Humane Slaughter Association

# On-farm killing for disease control purposes

## Introduction

During an outbreak of infectious disease, large-scale depopulation of livestock may be necessary to curb further spread of the pathogen and prevent associated welfare problems arising. The health and welfare of infected or at-risk animals is a primary concern. Additionally, zoonotic diseases which can be transmitted between animals and humans pose health risks to people. If a notifiable disease is confirmed on your premises, the relevant authorities must be informed. In the UK this is the Animal and Plant Health Agency (APHA).

This online guide provides practical guidance on the emergency killing of cattle, sheep, goats, pigs, deer and poultry for disease control purposes. It is primarily aimed at livestock producers, veterinary surgeons, knackermen, killing personnel, animal welfare inspectors, animal health officers, students and other people who may be involved with the emergency killing of livestock. Some information is provided which relates to UK regulations and practices but the general principles should be useful to those in other jurisdictions. It is the responsibility of everyone involved in depopulation to ensure they comply with relevant local legislation.

### Important points about this website

This guide is intended to assist operators in planning for, and performing, the emergency killing of livestock during outbreaks of disease. 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.

For more detailed information about the equipment mentioned in this guide, see the other titles available in the HSA's series of online guides e.g. 'Humane Killing of Livestock Using Firearms' http://www.hsa.org.uk/humane-killing-of-livestock-using-firearms-introduction/introduction-2. All methods of killing livestock are also potentially lethal to humans. 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 firearms are used, or any loss, damage, injury or death caused thereby, since this depends on circumstances wholly outside the HSA's control.

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 on the HSA website.

## Guide organisation

This guide will address the subject of killing for disease control under the following headings:

- General principles relating to the killing for disease control.
- Organisation of on-farm killing for disease control purposes.
- Individuals and their duties.
- Logistical and biosecurity issues associated with disease control at a farm level.
- Human safety.

- Practical points for the humane killing of animals for disease control purposes.
- Stunning and killing.
- Humane killing.
- Killing methods available for species and their suitability for circumstances.
- Carcase disposal.
- Points for consideration after killing/end of the day.

Mounting a national defence against notifiable contagious diseases requires cooperation between a range of government departments, stakeholders, partners, NGOs, local councils, farmers, hauliers and other parties. In many cases infected animals, and those seen to be "at risk", will need to be humanely culled. It is vital these animals are killed as quickly as possible. During an emergency situation, derogations from specific requirements might be applied at the time of emergencies, but it is important that every effort is made to aim for best practice and uphold high standards of animal welfare. The EU regulation 1099/2009 includes provisions for depopulation due to disease control and lists permitted killing methods (excluding fish). In exceptional circumstances the competent authority may deviate from these regulations.

## General principles relating to the killing for disease control

General principles regarding the welfare of livestock killed for disease control purposes have been developed by the World Organisation for Animal Health (OIE). The principles should also apply when animals need to be killed for other purposes, such as after natural disasters. These general principles are:

- Each case should be considered independently because the circumstances surrounding the cull will differ between farms, incidents and species affected. The procedures should be individually tailored to meet the needs of the affected animals and those nearby, the practicalities of the killing method, financial restrictions, operator safety, resources available, biosecurity and environmental impact.
- With regard to biosecurity, where there is an outbreak of infectious disease, infected animals should be killed first. Secondly, animals which are known to have been in contact with infected animals, and finally the remaining animals on the premises.
- In accordance with the UK DEFRA guidelines produced in 2003, if more than one species are held on the premises they should be killed in the following order:
    - Pigs
    - Cattle
    - Goats
    - Sheep
    - Poultry
    - Farmed deer

  However, it is worth noting there may be situations in which a different kill order may be more appropriate.

- To prevent unnecessary distress, young animals should be killed before older animals. It is particularly important for young un-weaned animals to be killed immediately following separation from their dams. All people involved in the humane killing of animals in this situation must have the relevant training and skills in order for them to be competent in their role. Competence may be gained through formal training and/or practical experience.

- Regardless of the species present on-farm, killing should be carried out as quickly and humanely as possible. Where feasible, normal husbandry should be maintained until the animals are killed.
- Handling and movement of animals, outside of the usual routine, should be minimised. If animals have to be relocated it should be performed in accordance with the recommendations described later in this guide.

- Restraint of animals should only be performed when necessary as an aid to efficient and humane killing. Restraint should be performed in accordance with requirements regarding animal welfare and operator safety. Killing should follow with minimal delay.
- When animals are killed, the methods used should result in immediate death or immediate loss of consciousness lasting until death. When loss of consciousness is not immediate, the induction of unconsciousness should be non-aversive. Where this is not possible we should aim for the least aversive means possible. It should not cause avoidable anxiety, pain, distress or suffering.
- Continuous monitoring of the procedures should be performed by the competent authorities to ensure high standards are maintained regarding animal welfare, operator safety and biosecurity.
- When the planned cull has been completed, a report should be written describing the practices adopted and their impact on animal welfare, operator safety and biosecurity. In the European Union there are specific requirements for the reporting of infectious animal diseases. Details of the Animal Disease Notification System (ADNS) can be found here https://ec.europa.eu/food/animals/animal-diseases/not-system_en

## Organisation of on-farm killing for disease control purposes

An outbreak of infectious disease can be a stressful and potentially confusing time for all involved. Therefore, it is advisable for contingency plans to be prepared before such an outbreak occurs. As mentioned above, National Disease Control/Contingency Plans are required in EU member states prior to a disease outbreak. Having these plans established allows for appropriate coordinated action to be taken immediately. It is also good practice to have local and farm-level plans in place before a disease outbreak is confirmed. It is possible the exact strategies may need to be adjusted to meet the needs of a specific situation, so flexibility is important. However, giving plans thought and consideration during a disease-free period is invaluable.

**Disease Control Plans**, also known as Contingency Plans, must be developed in accordance with EU Regulations 1099/2009. These are to be written by government bodies and relevant stakeholders prior to an outbreak of notifiable disease. These plans should be reviewed annually and, if a disease outbreak is confirmed, these plans may be modified and should be in place at national level and contain details of management structure, disease control strategies and operational procedures. The welfare of the affected animals throughout the process, including the potential welfare issues arising due to animal movement controls, should be carefully considered and addressed within these plans. The plans should also include a strategy to ensure an adequate number of personnel, who are competent in the humane killing of animals, are available on site.

**Local Level Control Plans** (in the UK these cover regions) are based upon national plans but include specific knowledge of the local area. These plans are developed through engagements between the competent authority (APHA in the UK) and local partners and stakeholders.

At the farm-level, a Killing Plan is devised by the appointed Incident Commander (IC). The role and responsibilities of the IC are listed later in this document. The farmer, possibly with the help of a vet or the IC, should devise a **Biosecurity Plan**, details of which are listed later in this section and can be found in the disease control document produced by the OIE. It is crucial that those developing the plans are mindful of overall communications and take into account the emotional aspects of the task for the owners of the animals, the emergency response staff and the wider community. Members of the general public are not generally accustomed to such practices and care should be taken to prevent any distress caused by people overlooking the killing or carcase-disposal site. Those assisting as part of the emergency response staff may also be unfamiliar with such procedures and the psychological impact of a large-scale cull should be appreciated. Figure 1 below provides an example of the organisation implemented within the UK.

In addition, it is important for those working on farms to create their own farm-level contingency plan to help them continue daily operations if movement restrictions are imposed, e.g. delivery access, transfer of people, animals and supplies between holdings, etc.


**National Plans**

**Level: National Disease Control/Contingency Plans**

**Written by**: Government bodies and stakeholders.

**Includes**: Management structure, disease control strategies and operational procedures. The welfare of the affected animals throughout the process, including the potential welfare issues arising due to animal movement controls, should be carefully considered and addressed within these plans. The plans should also include a strategy to ensure an adequate number of personnel who are competent in the humane killing of animals are available on site. Scotland, England and Wales all have National Plans published by their individual government bodies, and all fall collectively under the Foot and Mouth Disease Control Strategy for Great Britain. Northern Ireland is viewed as a separate epidemiological unit.

**Biosecurity Plan**

**Level: Farm**

**Written by**: Farmers, veterinarians and the IC.

**Includes:** Means of securing the premises. Preventing the escape of the agent on animals, animal products, clothing or equipment or through environmental factors (e.g. wind). The division of "clean" (pathogen free) and "dirty" (infected) areas on a farm must be clearly marked to avoid accidental contamination by people moving between sites.

**Local Level Control Plan**

**Level: Regional (local)**

**Written by:** Local authorities, partners and stakeholders.

**Includes:** Management structure, disease control strategies and operational procedures. The welfare of the affected animals throughout the process, including the potential welfare issues arising due to animal movement controls, should be carefully considered and addressed within these plans. The plans should also include a strategy to ensure an adequate number of personnel competent in the humane killing of animals are available on site.

**Killing Plan**

**Level: Farm**

**Written by:** The Incident Commander, team leader and appropriate farm staff.

**Includes:** The scale of the operation: the species, number, age and size of the animals to be killed and the order in which to kill them. Information on the housing, husbandry and location of the animals. The site(s) where the animals of all affected species will be killed and provisions taken to minimising movement and handling. The presence and availability of suitable handling and restraint facilities for all classes of animals to be killed. Whether additional equipment needs to be brought on site and subsequent biosecurity protocols. Preferred methods of killing and associated costs, i.e. time, labour and financial outlays and predicted legal complications, e.g. use of restricted drugs. Instructions for work following the kill, i.e. methods for carcase removal, disposal and destruction. The accessibility of the farm and proximity of other premises holding animals and their susceptibility to the outbreak. Biosecurity and environmental issues resulting from the situation, e.g. pollution or potential risks to wildlife.

**Considerations when developing Killing Plan:**

If mobile equipment is to be moved on- and off-site it is essential that detailed biosecurity protocols are developed. Depending on the circumstances the carcases may be destroyed on the farm or removed to another location (ensure moving equipment and machinery are on-site and available). The use of some drugs during killing may limit options for carcase disposal. The physical health and safety of the personnel doing the killing, and the potential psychological impact of the situation on everyone involved, must be recognised. The kill site should be chosen carefully. It should be hidden from public view and screening may be used to conceal the operation.

**Figure 1: Illustration of UK organisation required during an outbreak of notifiable disease. Includes plans made at national, regional and farm-levels. Some information from OIE (2013) Terrestrial Health Code. Chapter 7.6 Killing of Animals for Disease Control Purposes.**

## Individuals and their duties

Creating disease control plans ahead of an outbreak provides time for local authorities, farmers, vets and others to discuss, consider and understand their duties. This minimises confusion during depopulation, as the roles of individuals and groups are already clearly assigned and agreed. Killing for disease control is a unique situation which greatly differs from normal farm routines and, for many people, it is likely to be the first time they are involved in such work. It is important the right people are selected for each job, i.e. people with knowledge of animal handling and/or slaughter should be assigned these tasks where possible in order to maintain the highest possible standards of animal welfare.

As each case should be considered individually, the exact roles and staff numbers required to carry out the strategy laid out in the local/regional Control Plans will differ. The operational activities described in the Control Plans should be led by a competent person, with the relevant skills and experience, acting as the IC. Usually this is a veterinary surgeon or senior animal health officer. The IC is sometimes also referred to as an Official Veterinarian (e.g. in the OIE guidelines). The IC manages a specialist team of people which is headed by a Team Leader (see Figure 2). The team leader is directly answerable to the IC. The team members are allocated roles across the affected site. Each team should contain a veterinary surgeon or at least have access to veterinary advice at all times. The team should consist of personnel with the competencies to conduct all required operations. The team leaders, vets, animal handlers, killing personnel, carcase disposal personnel and farmers all contribute to the success of the operation and have their own roles within this task. In some situations personnel may be required to fulfil more than one function. Although it is the job of the killing personnel to kill the animals, it is everyone's responsibility to ensure animals are treated humanely and killed efficiently. Figure 2 shows the hierarchy of individuals and teams employed during an outbreak of disease. The roles and responsibilities of each are shown as described by the OIE in their Terrestrial Health Code.

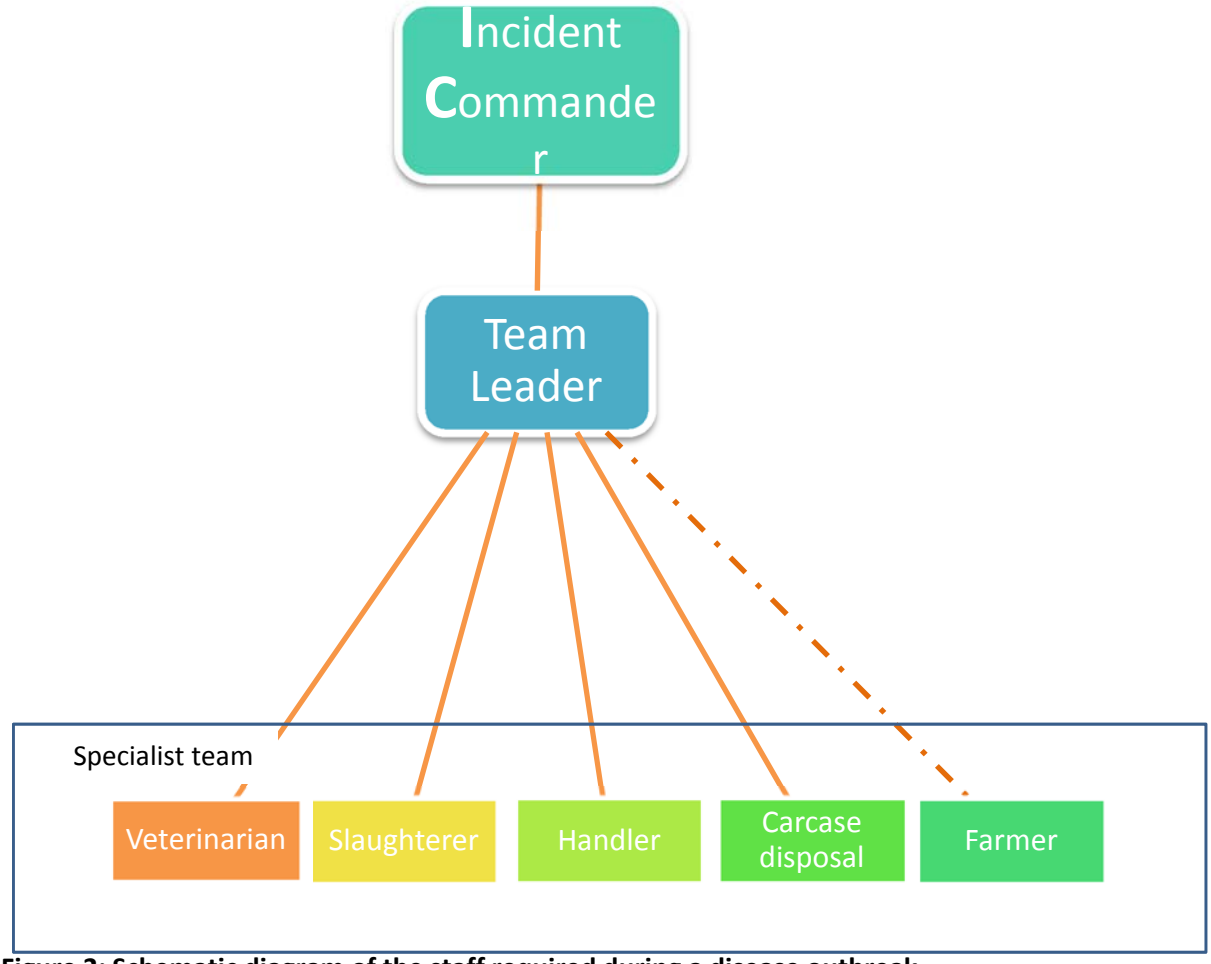



**Figure 2: Schematic diagram of the staff required during a disease outbreak.**

## Role and responsibilities of the Incident Commander (local/regional level plans)

The IC:

- is responsible for all activities across the affected premises, whether on one or multiple holdings. The IC should be supported by coordinators when planning the logistics and during the operations;
- has the authority to select and appoint personnel to specialist teams and ensures team members adhere to the required animal welfare and biosecurity standards. When appointing personnel, the IC should ensure the people involved have the required competencies for their role as described in this online guide;
- provides guidance and support to team members regarding the operations and associated logistics. This is to ensure consistency in adherence to the OIE animal welfare and health recommendations;
- must be aware of the pros and cons of the available killing methods available. The methods selected by the IC depend upon the circumstances surrounding each affected site.

## Role and responsibilities of the Team Leader (farm-level plans)

The leader of the specialist team has responsibilities to:

- plan overall operations on affected premises and develop a Killing Plan;
- determine and address the animal welfare, operator safety and biosecurity requirements;
- monitor operations to ensure animal welfare, operator safety and biosecurity requirements are met;
- organise, inform and manage a team of people to facilitate the humane killing of relevant animals on the premises, in accordance with national regulations and the recommendations provided here;
- determine the required logistics;
- report back to the IC on both progress and problems experienced;
- provide a written report to the IC at the conclusion of the killing describing the practices adopted and their effect on animal welfare, operator safety and biosecurity outcomes.

The team leader must have:

- appreciation and understanding of normal animal husbandry practices;
- appreciation and understanding of animal welfare and the underpinning behavioural, anatomical and physiological processes involved in the killing process;
- appropriate skills to manage all activities on premises and deliver outcomes on time;
- awareness of potential psychological effects on farmer, team members and general public;
- effective communication skills;
- appreciation of the environmental impacts caused by their operation.

## Role and responsibilities of veterinary surgeons (farm-level plans)

The role of veterinary surgeons in the specialist teams is to:

- determine and supervise the implementation of the most appropriate killing method to ensure that animals are killed without avoidable pain and distress;
- determine and implement the additional requirements for animal welfare including the order of killing;
- ensure death is confirmed by competent persons at appropriate times after the killing procedure;
- minimise the risk of disease spread within and from the premises through the supervision of biosecurity procedures;
- continuously monitor animal welfare and biosecurity procedures;
- prepare a written report in cooperation with the IC, at the conclusion of the killing, describing the practices adopted and their effect on animal welfare.

The veterinarians must be competent in their ability to assess:

- animal welfare, especially the effectiveness of stunning and killing and to correct any deficiencies;
- biosecurity risks.

### Role and responsibilities of animal handlers (farm-level plans)

The animal handlers:

- evaluate the suitability of on-site facilities;
- design and construct temporary animal handling facilities when required;
- move and restrain animals;
- continuously monitor animal welfare and biosecurity procedures.

The animal handlers must be competent in:

- animal handling in emergency situations including during close confinement when required;
- understanding biosecurity and containment principles.

### Role and responsibilities of animal killing personnel (farm-level plans)

Animal killing personnel are responsible for ensuring the humane killing of the livestock through effective stunning and killing.

They must be competent in:

- the use of techniques required for stunning and killing the species involved;
- the use of specialised equipment and where necessary hold the correct licences required for such equipment;
- the use and maintenance of relevant equipment;
- the assessment of effective stunning and killing.

### Role and responsibilities of carcase disposal personnel (farm-level plans)

The carcase disposal personnel are responsible for:

- efficient carcase disposal complying with biosecurity rules;
- ensuring the carcase disposal does not hinder/effect killing operations.

The carcase disposal personnel must be competent in the:

- the use and maintenance of available equipment;
- application of techniques for the species involved.

### Role and responsibilities of farm owners/managers and stockpeople (farm-level plans)

The psychological impact of these operations on the farm owners/managers and stockpeople must be appreciated by all personnel involved in the killing of animals for disease control purposes. They should be allowed to engage with the operation to the extent with which (s)he feels comfortable. The role of the farm owners/managers and stockpeople during depopulation for disease control is to assist the team when requested.

The farm owners/managers and stockpeople must be competent in their:

- specific knowledge of their animals;
- understanding of biosecurity;
- knowledge of the local area and environment.

## Logistical and biosecurity issues associated with disease control at a farm-level

When planning and performing an infectious disease control operation, the aim is to contain the pathogen within the affected premises and prevent further transmission. The classification of the biological agent, number of other susceptible animals in the area and way in which the disease is transmitted (vectors, direct contact, airborne etc.) will determine how quickly the animals should be killed. For example, there would be more urgency in the case of Foot and Mouth Disease (FMD) than of BSE. The elimination of infectious disease from an infected area must be performed in a timely and effective manner. As live animals present a major risk of spreading infectious pathogens they need to be killed quickly and humanely.

As stated previously, at national level a Contingency Plan must be established to control the spread of disease between premises across the country. Local and farm-level Biosecurity Plans must also be written by farmers and stockowners, describing the protocols in place on their own farm. Some governments offer guidance on the development of farm Biosecurity Plans on their websites. A Biosecurity Plan must include means of securing the premises and preventing the escape of the agent on animals, animal products, clothing or equipment or through environmental factors (e.g. wind). The division of "clean" (pathogen free) and "dirty" (infected) areas on a farm must be clearly marked to avoid accidental contamination by people moving between sites. Disinfectant should be provided and all personnel instructed in the efficient application of steriliser to themselves, equipment and vehicles. All team members and visitors to the farm must adhere to these rules. When planning the positioning of killing areas and fallen stock pick-up points, the contamination risks from the vehicles have to be taken into account. These areas should be positioned close to farm entrances to minimise vehicle movement on the premises. It is also important to devise a system so that animals are moved in only one direction and do not pass through killing or fallen stock areas before it is time for them to be killed and removed from the farm. As vehicle and equipment movement is one of the biggest contributors of disease spread, parking areas for visitors (e.g. vets, killing personnel etc.) should be provided. If possible, it is recommended this is situated off site to prevent contamination from people and vehicles. These areas should be clearly identified on the farmer's Contingency Plan. If necessary, a dedicated vehicle should be arranged to bring personnel to infected premises from a dedicated meeting point. There should be facilities for the washing and disinfecting of people's clothing and vehicles to prevent spread between and within farms. If possible, visitors should limit their movements and only enter/exit using one route. Additional fencing around the farm can help to prevent disease transfer between the site and neighbouring farms. These fences can also stop wildlife, such as badgers and foxes, from entering the premises and spreading the disease further, or feeding on fallen stock. See Figure 3 below for an example for a farm layout.

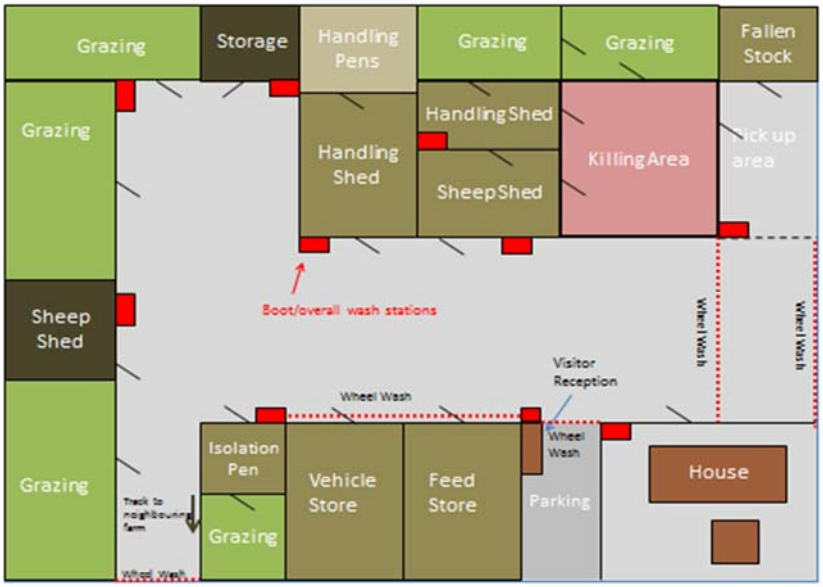



**Figure 3: Diagram showing possible farm layout with consideration given to needs relating to animal and vehicle movement while maximising biosecurity provisions**.

## Human safety

Human safety should be considered carefully when developing the Control Plans. Risks to human safety can arise from the disease pathogen, the killing methods used and other hazards present in the environment, especially when personnel are working in an unfamiliar setting. Personnel may be exposed to zoonotic agents when moving and handling infected animals, or where the killing method initiates the spillage of potentially infectious body fluids. Initially these risks can be reduced by minimising the exposure to, and handling of, infected animals. In cases where physical contact with

animals and their fluids is unavoidable, the risks can be minimised by providing appropriate Personal Protective Equipment (PPE). It is essential to ensure that personnel involved in the killing of animals have the appropriate skills, training and competencies and that all operations are constantly monitored. Equipment used should be in excellent working order and regularly maintained. Back-up equipment should always be provided.

## Practical points for the humane killing of animals for disease control purposes

- Make full use of the farmer's knowledge of the farm, livestock and the resources available on the farm.
- Good communication is key.
- All personnel must have an understanding of:
    - team leadership;
    - job rotation and adequate breaks;
    - recognition of fatigue and stress;
    - the avoidance of personality clashes.
- Create a good handling system. This helps the handlers and minimises disruption when working with animals.
- Establish boundaries between "clean" and "dirty" areas and provide disinfectant and PPE.
- Remember that everyone is responsible for their own and their colleagues' safety
- On-site risk assessment is essential.
- Remember that **everyone** has a responsibility to ensure all animals are killed efficiently.

## Stunning and Killing

Stunning an animal prior to killing renders it unconscious and insensible to pain by disrupting normal brain function. This benefits both animal welfare and human safety, particularly when dealing with large animals such as cattle. From a welfare perspective, it is very important that this loss in consciousness is immediate to prevent the animal experiencing discomfort or pain caused by the stunning method. The methods of stunning and killing described later in this guide include simple-stunning followed by a killing method, and stun-kill methods.

"Simple stunning" describes methods which render the animal unconscious and insensible to pain, but do not lead to death. Animals which have been stunned using a simple stunning method will eventually regain consciousness and recover. If such a method is used, it must be followed as quickly as possible by a procedure that causes death. When using simple stunning methods (e.g. electronarcosis), an additional step is required to kill the animal. It is important to ascertain the length of time available to perform the kill before the animal recovers consciousness.

There are many definitions of "death". For the purpose of this guide, death is considered to occur when the animal's brain irreversibly ceases to function. The part of the brain responsible for regulating essential body functions such as breathing, heart activity and responses to pain is called the brainstem. When the brain is starved of oxygen it can no longer function and the animal dies. This may be achieved by directly causing physical damage to the brainstem (e.g. by pithing) or disrupting the function of the heart (e.g. using electricity) to prevent oxygenated blood reaching the brain.

Some techniques, such as firearms or prolonged exposure to anoxic gas mixtures, are considered to be stun-kill methods. That is, they cause unconsciousness and lead to death without an additional action being taken.

Stunning and killing methods suitable for use on-farm during a disease outbreak are discussed later in this guide.

## Humane killing

During an emergency cull for disease control purposes many activities will need to be conducted on the affected premises. The job requiring the most preparation and planning is the humane killing of animals. Arrangements need to be in place for the killing of animals on affected premises. The IC and team leader should develop a Killing Plan for the humane destruction of animals on the premises. When planning the kill it is essential the methods chosen are consistent and reliable. All animals must be treated humanely throughout the process. The method of killing requires careful consideration. Following stunning and/or killing animals should be checked for signs indicative of absence of brainstem reflexes (Figure 4). This may include:

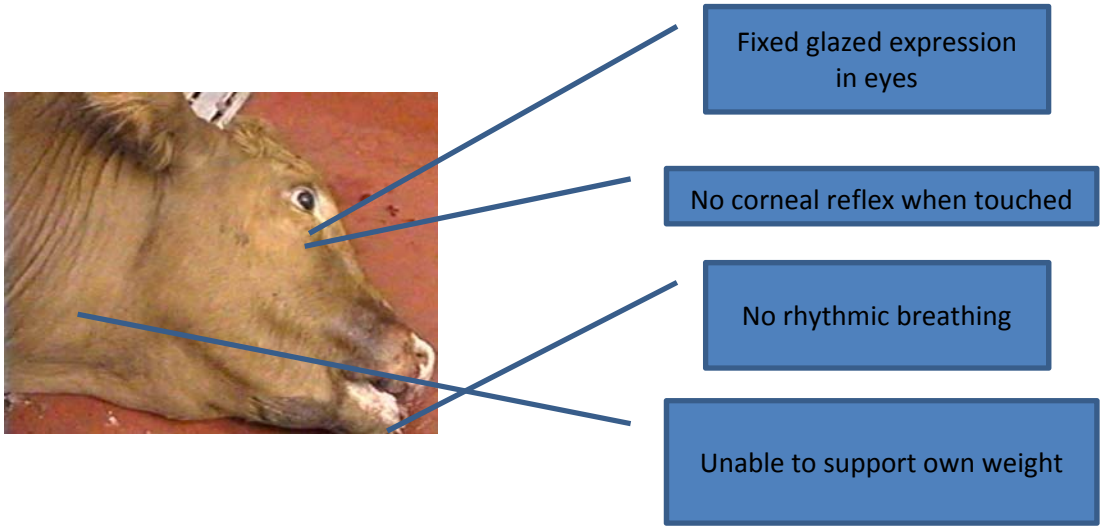



**Figure 4: Indicators used to determine the absence of brainstem reflexes.**

## Killing methods

When selecting killing methods for use during depopulation, the welfare of the affected animals must be a priority, but it is also important to note that the means used to kill may reduce the options for subsequent carcase disposal.

### Recommended Methods for killing mammals

When killing mammals a number of methods are available, however the species, age, size and location of the animals may limit your options. The methods available for adult mammals are:

1) Mechanical methods
    a. Free-bullet firearms
    b. Penetrative captive-bolt followed by pithing

2) Electrical stunning followed by electrocution

Additional methods suitable for use with neonate mammals are:

1) Mechanical methods
    a. Non-penetrative captive-bolt
    b. Manual blow to head

2) Lethal injection (administered by a vet only in the UK)

### Recommended methods for killing poultry

The methods suitable for the killing of adult poultry for the purpose of disease control are:

1) Mechanical methods

   a. Percussive stun/kill using captive-bolt

3) Electrical stunning followed by cervical dislocation, decapitation or bleeding*

4) Electrical killing

5) Killing by exposure to lethal gas mixtures (including Nitrogen foam)

6) Drugs
   a. Anaesthetics and poison in food/water

Options for killing chicks (up to 72 hours of age) include a macerator or exposure to gas.

*bleeding and decapitation following a stunning method may be suitable on premises which are not infected but are within a "firebreak" area. Bleeding should not be performed if animals are infected as blood poses a biohazard.

# Killing Mammals

## Mechanical methods

### *Free-bullet firearms*

Various firearms can be used to kill livestock. These are free-bullet firearms such as shotguns, rifles, and humane killers.

When used properly, a free-bullet provides a quick and effective method of killing as it requires minimal or no restraint of the animal and can be used to kill from a distance. This is particularly advantageous when dealing with extensively managed, wild or agitated animals which may be dangerous in enclosed spaces, including adult bovines and deer. With a successful shot, death is immediate and there is no requirement for further bleeding or pithing of the animal. This may be particularly useful when killing for zoonotic disease control, as it minimises handling and contact between humans and animals and prevents further disease transmission.

A free-bullet firearm, used from long range, should be aimed to penetrate the skull in a frontal position and proceed through the brain in to the upper neck, following the line of the vertebra. This will cause catastrophic injury to the mid-brain and brainstem leading to immediate death. This method should only be used by properly trained and competent marksmen. The marksman should ensure the animal is stationary and in the correct position to enable accurate targeting. In the interests of safety, the field of fire must be directed away from any roads and houses; any essential accompanying staff must remain behind the marksman. All personnel present must wear protective clothing. Once shot, animals should be checked to ensure the absence of brainstem reflexes and death confirmed.

See the HSA online guide to Emergency Slaughter and Humane Killing of Livestock Using Firearms for more detailed information on the use of firearms. Information is available on firearms equipment, the correct shooting positions for different species and the operation, maintenance and safety of firearms.

Legislation controlling firearms differs across the world. Operators must ensure that they operate within the bounds of relevant national legislation. Contact your local authority for information before obtaining or using any firearm.

### *Positioning*

In cattle, the brain is situated high in the head. The ideal point of penetration is in the middle of the forehead – at the crossing point of two imaginary lines drawn between the middle of each eye and the centre of the base of the opposite horn. This should give a position about 7cm, ±1cm, above a line drawn across the forehead at the back of the eyes. The shot should enter at **right-angles** to the skull as shown in Figure 5. When shooting bovine animals at range, the operator should be in an elevated position to ensure the correct angle of impact is achieved.

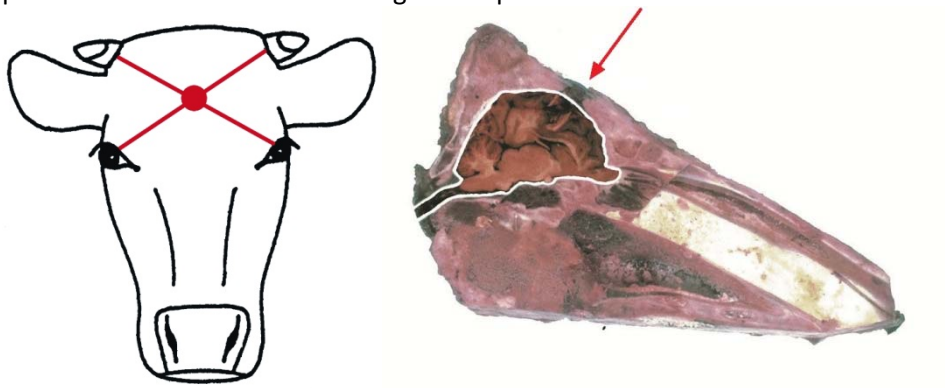


**Figure 5: Correct positioning for shooting cattle with a free-bullet.**

When shooting deer it must be remembered that antlers do not equate to horns in cattle. The ideal aiming point is in the middle of the forehead, at the crossing point of two imaginary lines drawn from the middle of each eye to the top of the opposite ear. In stags, this spot is found between the antlers. As with cattle, the angle of the shot should be directed through the brainstem (Figure 6). When shooting deer at range, the operator should be in an elevated position to ensure the correct angle of impact is achieved.

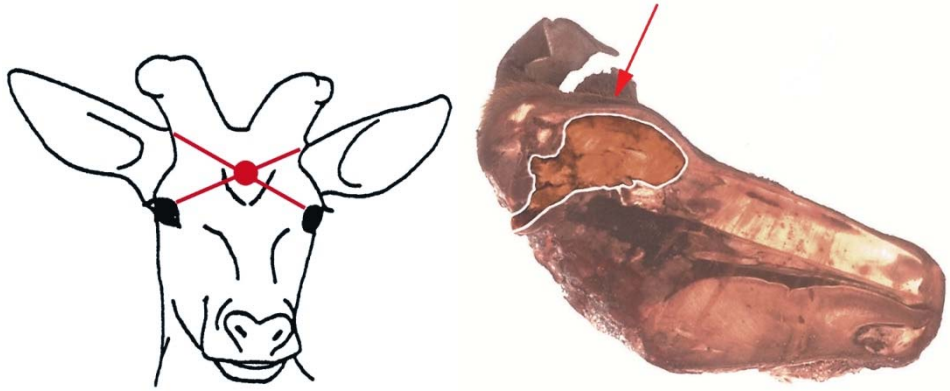


**Figure 6: Correct positioning for shooting deer with a free-bullet.**

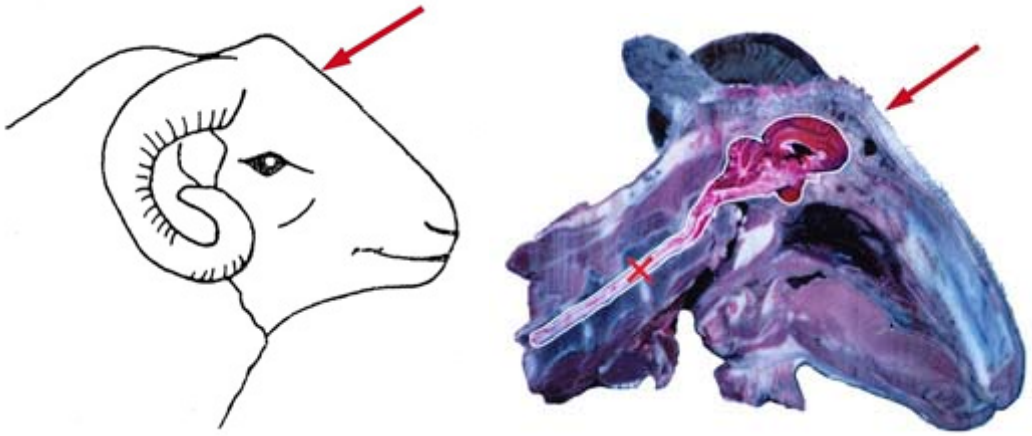


**Figure 7a: Correct positioning for shooting polled or lightly horned sheep and goats with a free-bullet.**

When shooting sheep and goats with a free-bullet firearm, the aiming point is on the mid-line, just above the eyes, directed down the line of the spine into the bulk of the body (Figure 7a). In practice this can be quite difficult to achieve and a slight error in the angle of shot, or minor movement on the part of the animal, can result in a free-bullet exiting from the animal's head or neck. In order to get this right when using a free-bullet weapon, the animal's head must be in the normal position.

Heavily horned sheep and goats can present a problem where a free bullet weapon is used. The mass of horn over the forehead can leave little or no target area: a shot between the eyes is too low and should not be used under any circumstances. Such animals can be shot from behind the poll (Figure 7b). However, this is dangerous with a free-bullet weapon and, if undertaken, the animal should always be situated on soft ground. Where possible, a shotgun is recommended for this type of shot.

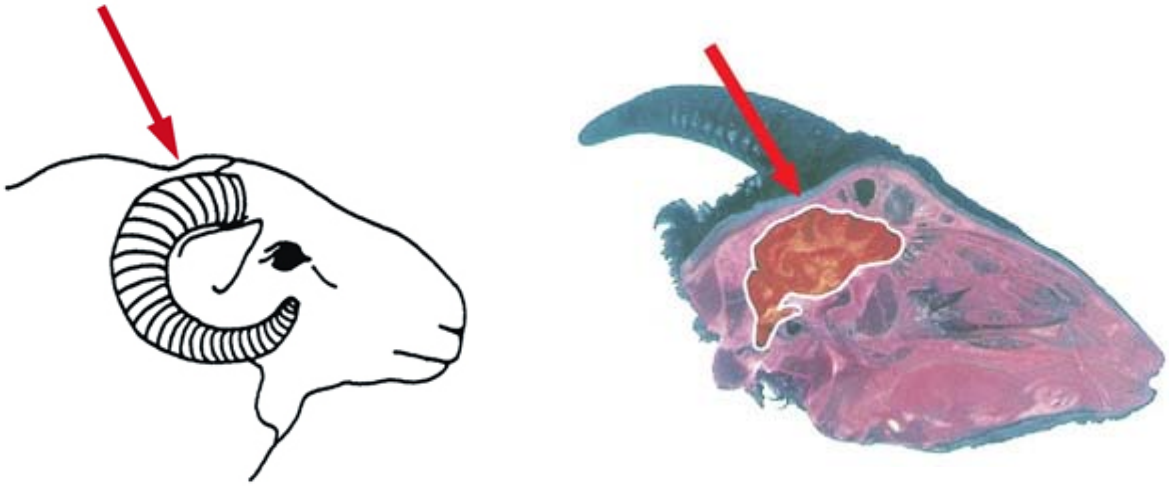


**Figure 7b: Correct positioning for shooting heavily horned sheep and goats with a free-bullet.**

Pigs are among the most difficult animals to shoot. There are two reasons for this: first, the target area is very small and this problem can be exacerbated by the 'dish' (concave) face shape of certain breeds and in aged pigs; second, the brain lies quite deep in the head, relative to other species, with a mass of sinuses lying between the frontal bone and the brain cavity. The ideal site for shooting pigs is one finger's width above eye level, on the mid-line of the forehead, aiming towards the tail (Figure 8).

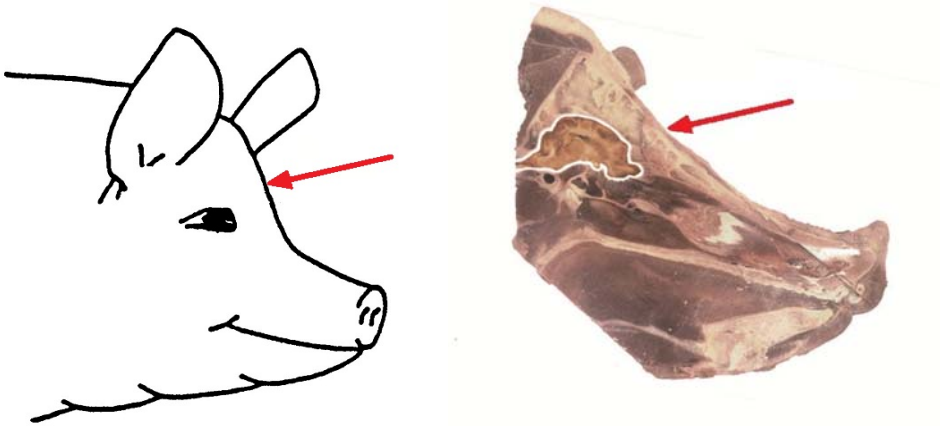


**Figure 8: Correct positioning for shooting pigs with a free-bullet.**

### *Considerations when using firearms during depopulation due to disease control*

Using a firearm to kill animals in this situation has a number of advantages and disadvantages. The method is advantageous in situations involving animals which are wild or free-ranging and cannot be easily gathered or restrained. There is no need for direct human-animal contact which is beneficial for many reasons. For example, it prevents the passing of zoonotic diseases and avoids the handling of agitated or unpredictable animals which may pose safety risks. When performed correctly, the animal is killed instantly due to destruction of brain tissue, making it a humane choice.

However, this method requires careful consideration as there are some serious disadvantages associated with the use of free-bullet firearms. If used improperly there is a great danger to humans and other animals in the vicinity and there is the potential of non-lethal wounding. The destruction of the brain tissue may preclude the diagnosis of some diseases during a post-mortem examination and leakage of body fluids through the entry wound, nose and mouth may present a biosecurity risk. Legal requirements may prevent or restrict the use of firearms and, in some areas, there may be a limited availability of competent and appropriately licensed personnel.

To protect the safety of the animals and other people on site, the operator of any firearm must be fully trained and competent. It is very important the correct ammunition is used, otherwise animals might not be killed immediately and/or the operator could be injured. The use of firearms in enclosed spaces, or when animals are on hard surfaces, could result in ricochet of free-bullets and is to be avoided for health and safety reasons.

### *Penetrative captive-bolt followed by pithing*

Captive-bolt devices work in a similar way to firearms, although unlike free-bullet firearms, the bolt remains captive within the barrel. This bolt strikes the animal's head (percussion) which causes concussion. When used successfully with ruminants and pigs, the impact of the bolt on the skull renders the animal immediately unconscious. A penetrative captive-bolt stunner also fires a retractable bolt into the animal's head allowing the bolt to penetrate the cortex and mid-brain of the animal. The bolt is projected either by compressed air or a blank cartridge. Following the administration of a successful captive-bolt stun the animal will collapse immediately, rhythmic breathing will cease and the corneal reflex will also be lost (a corneal reflex can be elicited by touching the cornea of the open eye with the fingertip - in a conscious animal the eyelid will close). The response to a painful stimulus (e.g. a nose-prick with a hypodermic needle) will be absent. These symptoms are accompanied by the onset of tonic seizures lasting several seconds. The clonic phase follows the tonic phase and can be recognized by the presence of kicking or paddling movements which generally last between about 15 and 45 seconds. There is likely to be some bleeding from the hole in the skull made by the bolt and from the nose of the animal. Physical damage to the brain caused by the penetration of the bolt may not necessarily result in death and so pithing must be performed as soon as possible to ensure the death of the animal. Pithing involves inserting a flexible wire or polypropylene rod through the hole in the head made by a penetrative captive-bolt. The movement of the rod destroys the brainstem and upper spinal cord, ensuring death, and reduces the reflex kicking which can occur after stunning. In the case of an on-farm kill for disease control, other implements such as screwdrivers may also be utilised to perform this function. 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' or `rodding'. Initially the animal will show violent muscle contraction, but then reflex muscle movement is inhibited. Disposable pithing canes, which remain in the carcase, are available. Whilst both these procedures are humane when carried out correctly, they may be distressing to watch and they require a competent and confident operator. For more information on pithing see http://www.hsa.org.uk/bleeding-and-pithing/bleeding

Animals should be closely monitored following stunning to ensure the absence of brainstem reflexes. If there is any doubt regarding the efficacy of the shot, the captive-bolt should be applied again. The correct positioning of these shots is described in the HSA online guide for Captive-bolt Stunning of

Livestock. Should there be any doubt in the mind of the operator as to the correct target area for firearms or captive-bolt equipment, then it should be identified and, if possible, marked. This can be done using a spray marker, a felt pen, or in the case of a very dark-coated animal, French chalk. For the application of the captive-bolt stunner the animals should be restrained. The aim should be to position the animal so it can be shot accurately and will be easily accessible for 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.

The bolt velocity and length of bolt should be appropriate to the species and type of animal and in accordance with the recommendation of the manufacturer. See the HSA online guide to Emergency Slaughter and Captive-bolt Stunning of Livestock for more detailed information on the use of captive-bolt equipment. Information is available on the types of equipment available, the correct positioning for different species and the maintenance procedures and safety considerations for captive-bolt equipment. When used for killing for disease control, more than one stunner may be necessary to prevent overheating. Furthermore, a back-up device should always be available.

### *Positioning*

Positioning of the captive-bolt for cattle, pigs and deer is the same as listed previously in the free-bullet firearm section (Figures 5, 6 and 8 in mechanical method section). However, the correct position for stunning sheep is different. For these animals it 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, on the mid-line and aiming straight down (Figure 9a). 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 9b).

Following stunning with a penetrative captive-bolt, pithing must be performed without delay to prevent the possibility of the animal recovering from the stun. Specifically, when horned sheep and goats are shot in the poll position they must be pithed within 15s.

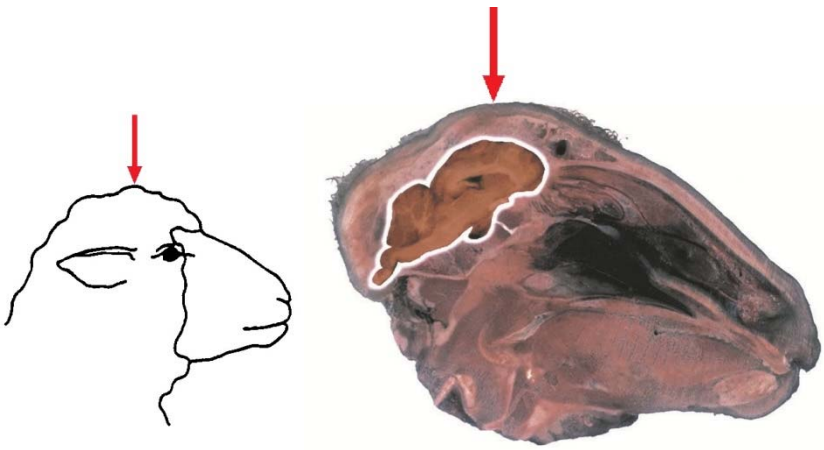


**Figure 9a: The optimum position for using a captive-bolt on hornless sheep.**

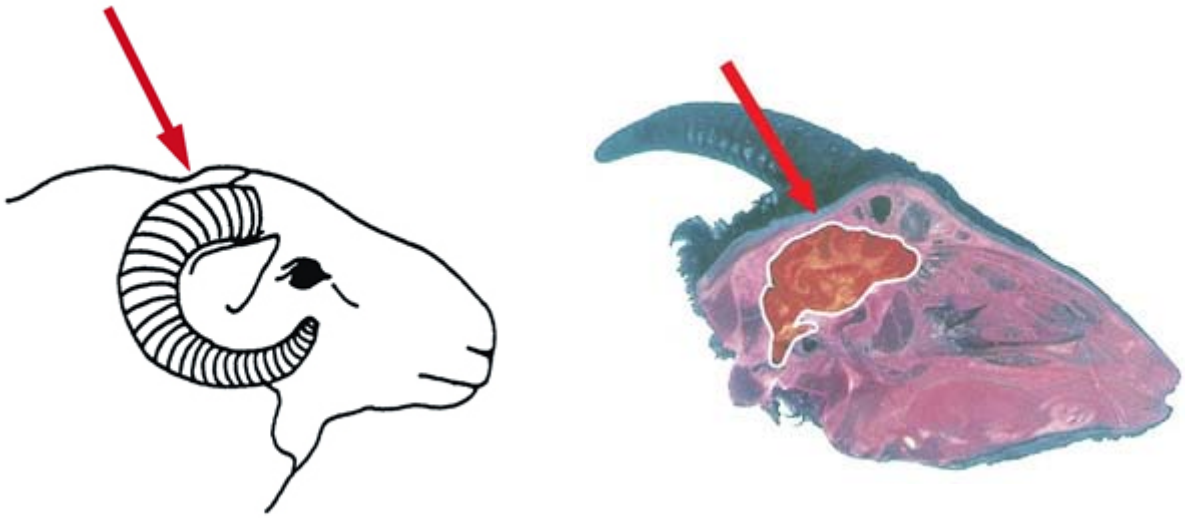


**Figure 9b: The optimum position for using a captive-bolt on heavily horned sheep and all goats.**

### *Considerations when using captive-bolt stunning and pithing for depopulation due to disease control*

Captive-bolt stunning followed by pithing can be used for on-farm killing of animals where a free-bullet is impractical, although certification may be necessary for the use of this method. When using a captive-bolt device it is vital that it receives regular cleaning and maintenance (see Captive-bolt Stunning of Livestock and https://www.hsa.org.uk/downloads/technical-notes/TN4-safety-maintenance-captive-bolt-HSA.pdf for details). At least one spare captive-bolt device should be available and the use of devices rotated to prevent overheating. Ensuring the correct positioning of the bolt is essential as misfiring may seriously compromise animal welfare.

The use of captive-bolt devices followed by pithing has advantages for use during on-farm depopulation. The mobility of this equipment reduces the need to move animals, which is beneficial for the welfare of the animals and also the prevention of the spreading of disease. A further benefit to animal welfare is the immediate onset of unconsciousness which is sustained throughout the killing process.

There are, however, disadvantages to this method. The animals have to be restrained and for animals which are not habituated to human contact, this may cause fear and distress. Misplaced shots may be a particular problem if the animals are not adequately restraint and/or become agitated as they may not remain still. The safety of the personnel performing the pithing or bleeding may be jeopardised by the animals' post-stun convulsions. As with the use of firearms the destruction of brain tissue may prevent the diagnosis of some diseases and the leakage of body fluids may pose a biosecurity risk.

If the animal was shot using a firearm, or stunned using a captive-bolt, but there is doubt surrounding the efficacy of the stun/kill the procedure should be performed again immediately. If the first attempt was off-target the second shot should be performed in the correct position. If the first shot was in the correct position but ineffective the second should be above and to one side of the normal target position.

### *Conclusion – species and situations*

Free-bullet firearms and captive-bolt stunning, followed by pithing, are methods suitable for killing pigs (up to six months of age), cattle, sheep, goats and deer. Due to the skull structure of adult pigs, problems may arise when using a captive-bolt and it is recommended that, where possible, they are

destroyed by a free-bullet humane killer or a shotgun, or stunned and killed using electricity (see Electrical Killing section below).

For adult cattle, it may be advisable to sedate them prior to stunning with a captive-bolt. This can be done by administering a sedative while they are in a race or crush and then allowing them to settle in a pen or shed. When the sedative has relaxed and immobilised the animals, stunning and pithing can be performed by a killing team. Sedating adult cattle enhances safety of personnel and potentially reduces the stress experienced by the animals.

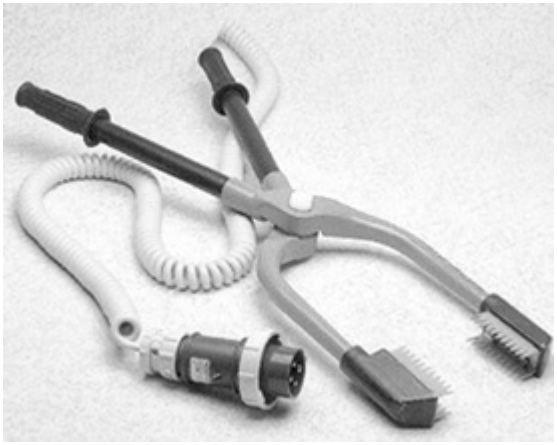
### Electrical killing

Electricity can be used to stun and kill animals. This method involves stunning the animals with electricity and 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). Bleeding is not recommended during a disease control operation as it is a biosecurity risk, and so electrocution should be performed.

The purpose of electrocution is to kill the animal by stopping the heart from pumping blood around the body (known as ventricular fibrillation). If this happens, the brain will be starved of oxygen and rapidly die. When an appropriate electric current is passed through the heart it goes into a state known as ventricular fibrillation, meaning 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. 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 stunned immediately using a captive-bolt device followed by pithing 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.

Please also see the HSA publication *Electrical Stunning of Red Meat Animals* on-line guide http://www.hsa.org.uk/electrical-stunning-of-red-meat-animals-introduction/introduction-1.

### Killing mammals using electricity – two stage application



The two-stage application of electric current may be performed to kill young and adult sheep and goats, and calves and pigs over one week of age. It comprises the application of current to the head by scissor type tongs which stuns the animal, followed immediately by the application of the tongs across the chest in a position that spans the heart which causes death by cardiac arrest. The heart is particularly susceptible to low frequency current e.g. 50 Hz, but not to higher frequencies. Therefore, it is important to check that the frequency of the stunning equipment is set to 50 Hz. The application of electricity to the animal's head during the first stage results in unconsciousness and seizures. 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. The electrical current is applied for a minimum of three seconds. Stage two is performed as soon as possible after the head-only stun when the animal

is unconscious and the tongs are applied across the chest so they span the heart for a further 8-10 seconds causing the death of the animal via cardiac arrest. It is vital that the operator ensures the animal is unconscious before the second application is performed, as electrocution is known to be an extremely painful experience. The electrodes should be applied firmly for the entire duration of time and the pressure should not be released until the stun is complete. Two team members are required to perform the two-stage killing method with electricity. The first is responsible for the application of the electrodes to the animal, and the second can manipulate the position of the animal to allow the second application to be made. Stunning equipment is developed and designed to be efficient in a specific context. Manufacturers are therefore required (EC 1099/2009) to provide detailed instructions to users, concerning the conditions under which equipment should be used and maintained, to ensure optimal animal welfare.

### *Stunning and killing parameters*

The frequency of the current should be no greater than 80Hz because, as frequency increases, ventricular fibrillation is less likely to result. The appropriate voltage and current required depends upon the species and age of animals as in Table 1.

**Table 1: Minimum electrical parameters for stunning and killing livestock.**

| Species and age of animals | Minimum current (A) for stun (head only) | Current (A) applied to heart in order to kill |
|---|---|---|
| Cattle | 1.28 | 1.5 |
| Calves | 1.25 | 1.25 |
| Adult sheep and goats | 1.0 | 1.0 |
| Kids and Lambs | 1.0 | 1.0 |
| Pigs 6 weeks + | 1.3 | 1.3 |
| Pigs under 6 weeks | 0.5 | 0.5 |
| Goats | 1.0 | 1.0 |

NB: These parameters have been developed for clean animals with relatively low resistance. High resistance caused by thick fleece or dirt may affect the efficacy of a stun and parameters should therefore be adjusted in accordance with Ohm's Law to ensure the animals are adequately stunned/killed.

It is important to keep the contact resistance as low as possible to maximise the flow of current. 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. The conductivity of the exterior of the animal may be improved by wetting the skin or fleece. From the perspective of the operator, it is possible to minimise the contact resistance by applying electrodes in the correct position and maintaining constant pressure for the duration of the application. Table 2 shows the variation in resistance (Ohms) caused by fleece cover on sheep.

**Table 2: Approximate electrical resistance of sheep with varying fleece cover.**

| **Species** | **Wool growth** | **Resistance (Ohms)** |
|---|---|---|
| Sheep | Light fleece cover | 150-400 |
| | Heavy fleece cover | 150-1000 |

Very often there is a build-up of grease and dirt on the electrodes. This is especially likely when the equipment is used on-farm. This build-up increases the electrical resistance and must be regularly removed. Failure to clean electrodes will lead to corrosion, further increasing resistance. The electrodes must be thoroughly cleaned to the manufacturer's specifications regularly, to maintain optimum electrical contact with the animal. 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 3 below shows the variation in stunning parameters required for an effective stun if resistance is high. For a more detailed explanation of electrical stunning and the parameters required please see the HSA publication *Electrical Stunning of Red Meat Animals* on-line guide http://www.hsa.org.uk/electrical-stunning-of-red-meat-animals-introduction/introduction-1.

**Table 3: Voltage and current required to effectively stun pigs and sheep if resistance is either low or high.**

| Species | Voltage (V) | Resistance (Ω) | Current (A) | Effective Stun? |
|---|---|---|---|---|
| Pig (clean electrodes) | 250 | 150 | 1.7 | Yes |
| Pig (dirty, worn electrodes) | 250 | 350 | 0.7 | No |
| Sheep (short, wet fleece) | 250 | 200 | 1.3 | Yes |
| Sheep (long, dry fleece) | 250 | 1000 | 0.3 | No |

Modern electrical stunning equipment is constant current by design and will automatically adjust the applied voltage to maintain the required current, this has obvious welfare benefits. However, it remains critical to reduce contact resistance by keeping the electrodes clean. Electrical stunning equipment should be regularly tested by a qualified electrician to ensure that the output to the tongs is isolated from earth.

The handler and slaughterman must wear appropriate protective clothing (rubber boots) to minimise the risk to their own health and safety. Animals should be located in a pen which has a reliable supply of electricity. The animals' death should be confirmed following the two-stage application of electricity using the criteria described in Figure 4. The person performing the kill should ensure the absence of brainstem reflexes for every animal. If there is any doubt surrounding the success of a stun or kill, an alternative method such as death by free-bullet firearm or captive-bolt followed by pithing, should be performed immediately.

### *Considerations when using electrical methods during depopulation due to disease control*

There are advantages in using electricity to stun and kill animals during a disease control operation. A major advantage over firearms and captive-bolt devices is the great reduction in risk to biosecurity. The method is non-invasive, ie. the skin remains unbroken. Therefore, there is less concern regarding the presence of contagious pathogens entering and contaminating the environment. Unlike the methods described in the previous section, the brain also stays intact, meaning it could potentially be used for diagnostic analysis post-mortem.

The two-stage application of electricity is particularly well suited for use with adult pigs. As mentioned above, due to the conformation of these animals' skulls, problems can arise when using mechanical killing methods. However, when using electricity this is not an issue. This method is also less hazardous for the handlers and killing personnel. Compared to mechanical methods, post-stun/kill convulsions of animals are reduced which means there is less risk to human safety.

There are disadvantages associated with the method. The two-stage method requires a reliable supply of electricity and the electrodes need to be applied and maintained in the correct positions to produce an effective stun and kill. The procedure may be physically demanding for the slaughterman and animal handler. If a large number of animals are to be killed, operator fatigue and poor electrode placement are a real concern. It is recommended that, where possible, the killing operative and handlers swap between tasks, or take regular breaks to prevent fatigue.

An important consideration regarding the welfare of animals is the risk of high contact resistance. This is a particular concern when applying the method to adult unshorn sheep as the fleece may prevent the required voltage from being administered, especially as the tongs are applied to the chest. In addition, sheep breeds with high levels of wool cover on the head can increase the difficulty in maintaining low resistance contact. If necessary a saline solution may be applied to aid conduction. The horn position of sheep, particularly males, may also impede the electrode placement during stage one. It is also very important to clean the electrodes regularly to maintain minimal resistance. Using a wire brush, powered wire wheel or cleaning solution after use on 20–25 animals will help to maintain the equipment. Between killing operations, the tongs should be stored in a dry environment with the electrodes protected from potential damage.

### *Conclusion – species and situations*

This method is suitable for use with small ruminants (although those with full fleece and horns may be problematic), pigs and calves (over one week of age).

## Methods suited for young animals (neonatal lambs, calves and piglets)

### *Blow to the head*

In an emergency situation infant lambs, kids and piglets (up to 5 kg) can be humanely killed by delivering a heavy blow to the head (only 70 animals per person per day). This must only be used if no other method is available.

There are two variations of this method:

- Hold the animal by the back legs and deliver a firm blow to the back of the head with a blunt instrument, e.g. an iron bar or hammer.
- Hold the animal by the back legs and swing it through an arc to hit the back of its head with considerable force against a solid object, e.g. a brick wall or metal stanchion.

With both methods it is essential that the blow is delivered swiftly, firmly and with absolute determination. If there is any doubt that the animal has not been killed effectively, the blow should be immediately repeated.

Death should be ensured by bleeding the animal by cutting the throat from ear to ear to sever both carotid arteries and both jugular veins. However, as mentioned previously, bleeding should only be performed during a disease outbreak when absolutely necessary. An alternative method is to insert the knife into the base of the neck towards the entrance of the chest to sever all the major blood vessels where they emerge from the heart. More information: Bleeding.

### *Considerations when using blow to the head during depopulation due to disease control*

As this method should only be used as a last resort it is not appropriate for the advantages to be listed.

There are a number of disadvantages which should be considered fully before resorting to this method. There is great risk of human error and inconsistency when delivering a blow to an animal's head manually. Although the number of animals is capped at 70 per day it is still very likely the person performing the method will fatigue before this number is reached. This raises the possibility of misplaced strikes and insufficient power. The force applied to the back of the head may cause bodily fluids i.e. blood to enter the environment, and the subsequent "bleeding" presents a possible biohazard if the animals are infected with disease. This method can only be performed on animals which are not currently infected with disease.

### *Conclusion – species and situations*

If no other methods are available delivering a blow to the head can be used with small numbers of neonatal lambs, kids and piglets which weigh less than 5 kg. Under 1099/2009 personnel are limited to 70 animals per day. Due to the high risk of human error which could cause suffering to the animal this method should only be used as a last resort.

### *Captive-bolt followed by pithing or bleeding for neonates*

Recent research has demonstrated that non-penetrative captive-bolt devices are capable of humanely stun/killing neonate piglets and goat kids. Piglets up-to 10.9 kg (0 – 28 days old) should be shot on the midline on the frontal/parietal bone, whereas goat kids less-than 8-days old, should be shot on the midline, between the ears with the chin tucked into the neck. With both species a mechanical captive-bolt device should be used that develops ≥27.7 Joules energy.

Young lambs (under 9 kg) can be killed by a non-penetrative captive-bolt device with sufficient power (≥50 Joules) applied to the head, followed by the severing of the neck vessels as a small proportion of the lambs are simply stunned and not killed.

To kill calves it is recommended that a penetrative-captive-bolt is used along with the heaviest charge available. The animal should be then pithed (see Pithing in adult mammal section) or bled to ensure rapid death. A deep cut from ear to ear with a sharp knife will ensure all major vessels are severed. However, when bleeding calves it is better to use a chest stick where possible.

As mentioned previously in the Penetrative captive-bolt (adult mammal) section, captive-bolt equipment must always be cleaned after use in order to prevent corrosion and pitting of the bolt. A build-up of carbon deposits in the breech can greatly reduce the velocity of the bolt; regular cleaning and maintenance will prevent this. The HSA publication package (DVD and booklet) on Emergency Slaughter https://www.hsa.org.uk/shop/publications-1/product/emergency-slaughter describes and shows the recommended cleaning method in detail.

As with adults, if there is doubt surrounding the efficacy of the stun the procedure should be performed again immediately. If the first attempt was off-target the second shot should be performed in the correct position. If the first shot was in the correct position but ineffective the second should be above and to one side of the normal target position.

### *Considerations when using blow to the head during depopulation due to disease control*

This method has many advantages. Primarily, the immediate onset of unconsciousness which is sustained throughout the killing process minimises pain and suffering making it a very humane method. Compared to delivering a blow to the head manually, using a captive-bolt device gives much higher reliability in terms of power. Also, as the device is positioned when stationary there is a reduced risk of misplaced impact. In addition, the mobility of this equipment reduces the need to move animals, which is beneficial for animal welfare and also for the prevention of disease-spread.

There are also disadvantages associated with using captive-bolt devices to stun or kill neonate mammals. As with using a captive-bolt device on adults, the animal must be restrained. Restraining a neonate may be easier than an adult but care must still be taken to prevent injury. Misplaced shots may be a particular problem if the animals are not adequately restrained and/or become agitated as they may not remain still. The safety of the personnel performing the pithing or bleeding may be jeopardised by the animals' post-stun convulsions. As with the use of firearms the destruction of brain tissue may prevent the diagnosis of some diseases and the leakage of body fluids may pose a biosecurity risk.

### *Conclusion – species and situations*

This method is humane and suitable for use across mammalian species: piglets, kids, lambs and calves.

### *Lethal injection*

In the UK, killing by lethal injection can only be carried out by a veterinary surgeon. The animal will be injected intravenously with a lethal dose of anaesthetic drugs following, in some cases, initial injection of a sedative. The animal will rapidly lose consciousness and die. The most commonly used drugs for this are barbiturates in combination with other drugs. Animals should be restrained in order to guarantee effective administration. For some animals sedation may also be required to prevent movement during the injection. Intravenous administration is preferred, but intraperitoneal or intramuscular administration may be chosen. Doses and routes of administration which cause rapid loss of consciousness followed by death should be used. Animals should be monitored throughout the administration and the following period in order to ensure the drugs have been effectively administered and death can be confirmed by the absence of brainstem reflexes.

When an animal is killed by lethal injection there may be restrictions on how the carcase can be disposed of. The carcase cannot be used for human or animal consumption if it has been killed by lethal injection.

### *Considerations when using lethal injection during depopulation due to disease control*

This method is appropriate during disease control operations, as the risks of infected body fluids entering the environment are minimal. Careful thought, however, must be given to the disposal of carcases when lethal injection has been used, as restrictions may be in place. The method is best suited to smaller animals but could potentially be used in all species across a variety of ages.

This method is advantageous from an animal welfare perspective as death is induced smoothly. As this method does not require bodily fluids to be expelled from the carcase, the biosecurity risk is minimised.

From a practical perspective there are a number of disadvantages to using this method during depopulation for disease control purposes. The application of restraint or sedation may cause distress to the animal, and close handling may prove to be a biosecurity risk when dealing with zoonotic

diseases. There are also serious human safety risks if accidental injection to a person occurs. The availability and use of some drugs is restricted to veterinary surgeons and the administration requires specific skills and training. The time taken to perform this method means it is only suitable for use for a small number of animals. Some combinations of drug type or route of administration may be painful and should only be used in unconscious animals. Carcases which are contaminated with drugs present a risk to wild or domestic carrion feeders and, as such, there may be restrictions on carcase disposal.

### *Conclusion – species and situations*

This method is most appropriate for use with small numbers of neonatal lambs, kids and piglets. Although potentially a high-welfare option, it is costly both in money and time. Its use may also be restricted due to the availability of particular drugs and skilled/licenced personnel.

# Killing poultry

## Mechanical Methods

### Non-penetrative captive-bolt

A captive-bolt device powered by a blank cartridge propels a short, mushroom-headed bolt to deliver a fatal percussive blow as described in the mammal section (captive-bolt). Unlike free-bullet firearms, the bolt remains captive within the barrel because the flange and the buffers returns the bolt to the pre-firing position after the shot. This bolt strikes the animal's head (percussion) which causes concussion and trauma to the brain. In smaller animals such as poultry this blow is sufficient to produce significant damage to the skull and brain resulting in immediate loss of consciousness and death.

For the application of the captive-bolt device the birds should be restrained in cones, shackles or by hand. The bird's head should be held lightly by holding the beak, gently between thumb and finger. The muzzle of the captive-bolt should be positioned on the highest point of the head on the midline of the skull. When looking from the side, the captive-bolt should be pointing towards the area between the bird's eye and ear at 90 degrees to the head. When the bolt is projected allow the head to be propelled out of your hand. Do not try to hold on to the head after firing.

For a small bird such as a chicken you can use either a flat or convex head. For larger birds (duck, goose, and turkey) we recommend that you use a convex head. See Table 4 below for guidelines and consult the HSA technical poster http://www.hsa.org.uk/shop/publications-1/product/stunning-poultry-mechanical-percussive-devices for further information.

**Table 4: Captive-bolt head design and suitability for poultry species.**


If there is any doubt regarding the efficacy of the shot an alternative method such as cervical dislocation should be performed immediately. When used for killing for disease control, access to more than one device may be necessary to prevent overheating. A back-up device should always be available. See the HSA online guide to Emergency Killing and Captive-bolt Stunning of Livestock for more detailed information on the use of captive-bolt equipment. Information is available on the types of equipment available, the correct positioning for different species and the maintenance procedures and safety considerations for captive-bolt equipment. For specific advice regarding non-penetrative stunners for use with adult poultry consult the HSA technical poster http://www.hsa.org.uk/shop/publications-1/product/stunning-poultry-mechanical-percussive-devices

### *Considerations when using non-penetrating captive-bolts during depopulation due to disease control*

This method induces an immediate onset of unconsciousness in birds of all ages. When using non-penetrative captive-bolt devices on-farm, there are some factors to be taken in to consideration.

Care must be taken to ensure the device is well maintained and the positioning is correct when applying the technique. Following the blow, post-stun convulsions can be dangerous to handlers when working with large, heavy birds such as turkey stags; therefore care must be taken to ensure the personnel performing the killing are not injured by involuntary wing flapping. It may not be feasible to use this method for disease control on large farms, particularly with caged poultry as they have to be handled and restrained individually. In these situations alternative methods, such as those described in the following sections may be more suitable.

### *Conclusion – species and situations*

When using cartridge powered devices this method is suitable for killing relatively small numbers of adult poultry on-farm. However, when using compressed-air-powered captive-bolt equipment, larger numbers of birds may be killed in a relatively short time. Care must be taken to ensure the blow delivered by the captive-bolt device is sufficiently powerful and the correct bolt head is used for the species involved.

## Stunning and killing poultry using electricity

As with mammals (described earlier) electricity can be used to stun and kill poultry. When killing large numbers of chickens during a disease outbreak, an electrical waterbath is an option for stunning and killing the birds. Alternatively, birds can be stunned individually using tongs before a killing method, such as cervical dislocation can be performed. Stunning and/or killing using electricity is possible for use with all poultry species, although the head feathers of waterfowl may result in an excessively high contact resistance and therefore the use of a non-penetrative captive-bolt or alternative stunning system are preferred for these animals. Of the common poultry species, electrical stun/killing is best suited to broiler and laying chickens.

## Electrical current applied to poultry through an electrical waterbath

A bird may be electrically stun-killed by applying a current at a frequency and amplitude that causes unconsciousness and simultaneously stimulates cardiac muscle into ventricular fibrillation resulting in death by cardiac arrest in a stunned bird. The birds are inverted and shackled before being passed through an electrified waterbath stunner (Figure 10). The birds are stunned and killed simultaneously as electrical contact is made between the live water and earthed metal shackle. When the head of a bird enters electrified water, the electrical circuit is completed. The current flows from the submerged electrode in the waterbath through the water and head of the bird, through the body and legs, to the metal shackle in which the bird is restrained and finally via the earthed rubbing bar.

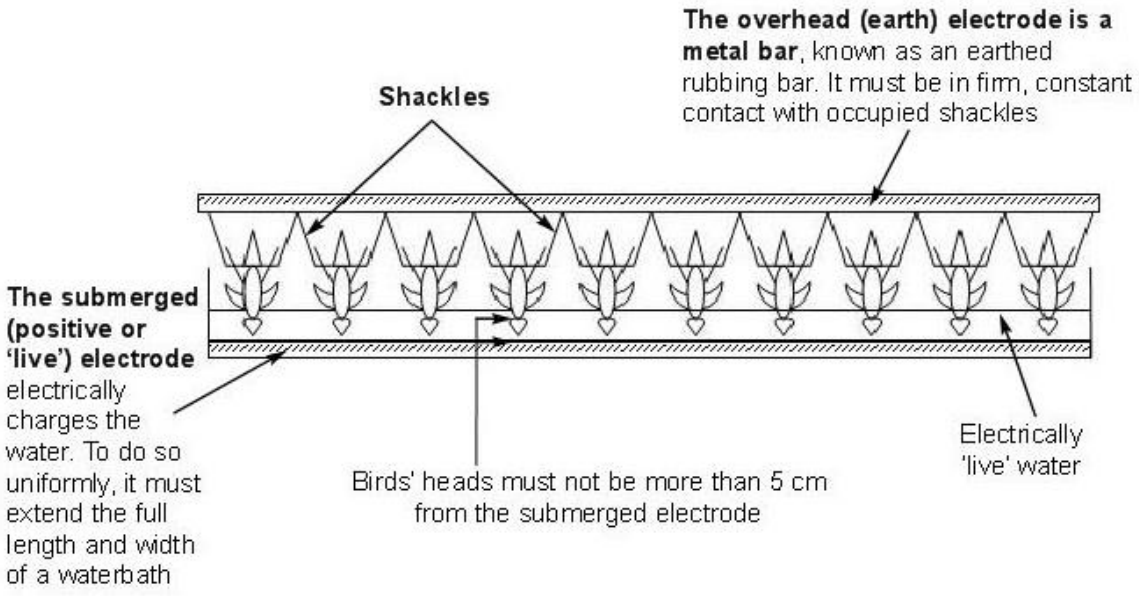



**Figure 10: Illustration of poultry suspended from shackles in waterbath stunner.**

The electrical parameters (voltage, current, frequency and waveform) of a waterbath system can be set to either stun or stun-kill the birds. During a kill for disease control, stun-kill is preferable in terms of efficiency and biosecurity. Table 5 displays the recommended parameters for stunning and killing poultry using an electrical waterbath. Note, the values provided in this table are higher than in the *Electrical Waterbath Stunning of Poultry* online guide. When killing for disease control meat quality is not a consideration and so current should be increased in order to ensure all birds are dead upon leaving the waterbath.

As with all methods, birds should be assessed to ensure they have been killed effectively. If there is any doubt, they should be killed immediately using another method such as captive-bolt or cervical dislocation.

**Table 5: Minumum parameters required to stun and kill poultry using an electrical waterbath.**

| Species | Minimum current amplitude (mA) | Waveform |
|---|---|---|
| Chicken | 400 RMS | Sinewave AC 50Hz |
| Guinea Fowl | 400 RMS | Sinewave AC 50Hz |
| Duck | 400 RMS | Sinewave AC 50Hz |
| Goose | 400 RMS | Sinewave AC 50Hz |

NB: Figures provided for chickens: Gerritzen et al 2006. Turkeys and ducks: M Gerritzen pers comm. 2014.

For more detailed information regarding the use of electrical waterbaths with poultry please see the HSA electronic publication *Electrical Waterbath Stunning of Poultry*
http://www.hsa.org.uk/electrical-waterbath-stunning-of-poultry-introduction/introduction-7

### *Considerations when using electricity during depopulation due to disease control*

The main advantage of using electricity to kill birds during a disease outbreak is that the head and body of the bird remains intact – it is a non-invasive method. This is particularly important when dealing with infected birds as the risk of disease spread is reduced. This method of stunning and killing the birds simultaneously is suitable for use with large numbers of birds.

There are some disadvantages to the use of this method on farm, as it requires specialised, equipment and a reliable supply of electricity at the killing area is essential. The birds need to be caught, handled and transported from their housing to the killing site, which increases the risk to human handlers if the birds are infected with a zoonotic disease. Manual restraint, bird inversion and shackling can also raise welfare concerns particularly with unfit birds. Waterfowl may be particularly difficult to stun/kill effectively with an electric waterbath as they are able to curl their necks, lifting their heads above their breast. If the chest makes contact with the electrified water before the head, there is a risk the duck may experience current flow without loss of consciousness because the brain is unlikely to be in the path of current flow. Regardless of species, if the birds' wings or beaks enter the water first there is also a risk of pre-stun shocks which cause pain and can prevent effective stunning. This will be inhumane. Currently there is limited evidence on the recommended settings for use with waterfowl and therefore alternatives to this method may be more suitable for these species.

### *Conclusion – species and situations*

This method is suitable for use with large numbers of birds such as quails, chickens, ducks, geese and turkeys. However, as welfare problems may arise when using waterbath stunning on waterfowl, alternative means may be better suited to the humane killing of these animals. As electrical stun/killing of poultry requires specialist equipment, gas may be a better alternative for killing large numbers of birds during a depopulation.

## Stunning poultry using electricity followed by a killing method

A single application of an appropriate electric current to the head of poultry causes unconsciousness. This can then be followed by a killing method such as cervical dislocation. The current should be applied to a restrained animal using a device which spans the brain and generates sufficient current to stun. The efficacy of the stun should be confirmed by assessing the bird and ensuring the absence of brainstem reflexes.

The level of current must be sufficient to cause an immediate and effective stun. Recommended levels are 600mA/duck, 400mA/turkey and 400mA for chickens. The electrodes used for this stunning should be cleaned and maintained properly, following the manufacturer's instructions. The personnel performing the stunning should have adequate protective equipment, such as rubber boots and gloves to minimise the risk of injury.

Current flow is reduced by poor contact between the electrodes and the head, which can be made worse by dirt on the electrodes or the bird. Poor current flow can result in an ineffective stun and considerable suffering to the bird. Contact resistance must therefore be kept to a minimum. Using a wire brush, powered wire wheel or cleaning solution after use on 20–25 birds will help to maintain the equipment. Pre-wetting birds' heads (using a wet sponge) can also improve the electrical contact. Current flow can be particularly poor for ducks, geese and turkeys, so the use of concussion stunning equipment is preferable for these species.

### *Considerations when using electricity followed by a killing method during depopulation due to disease control*

Stunning birds using electricity renders the birds insensible instantaneously. From a welfare perspective this is a major advantage of this method. When this non-invasive stunning method is combined with a killing method which also does not require the skin to be broken, e.g. cervical dislocation, the risk of environmental contamination due to body fluids is minimal. This makes it particularly suitable for animals infected with a non-zoonotic disease.

However, when dealing with a zoonotic disease the acts of handling and restraint pose a potential biohazard. Disadvantages also include the need for handling and inversion, which are also likely to cause distress to the bird. This stunning method requires a reliable and sufficient supply of electricity and the electrodes must be positioned with care and attention to guarantee an effective stun. It is also very important to clean the electrodes regularly to maintain minimal resistance. Using a wire brush, powered wire wheel or cleaning solution after use on 20–25 animals will help to maintain the equipment. Between killing operations, the tongs should be stored in a dry environment with the electrodes protected from potential damage. Due to the high time and labour input, this method is not suitable for use during large scale depopulation but is better suited for use with small numbers of poultry. This stunning method must be immediately followed by a killing method, such as neck dislocation.

### *Conclusion – species and situations*

Using electricity to stun individual birds prior to dispatch is suitable for use with small numbers of adult poultry.

## Cervical dislocation and decapitation (manual and mechanical)

Cervical dislocation (pulling the neck to sever the spine) causes death from cerebral anoxia (interruption of the supply of oxygen to the brain) due to the cessation of breathing and/or blood supply to the brain though haemorrhages from damaged blood vessels in the neck. If there are only a small number of birds to be killed (i.e. up to 70 a day to prevent operator fatigue), and other methods of killing are not available, conscious birds can be killed using cervical dislocation but this is not recommended. The HSA strongly advise this method only for killing stunned birds. Birds should be monitored continuously until death to ensure the absence of brainstem reflexes. The killing of birds can be performed either manually (using own hands) if birds weigh less than 3 kg, or mechanically (assistance from a device) if birds are between 3 and 5 kg. The neck should never be crushed using equipment such as pliers as this does not provide a fast and humane death. Performing this method effectively and consistently requires strength and skill, so team members should be rested regularly to prevent fatigue. As this method does not guarantee immediate insensibility, it should be used in

conjunction with a stunning method such as electrical stunning. As with the use of the non-penetrative captive-bolt, an effective kill will most likely result in involuntary wing flapping. For further information on cervical dislocation see the *Practical Slaughter of Poultry* on-line guide http://www.hsa.org.uk/introduction-1/introduction-3

### Manual cervical dislocation

For adult chickens, hold the bird's legs (and the wing tips if possible) in one hand, close to your hip with the underside of the bird's body against your thigh. Using the first two fingers of your other hand, grip the head immediately behind the skull with your thumb under the beak. Stretch the neck downwards, at the same time pressing your knuckles into the neck vertebrae and pulling the bird's head back. Neck dislocation should be achieved in one, swift pull.

### Killing cone

The killing cone consists of a restraining cone with a clamp device below to dislocate the neck. Although not ideal, this method can be used for the slaughter of small numbers of birds. In the EU, this method must not be used to slaughter birds more than 5 kg liveweight. The bird is placed in the cone with the head hanging below. Grip the neck in a clamp and firmly pull the handle down to dislocate the neck.

### Heavy stick

Two people are needed for this method which, although not ideal, may be used to slaughter large birds such as turkeys and geese. In the EU, this method must not be used to slaughter birds more than 5 kg liveweight.

Hold the bird by the legs (and wing tips if possible), with the head and neck on the ground. An assistant should place a heavy stick (or metal bar) across the neck, behind the head. The person holding the legs should then apply firm pressure to the bar, either side of the head, with his or her feet and immediately pull the bird's body upwards using sufficient force to dislocate the neck (this may cause some bleeding).

### *Considerations when using manual dislocation and decapitation during depopulation due to disease control*

There are some advantages to using cervical dislocation after simple-stunning using electricity. As discussed previously the ability to kill the bird quickly while it is unconscious and unable to suffer is beneficial for welfare. Additionally as the technique is non-invasive, i.e. the skin remains unbroken, the risk of disease spread is minimised.

There are some disadvantages associated with the technique. The method is often more difficult to perform with larger birds and it requires trained personnel to perform this task humanely. Regardless of the size of the bird, operator fatigue is a real problem. There are also animal welfare implications as the animals may suffer stress due to handling and inversion. The handling also may cause problems for human health and safety especially if killing due to a zoonotic disease.

### *Conclusion – species and situations*

Cervical dislocation should only be used following appropriate electrical stunning. It can be performed to kill birds during disease control, although it must only be performed on a small number of birds and care must be taken to prevent operator fatigue. In Europe, regulations restrict this method to poultry up to 5 kg live weight when using a mechanical method, and 3 kg liveweight when performed manually. A maximum limit is in place of 70 a day per person.

### Gaseous killing

Gas mixtures which are anoxic, that is lacking in oxygen, can be used to stun and kill poultry. Gas killing is possibly the most feasible option for the mass culling of poultry on-farm during a disease outbreak. Compared to the alternative methods discussed in previous sections, using gas mixtures requires less handling and a higher number of birds can be processed in a relatively short time.

A number of gas mixtures can be used to stun and kill poultry. For welfare reasons the HSA suggests:

(i) any mixture of argon, nitrogen or other inert gases (maximum of 2% total oxygen by volume) OR

(ii) A mixture of argon, nitrogen or other inert gases and $CO_2$ (provided the $CO_2$ does not exceed 30% and maximum free $O_2$ 2% by volume). Some commercially available welding gas mixture may be suitable[+].

[+]When selecting an appropriate pre-mixed gas the best option is to select one with no oxygen in it. Many welding gas mixes include 2% oxygen meaning when you are trying to purge the chamber down to low oxygen levels you can never get below 2%, and would have to purge ALL the atmospheric air to do so.

Birds can be exposed to these gas mixtures by three methods:

1. The first method, controlled atmosphere stunning/killing, is performed by exposing animals to a predetermined mixture of gas in a gas-filled container or apparatus i.e. the animals are introduced after the gas is present
2. The second method also relates to the killing of poultry using a controlled atmosphere. In this method birds are placed in crates or transport modules and put in a sealed container into which the gas mixture is introduced i.e. the animals are put in the container then gas turned on.
3. Method 3 involves the introduction of gas in to a sealed poultry house. This includes the use of Nitrogen filled foam.

When stunning and killing using gas, it is essential that the equipment allows the oxygen concentration to be constantly and reliably monitored. It is also advisable that, where possible, a viewing window allows operators to visually inspect birds while they are in the apparatus or house. To prevent disease spreading, if equipment such as crates, gas containers and hoses are transported between farms, or even different locations on the same farm, it is essential that these are fully cleaned and sterilised.

### Method 1 – Animals placed in container or apparatus pre-filled with gas

Large metal containers, such as skips, can be covered and the gas mixtures introduced. When the desired concentration of gases is achieved, birds are introduced through openings in the top. The birds are added into the container by hand after being carried from their housing. When introducing birds from the top of a container, care should be taken to prevent broken bones and bruising while they are still conscious. Birds should have sufficient space while in the container to ensure they are not overcrowded which may lead to them unintentionally suffocating. The rate at which birds are added to the chamber must also be carefully controlled to prevent smothering before the onset of unconsciousness

The gas concentration must be continually monitored, especially when doors or hatches are opened and closed allowing gas to escape. The desired concentration must be maintained for a sufficient time to allow all animals to die before being removed. It should take less than 2.5 minutes to kill chickens and turkeys, but five minutes for geese and ducks. However, the concentration should be maintained for *at least* five minutes after the last birds have been added to the container regardless of species. If the container has a viewing window this can be used to assess the state of the birds. Without a viewing window, the cessation of vocalisation and wing flapping sounds can be heard from outside the container and can be used to determine the birds are unconscious and after continued exposure will be dead. Birds leaving the container *must* be confirmed to be dead; any for which there is doubt must be killed using a back-up method such as non-penetrative captive-bolt. The carcases of birds from previous batches must be removed before birds from a subsequent batch are added.

### *Considerations when using pre-filled gaseous methods during depopulation due to disease control*

There are a number of advantages of using this method during a disease outbreak. The sizes of the containers are known and therefore the volume of gas required can be estimated during the planning

stages. As more birds are added to the containers, gas will be lost from the opening and therefore the actual amount of gas required will depend on how frequently the flaps are opened and closed. As the technique is non-invasive, meaning the skin remains unbroken, there should be no release of contaminated bodily fluids entering the environment. This ensures the disease transmission risk is kept to a minimum. These containers are dead bird disposal skips with specially designed tops. Once the skip is full, and all the birds dead, a telehandler is used to remove the lid which is replaced with a sheet. The skip is then pulled on to a lorry and removed. The containers are typically made of metal and can be easily disinfected after use. Although the apparatus and equipment used may differ from those used by catchers and handlers on a daily basis (skip rather than crate) it should not be hard for the skilled handlers to use the system.

Handler health and safety is generally maintained as the units are operated from the outside and the gas disperses quickly once the doors are opened. However, when adding birds in to the top of the containers the handlers must climb stairs. Adequate care and attention is required when walking up and down stairs, especially when carrying restless birds in wet weather.

There are some disadvantages to this method. From a practical perspective the containers and apparatus may be difficult to obtain, or may be expensive. The number of birds in a batch is limited by the number of people in a catching team and the size of the containers. When considering animal welfare, this approach raises some important concerns. The stocking density of the animals may increase the risk of suffocation due to overcrowding. The speed at which birds are added to the container needs to be carefully controlled to allow them to become unconscious before more birds are added in on top of them – for welfare reasons they should not be added in continuously. The act of dropping birds in through the roof of the container is also particularly concerning as it may lead to broken bones and bruising while the animals are conscious. Immediately entering an anoxic environment is known to be aversive and the animals are not rendered immediately unconscious. Confirmation of death should occur before the animals are released from the container, however, as the humans and animals are apart this is difficult and animals which are not killed may go unnoticed. If any birds are still alive following removal from the container, a backup method such as a captive-bolt must be used immediately.

### *Conclusion – species and situations*

Method 1 is suitable for use with poultry although, as there are serious welfare concerns, alternative methods should be considered first.

### Method 2 – Poultry confined in crates or modules placed in chamber into which gas is then introduced

Birds may be killed by loading them into a chamber while confined in crates or modules. In contrast to method one, when the birds are initially placed in the chamber the oxygen levels are still normal (i.e. 20.7%) and lowered gradually as the oxygen in the air is replaced with another gas mixture. This seeks to reduce the aversiveness of the experience as the animals gradually lose consciousness as the gases infuse over a period of 60 seconds.

The birds should be caught gently and placed in crates or modules and the stocking density should allow all birds to sit down.

The crates or modules are placed inside the container either by hand or by using machinery such as a forklift. The door is then shut when the operator is ready to administer the gas. When the door is secured the gas is delivered until a minimal concentration of oxygen is achieved at the top of the container (5% $O_2$ for chickens and turkeys, 2% for waterfowl when using inert gas/CO2 mix. 2% $O_2$ for all species when using pure inert gas). The gas concentration must be checked using a gas meter and this level should be maintained until all birds in the group have been killed. If the container has a viewing window, it can be used to assess the state of the birds. Without a viewing window the cessation of vocalisation and wing flapping sounds can be heard from outside the container and be used to determine the birds are unconscious and, after continued exposure, will be dead.

Upon removal from the chambers, all birds should be inspected and if any are found to still be alive they should be killed immediately by use of an alternative method, e.g. captive-bolt.

Although at sufficient concentrations (see above) it should take less than three minutes to kill chickens and turkeys, and five minutes for geese and ducks, the concentration should be maintained for *at least* five minutes after the desired gas concentration has been achieved.

### *Considerations when using chambers into which gas is introduced during depopulation due to disease control*

This method of killing birds has advantages. As with Method 1 the size of the containers are known and therefore the volume of gas required can be calculated during the planning stages. The containers are typically made of metal and can be easily disinfected after use. Handler health and safety is maintained as the units are operated from the outside and the gas disperses quickly once the doors are opened. The apparatus and equipment used is the same as, or similar to, those used on a daily basis and so skilled handlers should be able to perform these tasks easily. As with Method 1, this technique is non-invasive. Thus, there should be no release of contaminated body fluids in to the environment and the disease transmission risk is kept to a minimum.

Compared to Method 1 there are some improvements in terms of animal welfare. As the birds are placed in transport crates or modules uniformly they are less likely to smother each other and are unable to pile on top of one another. They are introduced into the chamber before additional gas is introduced. The slow introduction of anoxic gases is believed to be better for the birds' welfare. This system can also be scaled to suit the needs of the operator from a backyard smallholder to a large commercial unit.

There are some disadvantages to this method. Animal welfare may be compromised by the need to catch and handle birds. As poultry are not habituated to this experience it is likely to cause fear and distress. Improper handling is also likely to cause physical injury, particularly when being lifted out of cages or into the crate/module. From a practical perspective the containers and apparatus may be difficult to obtain, or may be expensive. When used for depopulation on a commercial scale, this method also requires machinery to load the crates or modules into the container, such as forklift trucks. As with all three methods it is difficult to assess welfare if the container does not have a window.

### *Conclusion – species and situations*

Method 2 is suitable for use with adult poultry, pullets and chicks during an on-farm kill for disease control. In theory there is potential for use with neonates such as piglets, but recommendations for durations or gas concentration for neonatal mammals are currently unknown. Although some work has been performed in continental Europe with piglets further research is required.

## Method 3a – Gas ($CO_2$) introduced to sealed poultry house

As an alternative to placing birds in a container pre-charged with a gas mixture, gases can be introduced directly in to the birds' house. In order to maintain birds' welfare, the house should be only be sealed immediately before the introduction of gas to avoid overheating or unintentional suffocation. If the poultry shed has a ventilation system fitted, this should be shut off immediately before gas delivery. There is a possibility that water pipes may freeze during the gas administration and therefore the water should be turned off at the mains and drained. The feeders and drinkers inside the houses with floor reared birds should be raised or removed to prevent obstruction to the gas delivery or injury to birds.

The house should be gradually filled with gas so that all birds are ultimately exposed to a concentration of >45% $CO_2$, measured 50cm above the level of the highest bird, until they are dead. The most common method is to use a source of liquid $CO_2$ which is pumped into the house and released. Preferably the liquid carbon dioxide should be passed through a vaporiser before entering the house. This not only removes the risk of exposing birds to sub-zero temperatures (potentially -80°C), but also speeds up the dispersal of gas throughout the shed. Care should be taken to ensure the birds will not be directly hit by very cold gas delivered at high pressures. Nets or mesh may be used to create a

distance between the gas delivery pipes and the animals. Devices should be placed inside the shed at the maximum height of accommodation of the birds.

### *Considerations when using gas in sealed poultry houses during depopulation due to disease control*

There are advantages when using this non-invasive method to depopulate birds in a poultry house. $CO_2$ is readily available and the application of the gas to birds in their housing eliminates the need to manually remove live birds. This is beneficial to animal welfare as it does not require handling and inversion, which is known to be stressful for birds, and the birds remain in familiar surroundings. The handler also benefits, as reduced handling minimises disease spread. It is believed the gradual raising of CO2 concentrations minimises the aversiveness of the induction of unconsciousness. As the skin is unbroken there should be no release of contaminated body fluids entering the environment, ensuring the disease transmission risk is kept to a minimum.

There are disadvantages to this method which may be detrimental to the birds' welfare. Unlike the containers described in Methods 1 and 2, the size and area volume of a poultry house may be unknown. This means it may be difficult to determine the volume of gas required to achieve adequate concentration of $CO_2$ in some poultry houses. It is also difficult to accurately determine the point at which all animals in the house are dead, which may lead to some animals requiring additional killing methods. The very low temperature of $CO_2$ entering the house, and the formation of dry ice, may cause concern for bird welfare if they come in to contact with it.

### *Conclusion – species and situations*

This method is suitable for use with poultry in a closed environment such as their rearing sheds. The OIE suggests that this method may also be suitable for housed pigs, although further work is required before this can be recommended.

## Method 3b –Nitrogen-filled foam introduced to a poultry house

Foam containing bubbles of anoxic gas has been researched and developed as a method of killing housed poultry during a disease outbreak. A benefit to this is that the house does not need to be sealed as when using gas. Even naturally ventilated, partially open sheds can be depopulated using this method. It is much more flexible and time saving as the foam can "plug" small holes in the house structure when it is pumped into the shed and fills the building.

In the USA, medium density fire-fighting foam created with atmospheric air has been approved for the depopulation for housed poultry. This foam has a high water content and the small bubbles do not break and are ingested by the birds, which are killed due to the obstruction of the airways by the liquid components of the foam. However, this is not recommended as death as occlusion of the respiratory tract is not considered to be humane.

A better alternative is a foam containing nitrogen. The movement of the birds breaks the bubbles and releases the inert gas. This foam differs from the medium density fire-fighting foam as it has a low water content and is sometimes referred to as "dry foam". This method is preferred as birds do not suffocate due to their airways being obstructed. Death is caused by exposure to the pure nitrogen gas contained within the bubbles which break around the birds.

**Figure 11: Use of nitrogen filled foam during depopulation of a poultry house. Note how the foam provides a seal for the building. Photo credit Julian Sparrey, Livetec Systems**

### *Considerations when using nitrogen foam during depopulation due to disease control*

Using gas-filled foam to kill birds in their houses has a number of advantages. As the technique is non-invasive, there is no contamination of the area with body fluids. When used during a particularly pathogenic strain of disease, such as avian influenza, it may be possible to add anti-viral compounds to the foam to assist in the decontamination and clean-up process, although further research is required in this area. No handling of live birds is required, which is beneficial as it prevents the spread of zoonotic diseases. As handling only occurs once the birds are dead it means this job does not require skilled personnel and, as such, can be performed by anyone. The procedure and time to cull a farm is quicker as sheds do not need to be sealed (see Figure 11). It is also possible that handling can be avoided entirely, as a catching machine could be used once the foam has subsided. From a practical perspective it is beneficial to Method 3a, as the foam can fill gaps in the house structure. This allows the shed to be filled even if small gaps between the walls and roof are present, which is not possible with whole-house gassing and reduces the need for people to enter the shed to make repairs prior to the kill. An additional benefit is that, as the foam covers the animals and contains the pockets of nitrogen gas, the foam does not need to fill the shed up to roof level. This allows the killing staff to view the shed through a window or gap in the roof to assess the coverage. The birds do not appear to be startled by the presence of the foam, nor do they try to escape from it once in contact. Additionally, the birds are killed in their home environment, which is likely to be beneficial to their welfare compared to methods which take place outside of the familiar environment. However, a disadvantage to this method is the cost. It is expensive compared to whole house gassing by direct liquid nitrogen injection.

### *Conclusion – species and situations*

Method 3b is suitable for the killing of large numbers of poultry during a disease outbreak. It has previously been used on-farm with chickens and successfully trialled with waterfowl and turkeys.

## Addition of anaesthetics to feed or water

An anaesthetic agent (e.g. alpha-chloralose) can be mixed with poultry feed or water in order to kill birds in houses. The birds which are not killed directly but are only anaesthetised must be killed immediately by another method such as cervical dislocation. In order for this method to be successful the birds must consume sufficient quantities of anaesthetic rapidly. In order to encourage birds to eat or drink the anaesthetic it may be worthwhile to fast them for a period of time.

### *Considerations when using anaesthetics during depopulation due to disease control*

Using anaesthetics to kill birds is advantageous in that it requires relatively low levels of human labour. As the agents are added to the feed and water the birds can be left to consume it themselves. Additionally, handling of birds is not required until they are anaesthetised, which make handling easier while reducing distress for the birds. As the skin remains unbroken and carcase intact, there should be no release of contaminated body fluids entering the environment ensuring the disease transmission risk is kept to a minimum.

There are a number of disadvantages associated with this method. The dose required to kill a house of birds may be difficult to calculate and there is no guarantee the animals will ingest the drugs as alterations to taste may cause the animals to reject the feed and water. For this reason, variable results may be obtained. Targeting of specific animals is not possible and, outside of a controlled environment, non-target animals may accidently access the medicated feed or water. The time taken for animals to consume the food and be affected may vary considerably throughout a shed. It is also possible that animals which are already anaesthetised or dead may prevent other individuals from accessing the feed and water points. Care is essential in the preparation and provision of treated feed or water and in the disposal of untreated treated feed/water and contaminated carcasses.

### *Conclusion – species and situations*

This method is suitable for killing large numbers of poultry in houses. However, due to welfare concerns this should only be used as a last resort.

## Chicks (less than 72 hours old) and embryonated eggs

### Maceration/Instantaneous Mechanical Destruction (IMD)

For the killing of embryonated eggs and day-old poultry, a mechanical apparatus can be used to macerate the animals. There are two types of device currently in use in the UK. The first is a "crushing" design which causes the chicks to be crushed between two rollers which are rapidly rotating. The second approach is a "knife-type" design containing fast moving blades which mince the chicks. Although it is aesthetically unpleasant, IMD is an acceptable and humane method of chick disposal providing the equipment has been well maintained and used responsibly.

It is essential the flow of birds into the apparatus is slow enough to avoid the equipment jamming, birds rebounding from the blades or birds suffocating prior to maceration.

For further information on the use of IMD devises see the HSA's Code of Practice for the Disposal of Chicks in Hatcheries http://www.hsa.org.uk/shop/publications-1/product/code-of-practice-for-the-disposal-of-chicks-in-hatcheries and technical note on IMDs http://www.hsa.org.uk/downloads/technical-notes/TN9-mechanical-destruction.pdf

### Gas

Young chicks may also be killed using anoxic gas mixtures. Chicks could be placed in to a pre-filled gas chamber. Alternatively they could be placed in to an open chamber which is then sealed and gas added when all chicks are in position. The latter is preferable from a welfare perspective as it allows gentler handling of the conscious birds and a more gradual introduction of gas mixture.

Gas mixtures can be:

(i) 90% argon (or other inert gas) and a maximum of 2% total oxygen by volume (2% total oxygen by volume is the proportion of oxygen in a 90% argon, 10% air mixture, as the amount of oxygen in air is 20.9%).

(ii) a maximum of 30% carbon dioxide and a minimum of 60% argon (or other inert gas) with no more than 2% total oxygen by volume

(iii) the highest possible concentration of carbon dioxide from a source of 100%
(not recommended by the HSA due to the aversiveness of high concentrations of $CO_2$).

It must be noted that when anoxic gas mixtures are used for the euthanasia of day-old chicks the residual oxygen concentration is critical. This must be kept below 2% and exposure to the gas mixture must be for long enough to ensure that all chicks are all killed effectively and as quickly and humanely as possible. The HSA recommends that residual oxygen level should not exceed 1%.
The minimum dwell times given in Table 6 below must be adhered to.

**Table 6: Minimum dwell times for chicks, poults, ducklings and goslings.**

| Species | Time |
|---|---|
| Chicks | 3 Minutes |
| Turkey poults: sickly, injured or deformed | 3 Minutes |
| Turkey poults: healthy | 5 Minutes |
| Ducklings and goslings | 5 Minutes |

For further information regarding the use of gas to kill poultry chicks see the HSA technical notes http://www.hsa.org.uk/downloads/technical-notes/TN14-gas-killing-of-chicks-in-hatcheries.pdf

The HSA's Code of Practice for the Disposal of Chicks in Hatcheries http://www.hsa.org.uk/shop/publications-1/product/code-of-practice-for-the-disposal-of-chicks-in-hatcheries

### *Considerations when using IMD during depopulation due to disease control*

IMD and gas can be used to kill a large number of young chicks quickly. IMD is preferred when possible as it results in immediate death. Both methods however required specialised equipment and macerated tissues and contaminated blades may present a biosecurity and human health and safety risk.

### *Conclusion – species and situations*

Gas is suitable for killing day old poultry chicks, however care must be taken to ensure the appropriate concentration of gas is maintained. IMD is suitable for killing day old poultry chicks and embryonated eggs.

## Carcase disposal

It is important that when animals have been killed on-farm or in other situations outside the slaughterhouse, the carcases should be disposed of properly and promptly. Apart from the obvious environmental, public health and disease implications, this is often also a legal requirement. Therefore, in addition to complying with the necessary firearms legislation and undertaking training to gain the skills required to kill animals humanely, the prospective operator should also have a carcase disposal procedure in place before killing an animal. However, it is recognised that this may not be possible in the case of an emergency such as disease outbreak. Also remember that if a large animal, an adult bovine for example, is killed in a confined space such as an indoor pen, the carcase must be removed promptly. If left for too long it will go into rigor mortis and will be difficult to remove.

You should avoiding piling carcasses where possible, as this traps heat and accelerates putrefaction. Carcasses should be sprayed liberally with disinfectant and, when they are moved, the ground beneath should also be sprayed well. Do not load carcases onto the lorries too far in advance of their departure. Bloating may cause the containers to split! To avoid cattle bloating, the abdomen may be cut open, although this may present a biohazard risk if the animal is diseased. If the carcases are not able to leave the site immediately wrap the heads, and in some cases feet, of dead animals in heavy duty plastic bags and secure well with tape. These can be covered with sheeting to prevent the attraction of wildlife which may lead to further disease transmission.

Legislation regarding carcase disposal varies between countries. Operators should take care to ensure that they comply with relevant local and national laws.
Depending on the circumstances, the options for carcase disposal may include:

1. transport to an abattoir, making sure to comply with any relevant food hygiene legislation;
2. collection by or delivery to a knacker yard for disposal;
3. collection by or delivery to a licensed incinerator.

Other options available for carcase disposal on-farm include hunt kennels, burial and incineration. Your options may be subject to national legislation, check with your local authority before proceeding to dispose of any carcases on-farm using these methods. If the animals have been killed by lethal injection the carcases must be identified especially if they are to be picked up by the knacker. Prior to their removal from the farm they must be stored in sealable containers.

## Points for consideration after killing/end of the day

After the last animal has been killed at least one slaughter-person must remain on site for an additional 30 minutes to ensure all animals have been successfully dispatched. If any animals are found to be alive they must be killed immediately before the slaughterman leaves the site.
When you are leaving the site clean then disinfect yourself and your vehicle thoroughly with soap/degreaser and rinse with water, prior to applying approved disinfectant. Remove your disposable overalls and ensure they do not accidently enter any “clean” areas. If they do, tell someone immediately. Any equipment, instruction manuals, fences/gates etc which have been used during the kill must be disinfected at the end of each day.

Psychologically it may be difficult to switch off after spending a day working in these conditions. However, allowing yourself some reflection may prove to be beneficial to your own mental health and may help you to plan in case you are involved in a similar situation in the future. Some questions you could ask yourself include:

- Were your tasks conducted in a safe manner, and were risks minimised?
- Were the animals treated humanely with no unnecessary suffering?
- Were the biosecurity protocols followed?
- If you performed the role of incident commander were you aware of any concerns, problems or difficulties the teams experienced? Were these problems rectified? Were the problems and solutions recorded in order to prevent the same issues arising in future?

### Additional Useful Links

DEFRA
https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs

APHA
https://www.gov.uk/government/organisations/animal-and-plant-health-agency

OIE
http://www.oie.int/

Northern Ireland’s Department of Agriculture, Environment and Rural Affairs
https://www.daera-ni.gov.uk/topics/livestock-farming