange & piston (C), Expansion chamber (D), Breech (E), Ejector (F), Hammer (G), Trigger mechanism (H), Trigger (I), Undercut (J), Recuperator Sleeves (K)



**Figure 3: Non-penetrative, trigger-fired captive-bolt stunner** Key: Cocking mechanism (A), Trigger (B), Breech (C), Ejector (D), Expansion chamber (E), Flange & piston (F), Bolt (G), Barrel (H), Damper (I), Mushroom head (J)



**Figure 4: Penetrative, contact-fired captive-bolt stunner** Key: Firing pin (A), Breech (B), Expansion chamber (C), Flange & piston (D), Stop washer (E), Cap (F), Retaining band (G), Recuperator sleeves (H), Stop washers (I), Bolt (J)

In the EU, operators must have a Certificate of Competence in order to use captive-bolt equipment for the routine slaughter or killing of livestock. The use of captive-bolt equipment in emergency situations does not require a Certificate of Competence although it is recommended that operators still seek appropriate training for such scenarios.

The law regarding licensing and certification of captive-bolt equipment differs according to the circumstances surrounding their use. Variation is also found within and between nation states. Users of captive-bolt equipment must be familiar with the statutory requirements relating to their particular situations.

## Energy Source

### Cartridge

Cartridges vary in strength and are classified according to the amount of propellant they contain, measured in grains. They range from 1.25 grain for small animals, such as lambs, to 3.0 grain and 4.0 grain for large cattle and mature bulls (1 grain = 0.0648 grams). It is important to refer to the manufacturers' instructions so that the correct cartridges are used for each model of stunner; they are identified by calibre (0.22 or 0.25), colour and headstamp.



Captive-bolt stunners are designed to absorb and withstand high levels of mechanical stress over prolonged periods of constant use. Repeated use of heavy charges on small animals can result in excessive wear on the entire mechanism and premature failure of parts. Similarly, constant use of underpowered cartridges on large animals will result in the mechanism becoming strained and the animals being inadequately stunned. Contact-fired stunners are designed and built to work on a heavy charge only; firing them using smaller charges can lead to inadequate stunning and uneven wear on the equipment. It is therefore essential that the correct cartridge is used for the type of stunner and the size of the animal being stunned.



## Compressed Air

Captive-bolt equipment powered by compressed air is limited to penetrative models designed for stunning cattle and sheep. The principle behind their operation is exactly the same as for cartridge-fired equipment, but the energy is supplied via a high-pressure compressor. With air-powered equipment, a higher throughput of animals can be achieved and less maintenance is required. However, the equipment is heavier and less manoeuvrable than cartridge-fired stunners and the animals must be fully restrained.

Refer to the manufacturers' instructions when choosing which cartridge size or air pressure to use.

## Restraint

Animals are normally restrained to facilitate effective stunning. A variety of devices are in use and the choice will depend on: the species being stunned; the situation (e.g. farm or slaughterhouse); and the number of animals being handled.

## Stun Boxes

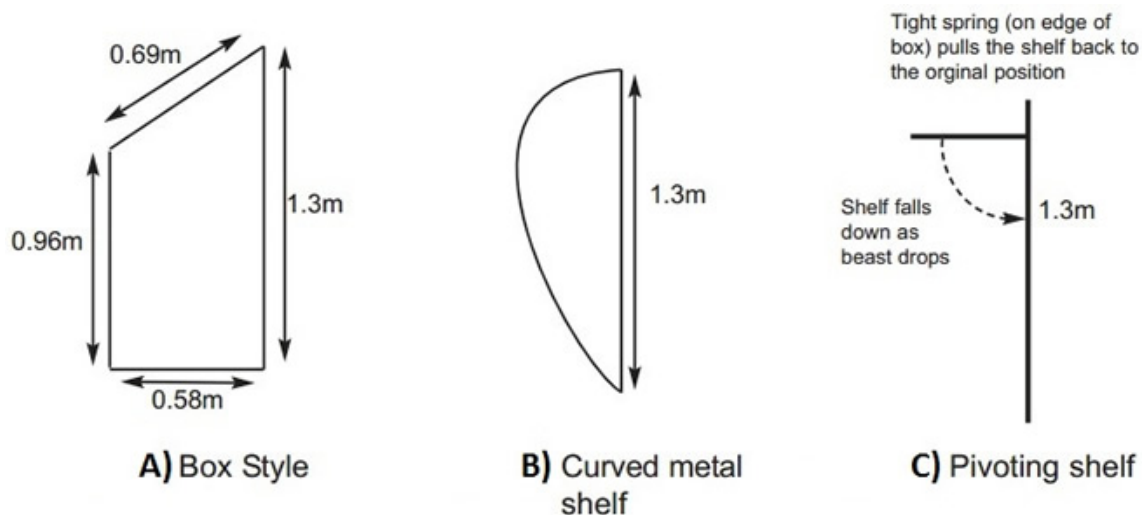
Stun boxes are principally used for restraining cattle in abattoirs. In some countries these are required by law and must limit the movement of the animal, forwards, backwards and sideways. Stun boxes usually have a guillotine door at one end, through which the animal enters, and a side door through which the animal is removed after being stunned. These side doors may be guillotine-type, partly-revolving or fully-revolving.

The law may also require that a head restraint device is fitted within the stun box to help improve the accuracy of stunning. There are two basic types of installation available: 'passive' and 'active'. Whichever system is installed, it should only be operated by appropriately trained and licensed members of staff.

'Passive' head restraints, such as the 'fixed shelf', are fitted at the front of the stunning box. See Figure 5 for visual representation. These prevent the animal from lowering its head, but do not hold the head fast or involve any moving parts. The performance of this type of device is improved if used in conjunction with a tail-push which prevents the animal moving backwards. 'Passive' head restraints are recommended as they improve stunning accuracy without increasing stress on the animal.

'Active' head restraints are of two types. The first is the 'neck yoke' system consisting of one or two vertical bars which grip the animal's neck within the stunning box. The bars then retract against the sides of the box when not in use. The second is a 'head yoke and chin lift' device, which holds the head right outside the stunning box. Both of these devices improve stunning accuracy but are likely to increase stress on the animal.





**Figure 5:** Side views of various passive head restraint shelf designs

### Restrainer-Conveyor

Restrainer-conveyor systems are used in abattoirs for both cattle and sheep. These may either hold the animal between two conveyor belts, set in a 'V' formation, or on a belly-conveyor system where the animal straddles a moving double rail. The speed of the restrainer-conveyor can be varied, according to the type of animal and capabilities of the individual operator. The system is usually operated with a foot pedal. It is important for the animals to be moved quietly and calmly into the restrainer, so that they arrive at the stunning point as relaxed as possible. Restrainer-conveyors must be properly adjusted for the size of the animal being stunned and on no account should any animal be left in a restrainer during breaks or stoppages. Procedures must be in place to enable the restrainer to be easily evacuated in case of an emergency.



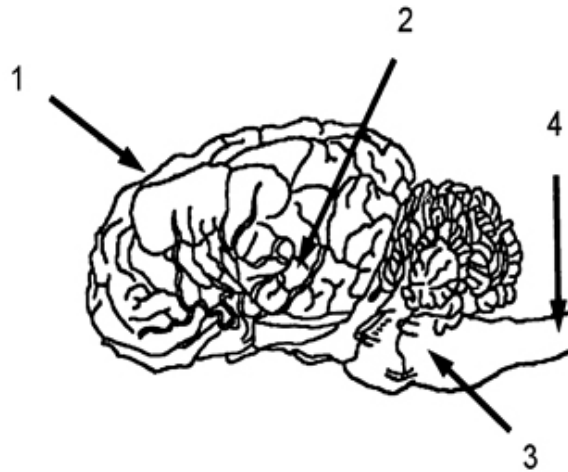
### Field Methods

Ideally, animals should be confined or restrained when captive-bolt equipment is used in the field situation. However, if animals are recumbent this may not be necessary. The aim should be to position the animal so that it can be shot accurately, and will be easily accessible for bleeding or pithing immediately after collapse. Animals can be confined within a small pen or behind a movable gate. Alternatively, the animal can be held with a halter. Individual pigs can be restrained by passing a rope noose around the upper jaw, behind the canine teeth: when the pig pulls back it will be in a position to be immediately stunned.

### Effective Stunning

An effective stun is dependant, amongst other things, on the blow being administered to the correct part of the skull. In order to ensure maximum impact on the brain (Figure 6), the best position is where the brain is closest to the surface of the head and where the skull is at its thinnest. In most

animals this is the frontal region of the head. The ideal position and direction of impact varies between species, within species, and according to whether the equipment is penetrative or non-penetrative. To obtain maximum effect, the muzzle of the captive-bolt stunner must always be held firmly against the head.



**Figure 6: Lateral view of a mammalian brain** Key: Upper brain/cerebral cortex (1), Mid-brain/cerebrum (2), Brainstem/medulla oblongata (3), Spinal cord (4).

### Failure to stun

If an animal is not properly stunned it must be re-stunned immediately. When a captive-bolt enters the skull it causes massive damage and swelling around the wound; the swelling will absorb much of the impact of the second shot and this will mean the shock wave is not as effectively transmitted to the brain. A repeat shot must always be placed so as to avoid the immediate area of the first shot. If the first shot is off target, the second should be placed as close to the correct stunning position as possible. If the first shot is on target but fails to produce an effective stun, the second shot should be above and to one side. If a third shot is required, this should be above and to the other side of the first shot. Once stunned, the animal should be bled or pithed without delay.

### Operator considerations

Experienced slaughtermen will have their own preferences for the way in which animals are presented for stunning. The operator should not have to concentrate on keeping his balance, or have to bend excessively each time he stuns an animal, as this becomes tiring and can lead to inaccurate stunning. Stunning pen and conveyor design is therefore of utmost importance for both animal welfare and the operator's health and safety.

In general, it is easier if the stunning box or restrainer-conveyor presents the animal to the slaughterman's favoured side, i.e. right-handed or left-handed. The system should also be designed so that the slaughterman does not have to bend right over to carry out the stunning operation. However, the sides of a stunning box must be high enough to prevent large cattle jumping out before they are stunned. Alternatively, overhead restraint bars must be fitted.

Where an air-powered captive-bolt stunner is used with a restrainer-conveyor, it should be properly counterbalanced above the stunning point so that it returns to the 'resting' position without the slaughterman having to lift it.

## Positioning

Positioning captive-bolt equipment correctly is essential in order to deliver an effective stun. Incorrect positioning, resulting in an ineffective stun, will cause the animal to suffer pain and distress. The following pages describe the correct positioning for the most common species of livestock to be stunned using captive-bolt equipment.



## Cattle

### Penetrative Captive-bolt

In cattle, the brain is situated high in the head. The ideal stunning position is in the middle of the forehead – at the crossing point of two imaginary lines drawn between the eyes and the centre of the base of the opposite horns (Figure 7a). This should give a position about 70mm,  $\pm 10$ mm, above a line drawn across the forehead at the back of the eyes. The muzzle of the stunner should be held at a right angle to the skull, so that the bolt is directed through the upper brain towards the brainstem (Figure 7b).

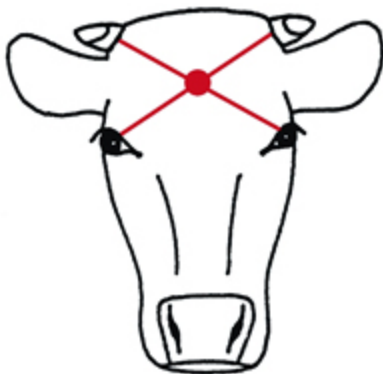


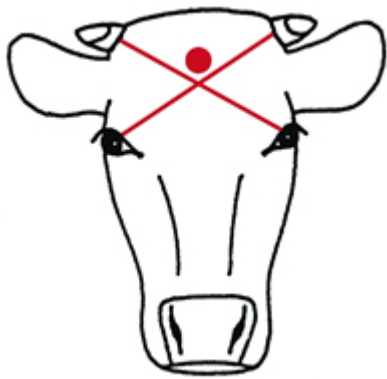
Figure 7a: Stunning position - Penetrative



Figure 7b: Cross-section

### Non-penetrative Captive-bolt

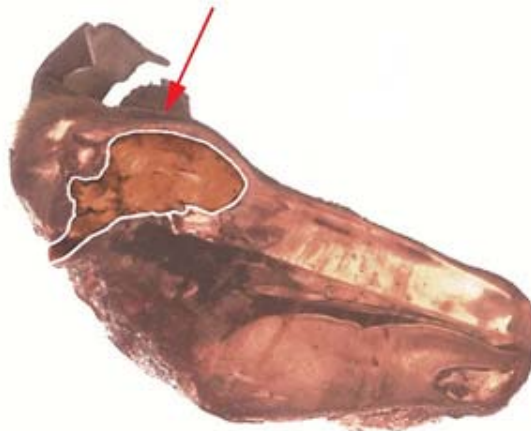
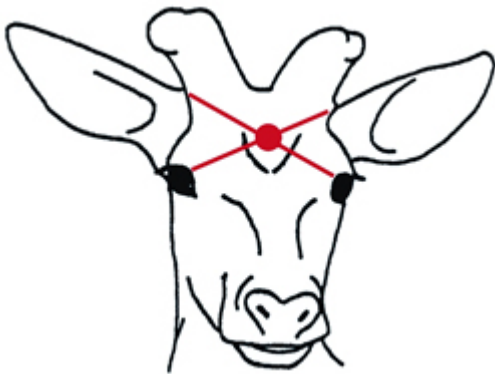
A non-penetrative stunner should be positioned approximately 20mm above the position used for the penetrative captive-bolt (Figures 8a and 8b), and the animal must be bled within 30 seconds. **The use of non-penetrative concussion stunners is not permitted for ruminants more than 10kg liveweight in the EU.**



**Figure 8a: Stunning position - Non-penetrative**      **Figure 8b: Cross-section**

### Deer

In deer, the brain is situated high in the head. The ideal point for stunning is in the middle of the forehead, at the crossing point of two imaginary lines drawn from the eyes to the top of the base of the opposite ears (Figure 9a). In stags, this spot is found between, or in some cases just behind, the antlers. The muzzle of the stunner must be held at right angles to the skull (Figure 9b).

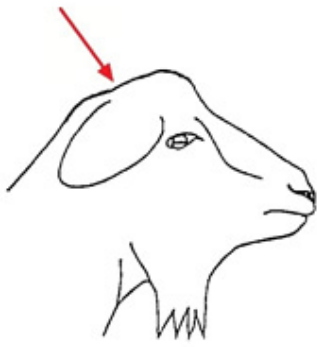


**Figure 9a: Stunning position - Deer**

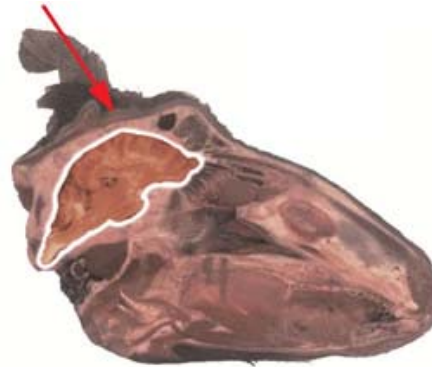
**Figure 9b: Cross-section**

### Goats

All goats should be treated as though they have horns. Therefore, the muzzle of the stunner should be placed behind the bony mass on the mid-line and aimed towards the base of the tongue (Figure 10a). The reason for this is that the large, bony mass on the top of the skull will absorb much of the energy from the bolt and may prevent bolt penetration through to the brain cavity (Figure 10b).



**Figure 10a: Stunning position - Goats**



**Figure 10b: Cross-section**

## Horses

In horses, the brain is situated high in the head. The ideal site for stunning is in the middle of the forehead. Take two imaginary lines drawn from the eyes to the opposite ears; stun the animal approximately 10mm above the point where they cross (Figure 11a). The muzzle of the stunner should be tilted, if necessary, so that the bolt is directed through the upper brain towards the brainstem (Figure 11b).



**Figure 11a: Stunning position - Horses**



**Figure 11b: Cross-section**

## Pigs

Pigs are the most difficult animals to stun with captive-bolt equipment. The target area is very small and this problem can be exacerbated by the 'dish-face' characteristic found in certain breeds and in aged pigs. In addition, relative to other species, the brain lies deep in the head with a mass of sinuses lying between the frontal bone and the brain cavity.

Captive-bolt stunners can be used on most pigs, but it is recommended that the heaviest cartridge available for the equipment is used, and that in all cases the animal is either bled or pithed immediately to ensure rapid death. The site for stunning pigs with a captive-bolt is 20mm above eye-level, on the mid-line of the forehead, aiming towards the tail (Figures 12a and b). The muzzle of the stunner must be placed firmly against the head.



Older sows and boars may also have a ridge of bone running down the centre of the forehead (Figure 12c). This may prevent the bolt penetrating the brain cavity and the pig will not be stunned effectively.

*Due to the problems which might arise with adult pigs it is recommended that, where possible, they are stunned electrically, or destroyed by use of a free-bullet humane killer or a shotgun.*



**Figure 12a: Stunning position - Pigs**



**Figure 12b: Cross-section**



**Figure 12c: Adult pig cross-section**

## Sheep

The correct position for stunning sheep depends on whether the animal is polled (hornless) or horned. For polled sheep, the muzzle of the stunner should be placed on the highest point of the head, and on the mid-line, aiming straight down (Figure 13a and b). For horned sheep, the muzzle of the stunner should be placed on the mid-line, behind the ridge between the horns, and aimed towards the base of the tongue (Figure 13c and d).

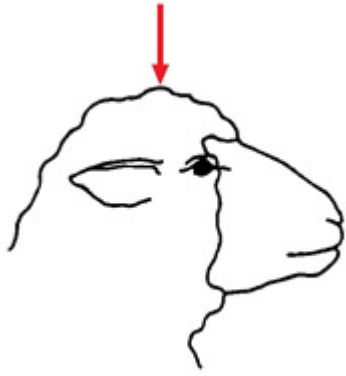


Figure 13a: Stunning position - Polled sheep



Figure 13b: Cross-section

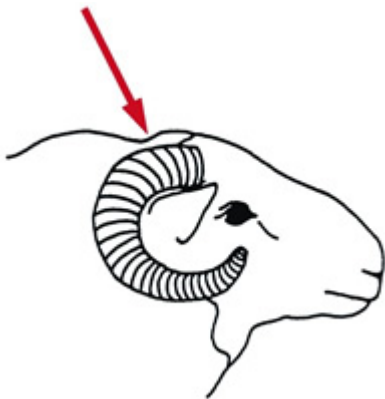


Figure 13c: Stunning position - Horned sheep

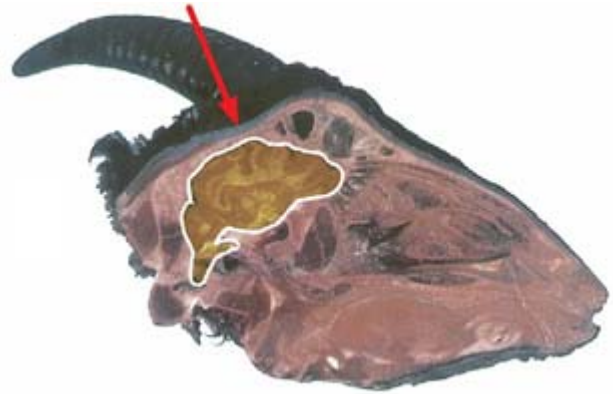
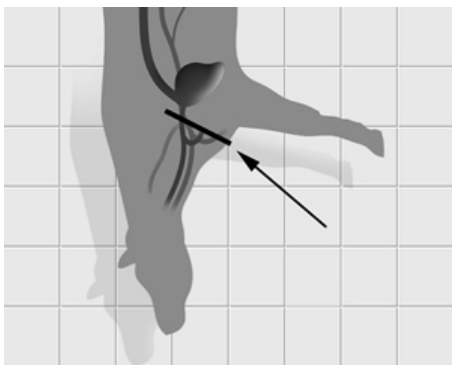


Figure 13d: Cross-section



## Bleeding and Pithing

The humane killing of livestock using captive-bolt equipment is a two-stage procedure. After the animal has been stunned, it must be bled or pithed immediately to ensure rapid death.

### Bleeding

To prevent the risk of recovery, animals must be bled as soon as possible after stunning, ideally whilst still in the tonic (rigid) phase. Bleeding involves severing the carotid arteries and jugular veins, or the blood vessels from which they arise. The animal then dies from loss of blood. It is important

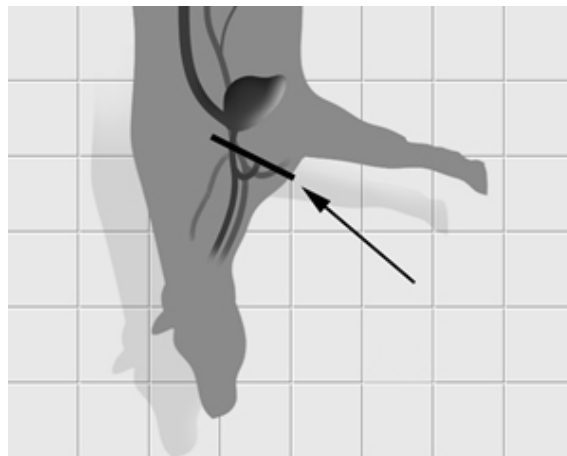


that all major blood vessels are severed. If only one carotid artery is cut the animal may take over a minute to die.

## Abattoir methods

### Cattle, deer and horses

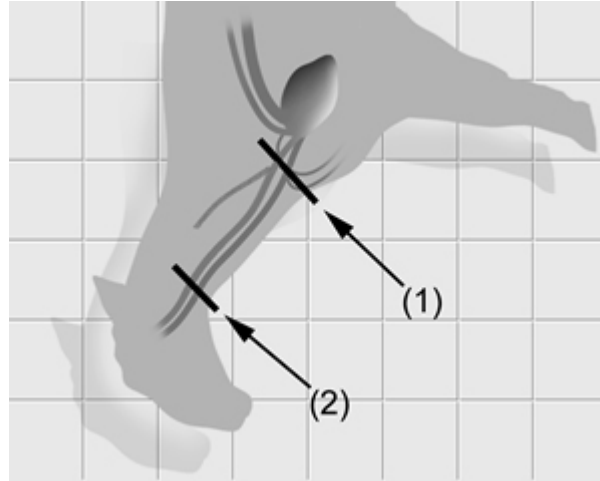
Bleeding should be carried out by an incision made with a sharp knife in the jugular furrow at the base of the neck, the knife being directed towards the entrance of the chest to sever all the major blood vessels arising from the heart (Figure 14). In the interest of good hygiene two knives should be used, the first to open the skin and the second to sever the blood vessels. This procedure is often referred to as 'sticking'.



**Figure 14: Cutting positions when bleeding cattle**

### Sheep and Goats

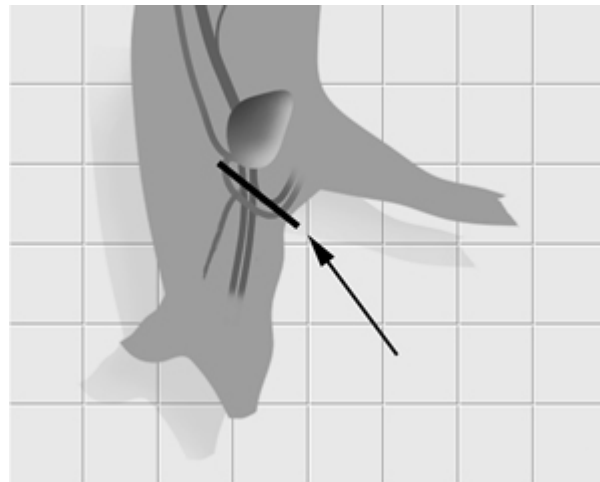
Bleeding may be carried out in a similar way as for cattle (Figure 15 cut position 1) or by an incision made close to the head using a blade at least 120mm long to sever both carotid arteries and both jugular veins, i.e. a cut across the throat (Figure 15 cut position 2). In the EU, the trachea and oesophagus of animals intended for human consumption must remain intact during bleeding, except in the case of slaughter according to a religious custom. An incision at the entrance to the chest must therefore be used (Figure 15 cut position 1).



**Figure 15: Cutting positions when bleeding sheep**

### Pigs

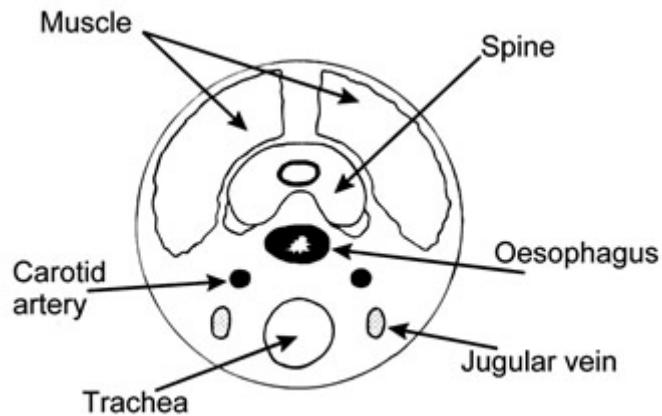
A knife at least 120mm long should be inserted in the mid-line of the neck at the depression before the breast bone, and the skin raised with the knife point using light pressure and a lifting movement. When penetration has been made, the knife handle should be lowered so that the blade is in a near-vertical position, and pushed upward to sever all the major blood vessels which arise from the heart (Figure 16).



**Figure 16: Cutting position when bleeding sheep**

### Field methods

In the field situation, the most practical method of bleeding is to make a deep transverse cut across the animal's throat at the angle of the jaw. Cut deeply, severing the blood vessels, trachea and oesophagus, until the blade of the knife touches the spine (Note: animals bled using this method will not be permitted for human consumption in the EU. There should be two powerful jets of blood from the carotid arteries, and a flow from the jugular veins (Figure 17). The heart may continue to pump until the carcass is exsanguinated. To carry out this task effectively, the operator needs a sharp knife with a blade at least 120mm long.



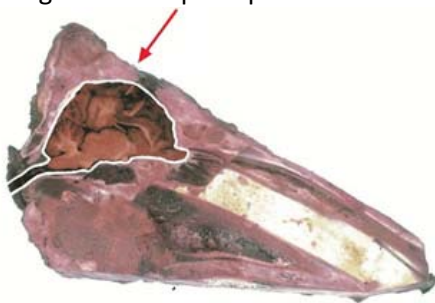
**Figure 17: Cross-section of neck**

### Stun-to-stick intervals

The stun-to-stick interval is the time from application of stunning equipment to the start of bleeding. A maximum stun-to-stick interval of 15 seconds is recommended for all species in the field. In the abattoir, all pigs, sheep and goats should also be stuck within 15 seconds. However, on the majority of cattle lines, where the carcass must be hoisted to a bleed area, maximum stun-to-stick intervals of 60 seconds for the penetrative captive-bolt and 30 seconds for the non-penetrative captive-bolt are acceptable. It is essential that equipment is well maintained and that stunning is carried out accurately, using the correct cartridge, to ensure that animals are effectively and irreversibly stunned.

### Pithing

The operation known as pithing (physical destruction of the brain to ensure rapid death following captive-bolt stunning) is no longer practised in UK slaughterhouses. It was banned by law in 2001 for all cattle, sheep and goats destined for human or animal consumption due to fears the practice may contaminate carcasses with brain tissue, potentially facilitating the spread of Transmissible Spongiform Encephalopathies such as BSE.



However, pithing remains an effective and legitimate means of ensuring the rapid death of animals not destined for human consumption, e.g. casualties, emergencies or those destroyed during disease control operations.

Pithing involves inserting a flexible wire or polypropylene rod through the hole in the head made by a penetrative captive-bolt. The rod is then thrust towards the tail through the brain to the level of the brainstem and, if it is long enough, into the spinal cord. It is then slid back and forth to cause maximum damage to the brain and upper

spinal cord, a practice known as 'fiddling'. Initially the animal will show violent muscle contraction, but then reflex muscle movement is inhibited. Disposable pithing canes, which remain in the carcass, are available.

## Safety

Captive-bolt stunning equipment is potentially lethal to the operator. However, the equipment includes a number of inbuilt safety features:

1. The bolt is 'captive' within the barrel of the stunner, rather than a free bullet which could ricochet around the slaughterhall.
2. Recuperator sleeves automatically return the bolt to its pre-firing position. This prevents it from becoming embedded in the animal's head and reduces the possibility of the operator being dragged down as the animal falls.
3. The double 'rolling block' action necessitates at least two positive actions by the slaughterman before it is possible to fire.
4. Most trigger-fired stunners have anti-drop mechanisms which prevent them firing if accidentally dropped, even when fully cocked.
5. There is a need for positive action from the 'safe' position on contact-fired equipment.

## Safety procedures

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 operators of stunning equipment should be properly trained in its safe operation and maintenance. Equipment must be regularly checked by a qualified engineer and the following procedures should be observed:

- When handling captive-bolt equipment, during and on completion of loading, the muzzle of the stunner must at be pointed away from any part of the operator's, or any other person's, body at all times.
- Refer to the manufacturer's instruction sheet for the correct loading procedure and the correct cartridge size. Avoid repeated use of too heavy a cartridge, or air shots, which can result in the bolt shearing and flying free of the stunner.
- Captive-bolt stunners should always be handled as if they are loaded.
- Once the stunner has been loaded, ensure that the mechanism is in the 'safe' position until an animal is ready to be stunned.
- Never leave a loaded stunner unattended.
- In the event of a misfire, do not open the stunner breech for 30 seconds. Sometimes slow primer ignition will cause a 'hang fire' and the cartridge will explode after a short pause.
- At the end of the day's kill, return the stunner to the person appointed to carry out the daily cleaning procedure.
- Make certain the stunner is unloaded before cleaning.
- Immediately report any faults in the operation of the stunner to the person responsible for maintenance and do not use the equipment until the fault has been rectified.

- When not in use, ensure that captive-bolt equipment is stored securely at all times.
- The captive-bolt stunner is a dangerous firearm, never point the muzzle of a stunner at yourself or anyone else.

## Maintenance

The ability of captive-bolt equipment to deliver an effective stun is mainly dependant on the velocity of the bolt. Lack of regular maintenance can significantly reduce bolt velocity and the efficiency of stunning.

Increased friction caused by a build-up of carbon deposits and/or defects in the firing chamber are the main conditions which lead to reduced bolt velocity. A build-up of carbon deposits in the breech of a stunner can reduce the velocity of the bolt by 50 percent. If the bolt cannot retract fully into the breech the explosive pressure exerted on the piston will be reduced, due to the increased size of the expansion chamber. This can also occur if any of the recuperator sleeves are worn. Similarly, if there is excessive wear on the piston, cylinder or flange, gases will escape around the piston and the propulsive force will be reduced. Corrosion, or build-up of carbon, can also cause increased friction around the cylinder, bolt and undercut.

The biggest single cause of power-loss is the failure of the bolt-piston to return fully into the breech after the shot, whether this is done manually or automatically. Where recuperator sleeves are fitted, care must be taken to ensure that when the muzzle is screwed into position it causes the sleeves to be compressed. If this does not occur, either insufficient washers or sleeves have been fitted, or some sleeves are worn and must be replaced.

Captive-bolt stunners should be dismantled, cleaned and lubricated after use even if they are used only a few times in the day, or even less frequently (see [Step-by-Step Maintenance](#)). Back-up equipment must also be regularly serviced, even if it has not been used. The continual use of the captive-bolt, as occurs on a busy line in a slaughterhouse, causes comparatively less build-up of carbon than sporadic use for the same number of shots.

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.

### Daily maintenance must include:

- Dismantling of the stunner.
- Visual examination for evidence of damage and signs of excessive wear.
- Removal of blood and water.
- Removal of carbon deposits from the breech and undercut.
- Checks on the condition of the recuperator sleeves.
- Reordering of the recuperator sleeves on the bolt assembly.
- General lubrication.

Daily removal and cleaning of the bolt assembly reduces the chance of excessive wear on any one part of it, ensuring continued, efficient operation.

## Step-by-Step 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.

The following procedures are written principally for the Cash Special model. All references are to Figure 2, which is a diagram of the Cash Special. The broad principles apply equally to all cartridge-fired captive-bolt equipment, regardless of manufacturer or model.

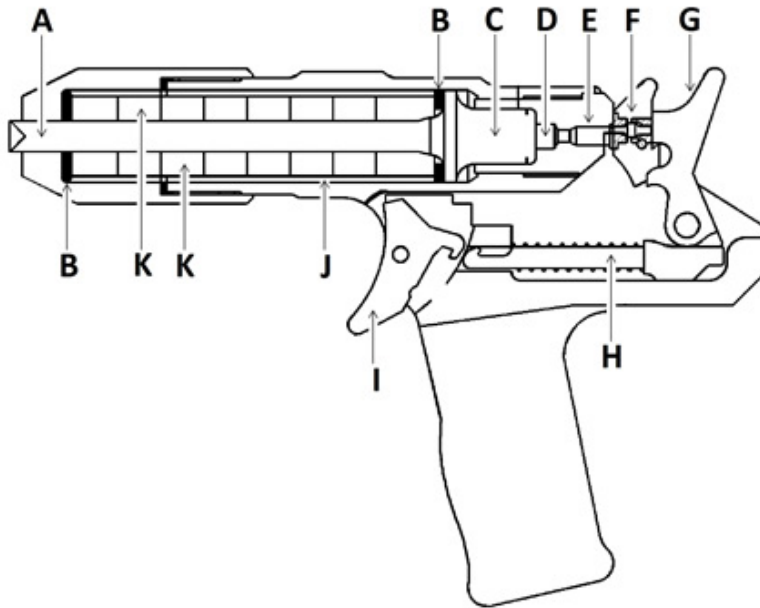


Figure 2: Penetrative, trigger-fired captive-bolt stunner Key: Bolt (A), Stop washers (B), Flange & piston (C), Expansion chamber (D), Breech (E), Ejector (F), Hammer (G), Trigger mechanism (H), Trigger (I), Undercut (J), Recuperator Sleeves (K)

## Daily Maintenance

Each time a captive-bolt stunner is used it should be cleaned to prevent corrosion and hardening of carbon deposits. It is essential that the following simple operations are carried out in order to ensure maximum bolt velocity and effective stunning:

- Unscrew the muzzle from the barrel and remove the bolt assembly, i.e. bolt, washers and recuperator sleeves. Older models may have rubber collars or Plasticine instead of recuperator sleeves.
- Wipe out the inside of the barrel with a soft, dry cloth and scrub with a wire brush to remove the day's soft powder and sludge. This is best done while the barrel is still warm and before the powder solidifies.
- Remove the washers and recuperator sleeves (or their equivalent) from the bolt and remove any carbon using a wire wheel or brush. Once cleaned, wipe the bolt over with a lightly oiled rag.
- Clean any powder and/or sludge from the recuperator sleeves and washers, reassemble

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them on the bolt in a different order to that in which they were removed, i.e. move former middle sleeves to the ends and former end sleeves to the middle. End sleeves wear the fastest, so rearranging the order minimises uneven wear. A full set of sleeves should last for approximately 4,000 shots.

- Using the tool provided, remove any carbon deposits from the breech and tap out onto a hard surface, such as a wooden table-top.
- Reassemble the stunner and wipe all metal parts with an oily rag. Wrap the stunner in an oily rag before locking it away in a secure cabinet.

## Weekly maintenance

The enlarged diameter inside the barrel at the breech block end (the undercut), must be kept from filling with powder, otherwise bolt return and stunning power will be adversely affected. Therefore, in addition to daily cleaning, the following procedure should be carried out weekly with an undercut cleaning tool which is provided with the stunner:

- Grip the undercut cleaner vertically in a vice.
- Slide the barrel down the cleaner until the breach face makes contact.
- Apply sideways pressure to the barrel, so that the cleaner enters the undercut in the barrel. Maintaining this pressure, rotate the barrel backwards and forwards two or three times.
- Turn the barrel through 90° and then repeat backwards and forwards movement. Repeat this process until the undercut has been thoroughly cleaned.

## Summary

Animal welfare and safety first:

- Inspect and test equipment before use.
- A working back-up stunner must always be immediately available at the point of stunning.
- Follow safety procedures.
- To stun effectively select:
  - The correct type of stunner
  - The correct cartridge or air pressure
  - The correct shooting position
- Always check for signs of an effective stun:
  - Animal collapses
  - No rhythmic breathing
  - Fixed, glazed expression in the eyes
  - No corneal reflex
  - Relaxed jaw
  - Tongue hanging out
- If you are in any doubt always stun the animal again.
- Bleed immediately after stunning.
- Clean and maintain the stunner after use.



## Appendix

### Troubleshooting Captive-Bolt Equipment

| Symptoms                                                          | Causes                                                                | Action                                                                                                                                                                                                                  |
|-------------------------------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cartridge does not detonate (a misfire)                           | Firing pin failing to make contact with cartridge.                    | Inspect cartridge for firing pin indent. If no indent is visible, strip down firing assembly and check condition and operation of parts. If indent is visible, check position of indent and rectify if necessary.       |
|                                                                   | Water or oil-damaged cartridges.                                      | Use a new box of cartridges.                                                                                                                                                                                            |
| Bolt does not return fully to the breech                          | Incomplete set of buffers and washers.                                | Check and make good, as necessary.                                                                                                                                                                                      |
|                                                                   | Worn washers and buffers.                                             | Check and replace as necessary.                                                                                                                                                                                         |
|                                                                   | Build-up of carbon deposits on piston, breech and in chamber.         | Check and remove if present.                                                                                                                                                                                            |
|                                                                   | Bolt is bent.                                                         | Replace immediately.                                                                                                                                                                                                    |
|                                                                   | Corrosion inside barrel.                                              | Check and remove if present.                                                                                                                                                                                            |
| Stunner fires, but there is insufficient power to stun the animal | Incorrect strength of cartridge being used.                           | Check type of cartridge against model of stunner and animals being stunned.                                                                                                                                             |
|                                                                   | Incorrect air pressure used.                                          | Choose air pressure according to manufacturer's recommendations.                                                                                                                                                        |
|                                                                   | Incorrect positioning of stunner on animal.                           | Check correct stunning position for type of animal being stunned.                                                                                                                                                       |
|                                                                   | Bolt not returning fully to the breech after each shot.               | Check for carbon deposits on bolt, breech or in chamber and remove if present. Check buffers, washers and collars for wear, replace as necessary. Check number of washers, buffers and collars, make good as necessary. |
| Bolt sticks in animal's head                                      | Bolt is bent                                                          | Replace immediately                                                                                                                                                                                                     |
|                                                                   | Recuperator sleeves excessively worn or missing.                      | Check and replace as necessary.                                                                                                                                                                                         |
|                                                                   | Cutting edge of bolt narrower than shaft due to incorrect sharpening. | Replace bolt and sharpen by grinding the <i>inside</i> diameter only.                                                                                                                                                   |
| Cartridge difficult to extract                                    | Damaged breech                                                        | Check for scored or split cartridge and if found, return stunner to manufacturer for repair                                                                                                                             |
| Unusually loud detonation                                         | Split cartridge                                                       | Check for damaged breech, return to manufacturer for repair. Check that the correct cartridge is being used.                                                                                                            |

If symptoms persist, return the equipment to the manufacturer for repair. Do not continue to use under any circumstances.

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