AUSTRALIAN VETERINARY EMERGENCY PLAN

AUSVETPLAN

Operational manual

Destruction of animals

Version 5.0

AUSVETPLAN is a series of response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

National Biosecurity Committee

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1 Introduction

1.1 This manual

This manual is an integral part of the Australian Veterinary Emergency Plan, or AUSVETPLAN (Edition 5). AUSVETPLAN structures and functions are described in the **AUSVETPLAN *Overview***. This manual has been produced in accordance with the procedures described in the **AUSVETPLAN *Overview*** and in consultation with Australian national, state and territory governments and the relevant industries.

This manual describes management considerations and best-practice procedures for achieving destruction of various animal species in an emergency animal disease (EAD) context. It draws on the *Australian Animal Welfare Standards and Guidelines* and *Australian Model Codes of Practice for the Welfare of Animals*, which are the primary references for most species and outline the recommended humane methods of destruction outside of an EAD response. This manual includes these methods, as well as additional options that may be considered in a declared EAD situation—provided the Chief Veterinary Officer is satisfied that a welfare assessment has been conducted. In an EAD response, animal welfare must remain a primary consideration, regardless of the method selected."

1.1.1 Purpose

The purpose of this manual is to provide clear guidance on acceptable destruction techniques for use on most species in most likely EAD situations. When applied skilfully, the techniques described will support the maintenance of animal welfare standards throughout the destruction process while still achieving the EAD response objectives. It is not possible to cover all possibilities, and professional judgment and ethics must be used. Novel techniques (such as those not described in this manual) should only be used with the approval of the jurisdictional Chief Veterinary Officer.

Veterinarians and the livestock owner, industry liaison officer and animal welfare officer may all be able to make a useful contribution to the planning and execution of animal destruction and should be consulted where possible, as suggested in the action plan.

1.1.2 Scope

This manual considers destruction of animals for the purposes of control, containment or eradication of EADs that are included in the *Government and Livestock Industry Cost Sharing Deed in Respect of Emergency Animal Disease Responses* (EAD Response Agreement (EADRA))[1] and for which there are AUSVETPLAN disease specific response strategies.

1.1.3 Principles

Humane destruction is defined as death with minimal pain and distress, and is usually synonymous with a rapid loss of consciousness and a loss of brain function. Death may result from cardiac or respiratory arrest or from destruction of the brain.

For an animal to experience pain, its cerebral cortex and subcortical structures must be functional. If the cerebral cortex is nonfunctional because of hypoxia, depression by drugs, electric shock or concussion, the animal does not experience pain. The process of achieving loss of consciousness with minimal pain and distress to the animal is the key first step to humane destruction. The choice of a terminal procedure to

[1] https://animalhealthaustralia.com.au/eadra/

cause death after loss of consciousness is less important, provided the animal does not regain consciousness.

It is important that the death of the animal be confirmed at an appropriate interval after destruction procedures (see Section 3) and before moving the carcass for disposal. It is the responsibility of all in the destruction team to ensure that animals are correctly assessed to be dead.

The methods described in this manual are contextualised to EAD responses. EAD situations may require depopulation. In these situations, consideration must still be given to the welfare of the animals. Efficient and timely destruction may be a consideration in some outbreaks to ameliorate the risk of disease transmission from pathogen amplification and spread by animals, and for animal welfare purposes.

Where circumstances necessitate large-scale destruction—as may be required in an EAD of intensive cattle, pigs or poultry—operations must be triaged and staged. It may not be possible to cull all the premises identified for depopulation at one time, or even every shed on a single infected premises. It is also important to consider disposal requirements as part of destruction activities. If destruction outruns disposal, it is likely to cause logistical and environmental hazards—for example, creating adverse conditions for responders and impeding disposal as a result of carcass desiccation. In some situations, such as in an outbreak of foot-and-mouth disease, the advantages of depopulating animals more rapidly than disposal may be warranted to reduce virus production and therefore the likelihood of disease spread. Triage should be performed daily because outbreaks are dynamic, especially when infection levels are high. There are many criteria that may be considered when deciding which animals should be prioritised for destruction, including:

- clinical signs—sickest cohorts should be destroyed first
- animal welfare—for example, overcrowding of growing pigs or broilers or feedlot cattle close to processing, young animals, animals in late pregnancy or aggressive animals
- risk of spread—proximity to other premises with susceptible animals and whether multiple production units on the same farm may be treated as separate epidemiological units
- feed availability
- safety of responders and the wider public.

Acceptable depopulation methods must be appropriately planned to ensure that animals to be destroyed are handled in a humane manner before and during depopulation, and experience a rapid loss of consciousness and brain function under the prevailing conditions (AVMA 2019). During depopulation situations, it is essential that these animals are confirmed to be dead before the disposal of their carcasses begins.

Demonstrating a high standard of destruction techniques and respect for the animals is essential during an EAD response. A person experienced in slaughter, euthanasia or destruction of the species, and appropriately trained in animal welfare aspects of animal handling and destruction, should be present at all times during the destruction process.

Health and safety considerations for destruction teams are a key consideration. Officers in charge of operations (usually site supervisors) should be aware of the impact that animal destruction will have on all people involved. They should quickly determine the knowledge, skills and experience of their assistants, and, if lacking, arrange for suitable skilled and competent staff to be developed or obtained.

Site supervisors should also be aware that some people will find the mental and physical stress of destruction procedures too taxing or distressing. Although the livestock owner and their family may choose to be present during the destruction process, this can contribute to significant distress and mental health issues, and this should be carefully considered before encouraging such an option. Counselling, welfare assistance and assessment should be made available for all people directly affected through on-farm destruction activities. The site supervisor should promote services and direct people to the appropriate organisation or service for assistance. This may include specific activities as part of induction and/or as a part of daily and weekly team check-ins.

Media management may be required because there may be media interest, at least initially, in the destruction of animals as part of an EAD response.

1.2 Other documentation

This manual should be read and implemented in conjunction with:

- other AUSVETPLAN documents—including the response strategies, enterprise and management manuals, and any relevant guidance and resource documents. The complete series of manuals is available on the Animal Health Australia website[2]
- relevant nationally agreed standard operating procedures (NASOPs). These procedures complement AUSVETPLAN and describe in detail specific actions undertaken during a response to an incident. NASOPs have been developed for use by jurisdictions during responses to EAD incidents and emergencies
- relevant jurisdictional or industry policies, response plans, standard operating procedures, safety data sheets and work instructions
- relevant Commonwealth and jurisdictional legislation and legal agreements (such as the EADRA), where applicable.

[2] https://animalhealthaustralia.com.au/ausvetplan/

2 Organisation of operation

2.1 Action plan

Planning is essential to ensure that the destruction task is carried out efficiently and is not impeded by lack of resources. An action plan should be drawn up by the animal destruction team leader in consultation with the owner, or the owner's agent, and other officers.

The following procedures form a checklist for the animal destruction team leader and should be followed.

- Consult with the infected premises (IP) or dangerous contact premises (DCP) site supervisor, the property owner/manager, and the local control centre (LCC) animal welfare specialist, veterinarian, technical advisor and industry liaison officer to establish:
  - property layout, facilities and equipment
  - the number, species and locations of animals to be destroyed
  - the destruction technique to be used and an alternative technique
  - the timeframe for animal destruction operations.
- Complete a work health and safety (WHS) risk assessment.
- Consider, in consultation with relevant environmental agencies, any necessary actions to limit possible environmental impacts of the operation.
- Consider media management strategies.
- Consider site security, and make provision to limit unauthorized access to the site.
- Consider closing small-aircraft airspace, especially if using firearms. Contact the Civil Aviation Safety Authority to determine whether a 'Notice to Airmen' (NOTAM) needs to be issued.
- Advise the IP site supervisor of immediate resources needed to move and secure animals to prepare for their destruction.
- Create good handling systems for live and dead stock.
- When practicable (and applicable), move animals to the centre of the IP or to areas furthest from other susceptible animals, including wild animals.
- Ensure that animals not to be destroyed, including domestic pets, are clearly identified and confined away from those animals that are to be destroyed.
- Decide on the appropriate methods and facilities needed for the safe, humane and efficient destruction of the animals.
- Consult with the officer in charge of the disposal team to determine the disposal method(s) and, if necessary, identify centrally located carcass disposal sites as close as practicable to the site of destruction. Coordinated destruction and disposal operations should ensure that both occur efficiently and safely.
- Provide the IP site supervisor with a concise written plan for approval, including:
  - destruction methods (see Section 3)
  - destruction sites (see Section 2.2)
  - order of destruction (see Section 2.3)
  - timeframe

- personnel required
- facilities and equipment needed
- WHS risk assessment.

- Details of the destruction operation should be included on a diagram of the premises on which the destruction will occur.
- Confirm that the site supervisor has a complete inventory of all animals on the property that are to be destroyed. Destruction should not be delayed even if there has been no agreement on valuation. However, where possible, all animals should be valued before destruction.
- If there is a delay in reaching agreement on valuation with the owner or their agent, authority to destroy should be sought from the LCC controller (see the **AUSVETPLAN *Operational manual: Valuation and compensation***). A signed legal order to destroy is mandatory.
- Brief the destruction teams and then supervise and coordinate their activities. Ensure that staff are familiar with the behaviour and handling of the animals and with the destruction technique, including how to assess and confirm death in animals.
- If possible, destruction should take place away from public view.
- Destruction facilities, methods and working conditions must be consistent with personal safety.
- Destruction should be by the most humane method that meets response objectives, and animals must not be removed for disposal until they have been assessed and confirmed as dead.
- Destruction teams should receive adequate rest and meal breaks. Consideration must be given to the mental and physical wellbeing of members of the destruction team. Appropriate resources should be allocated to ensure the health and wellbeing of team members.
- Make every effort to avoid damage to property. Any damage must be recorded and reported promptly to the IP site supervisor, who will draw it to the attention of the owner/manager.
- Check all destruction against the authorised inventory to ensure that all variations are accounted for (e.g. births and natural deaths) and that all susceptible animals scheduled to be destroyed on the day have been destroyed.
- Provide the site supervisor with a situation report at the end of each day.
- Advise the site supervisor of resource requirements.
- Advise the site supervisor immediately once destruction is underway, so that other tasks, such as disposal and decontamination, can be coordinated.

2.2 Selection of destruction site

The factors that need to be considered in selecting a destruction site are:

- facilities available on site
- additional facilities and equipment required
- ability to inspect animals post destruction for assessment of death
- site security
- potential for disease spread
- proximity, ease of access, and transport requirements to the disposal site
- safety of all personnel on the site and in the immediate vicinity

- acceptability to the owner/manager
- environmental considerations
- likelihood of damage to property and services
- the ability to screen the activities from other animals and public view.

2.3 Order of destruction

The order in which destruction is to occur will be determined after consultation with the LCC. The order will be determined by a risk-based, case-by-case assessment that focuses on meeting disease control objectives and acceptable animal welfare outcomes.

Disease-specific considerations may apply. For example, in an outbreak of foot-and-mouth disease, pigs may be destroyed before other species because of their capacity for generating virus aerosols, then cattle, goats and sheep, in that order.

In determining priorities for destruction, some animal welfare requirements could override disease eradication considerations. For example, animals that cannot obtain feed or water, or whose shelter or space requirements have been compromised, should be destroyed before less compromised populations. Sick and distressed animals may require immediate destruction and should be destroyed before healthy animals. Unweaned stock should be destroyed in a timeframe that takes into account their nutritional requirements; young stock would normally be destroyed first. Animals in parturition or late pregnancy should also be given special consideration. Death of the foetus *in utero*, following the death of the dam, is preferable to handling newborn animals. Fractious and potentially dangerous animals, such as bulls, sows with litters, and boars, should be prioritised for destruction.

3 Methods of destruction

This section lists and describes methods of destruction of animals. Preferred and acceptable methods for specific species are discussed in Section 4. Appendix 1 lists unacceptable agents and methods of destruction.

3.1 Choice of method

The final choice of a method, or combination of methods, will depend on many factors, including:

- animal factors
  - the animal species and the age grouping or class
  - the number of animals (individuals versus large numbers)
  - the state of domestication (tame, handled animals versus wild animals)
  - the status of the animal (pet versus production farm animal)
  - clinical presentation and clinical progression
- disease factors
  - type of agent (e.g. virus, bacteria, parasite, prion)
  - zoonotic potential
  - impact of disease on the health of animals (e.g. mortality/morbidity) and animal welfare
  - environmental impacts of the disease
  - mode of transmission (e.g. aerosol, vector-borne)
  - anticipated spread of disease
- logistics
  - resource availability including:
    - equipment
    - consumables
    - appropriate skilled, trained or experienced personnel
    - the type of facilities available
  - whether the animals are housed
- safety
  - firearm safety — proximity of people and infrastructure
  - personal health and safety
  - availability of or utility of personal protective equipment
- environment
  - weather
  - likely environmental contamination from method used
- the method itself

- the efficiency and acceptability of the method
- how rapidly the method can be completed (in consideration of impact of disease on the health or welfare of animals)
- the practicality of the method, including the availability of proficient operators
- the training required by operators to reach proficiency

- compliance with jurisdictional legislation, standards and guidelines
- ethical standards and considerations
- the cumulative level of pain and distress for the animal, including whether it is fit or unwell, and the overall impact of the method on the welfare of the group of animals to be depopulated
- the intended outcome for the carcass/carcase (i.e. method of disposal or future use) and any associated risk (including to people and nontarget species).

Human safety, disease management, and animal welfare are key considerations. Within these constraints, the best destruction method for the species and the circumstances should be selected. Methods of destruction are not ranked in this manual, because important but variable factors may determine the final choice of method.

The aim of any destruction technique is to achieve a rapid loss of consciousness, leading to death with no return to consciousness. The level of pain and distress to the animal before its death should be minimal. Some techniques produce loss of consciousness but not always death. These techniques must be followed by a terminal technique such as pithing or exsanguination. Note that loss of consciousness must be confirmed before use of these terminal procedures.

Where destruction has been performed, animals must always be assessed for vital signs of life (see Section 3.2). If there is any doubt that the animal is dead, it should be treated again; if it is merely unconscious, it should be subjected to a terminal procedure.

In some circumstances, special disease or sampling considerations apply. For example, rabid or suspected rabid animals should be destroyed in a way that avoids contamination of personnel with potentially infective brain or saliva and avoids the risks of handling a rabid animal, and ideally also will preserve the brain (which is the best diagnostic specimen). Similarly, animals with suspected bovine spongiform encephalopathy (BSE), scrapie and other nervous system conditions generally should not be shot through the head, as brain tissue is required for diagnostic testing. They may be shot through the cervical spinal column (neck shooting) or at the chest, to destroy the heart, lungs and large blood vessels, but an accurate shot for humane destruction requires expert anatomical knowledge. Where a head shot is necessary, care needs to be taken to avoid excessive damage to the cerebellum and brainstem. For suspect BSE cases, refer to the *National Transmissible Spongiform Encephalopathy Surveillance Project (NTSESP) National Guidelines for Field Operations*.[3]

If animals are highly infectious and/or are very sick, they should not be removed from the premises without a prior risk assessment and permit. Destruction in situ reduces the risk of spreading the agent, the extent of decontamination required, and risks to the welfare of the animal.

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[3] https://animalhealthaustralia.com.au/wp-content/uploads/dlm_uploads/2025/04/NTSESP-Field-Guidelines-2024-25_final.pdf

Abattoirs may be engaged to assist with destruction of animals following risk assessment and on agreement with government authorities and abattoir management.

3.2 Assessing death

Knowledge of the vital signs of life is important in certifying death. The various destruction techniques used for different species may result in different final behaviours, and it is necessary to understand what is 'normal'. For example, an animal that has recently died may display an 'agonal struggle' (uncoordinated limb movements and gasping), but this is not a welfare concern provided the animal is already dead. Using a terminal technique helps guarantee death but does not remove the responsibility of destruction team personnel to check and confirm death.

Death must be confirmed by competent personnel after destruction and before disposal of animals.

3.2.1 Assessing death following destruction of animals individually

When animals are destroyed by a method that requires individual handling, the following criteria should be confirmed for all species:

- no corneal reflex
- fixed dilated pupils (difficult to assess in some species) (World Organisation for Animal Health (WOAH) *Terrestrial animal health code* Article 7.6.1)
- absence of respiratory movements (temporary respiratory failure possible) (WOAH *Terrestrial animal health code* Article 7.6.1)
- loss of muscle tone—complete lack of movement and lack of muscle tone (e.g. flaccid lower jaw, flaccid tongue), lack of anal tone in mammals; and complete cessation of movement and lack of cloacal tone in poultry (Martin et al 2019; Bandara et al 2019).

Other criteria may include:

- loss of palpebral reflex (tapping the inner corner of the eye/medial canthus elicits a blink response)—although may also occur in heavily anaesthetised animals
- absence of heartbeat and/or pulse; note: heartbeat may persist for some time and may be difficult to hear in field situations and may not be a reliable indicator if used alone (NRC US Committee on Pain and Distress in Laboratory Animals 1992)
- loss of consciousness (animal may only be stunned) (AVMA 2020)
- glazing of the eyes
- lack of response to painful stimuli—withdrawal reflex (may occur if unconscious or unable to move)
- loss of mucous membrane colour (pale and mottled, without refill following digital pressure) (AVMA 2020).

3.2.2 Assessing death following destruction of animals in groups

When animals are destroyed by a method that is applied to a group of animals simultaneously (e.g. foam or bulk modified atmosphere) without handling each individual, every effort must be made to ensure that death is confirmed before carcass removal and disposal.

For a definitive confirmation of death, several observations at set intervals should be made over the immediate post-destruction period (e.g. at dissipation of foam) and if necessary, a secondary method should be applied. For example, for confirmation of death in a shed full of birds, once safe to do so, the shed may be inspected by a walk-through 5 minutes after destruction and venting of CO_2 to confirm no movement (including wing flapping) or vocalisation of birds, and by a second walk-through at 10 minutes. If no movement or vocalisations are observed following the two walk-throughs, then carcasses can be removed and disposed of.

Additional confirmatory criteria include those listed for animals destroyed individually when individual assessment (during destruction or disposal process) is possible.

Return of rhythmic breathing is the main sign that an animal is only stunned and requires retreatment. Signs that an animal has regained consciousness include head or body righting reflex; voluntary vocalizations; spontaneous blinking; eye pursuit (eyes tracking moving stimuli); response to threat/pain test (Terlouw et al 2016). Persistent lack of any respiratory movement is the best indication of death.

Confirmation of death should be included in the destruction plan and supporting standard operating procedures (SOPs).

As animals (other than poultry) are destroyed, they should be marked indicating confirmation of death. A spray pack of commercial stock marker or a crayon is suitable for the purpose.

3.3 Firearms (rifles, shotguns and handguns)

The use of firearms is an acceptable method of destruction, especially for larger animals, and especially where these animals cannot be safely handled and restrained.

Firearms and ballistics are a specialised subject area, and expert advice should be sought when choosing firearms and ammunition for a specific application and scenario. An ideally selected firearm, calibre and ammunition will result in the effective destruction of the target (brain and brainstem, or heart and/or lungs) without exiting the target and posing a risk to people or other animals. Heart or lung shots should only be considered where the accuracy required for a brain shot cannot be achieved—for example when aerial shooting or shooting over long distances, or where there are human safety, animal disease, or diagnostic considerations.

Generally, the minimum recommended firearm calibre for the destruction of large animal species at close distance (under 5 m) is a .22 long rifle (.22 LR). However, this calibre is typically only suitable for younger animals (calves and foals under 3 months of age or pigs under 25 kg). For cattle and horses over 4 months of age it may be necessary to use a .22 magnum or higher calibre at close distance, together with appropriately selected ammunition (cartridge loads and bullet configurations). Higher power (e.g. .223 to .308) may be required for larger, older animals or when shooting over longer distances.

Shotguns are very effective for the killing of most species of livestock in an emergency and may be safer than rifles where there is a risk of overshooting. Although shotguns can be used within 10-15 m, they are very effective when fired 5-25 cm from the target.

For all conventionally farmed livestock species, a 12, 16 or 20-bore shotgun can be used with no. 4, 5 or 6 bird-shot. Buckshot may be more appropriate for mature bulls and boars. Alternatively, in circumstances in which large animals must be destroyed from a distance (approximately 40 m), solid slugs may be an alternative (HSA 2016b).

The *Australian Model Code of Practice for the Welfare of Animals: Feral Livestock Animals: Destruction or capture, handling or marketing* (Standing Committee on Agriculture, Animal Health Committee 1992) is a useful resource and contains additional recommendations for field shooting. The PestSmart website[4] also has very good reference materials as do National Standard Operating Procedures for the use of firearms in various scenarios.

Firearm licensing requirements, and the laws governing storage and transport of firearms, vary from between jurisdictions and must be complied with. Only licensed operators may use firearms. Firearms require registration in the relevant state or territory. Furthermore, it may be prudent to ensure that the reasons for holding a firearm licence (listed as 'genuine reasons' in some jurisdictions) permit the destruction of animals in an emergency response or that firearms registry dispensation is received. In addition to licensing, some jurisdictions may also require licensed shooters to be accredited for the humane destruction of animals.

It is advisable to determine if personnel and contracted shooters are permitted to operate under their own firearms licences or are required to operate under, and comply with, a business or government agency firearms licence. This is often a poorly understood condition for firearms use during emergency animal disease responses, during which a combat agency is required to hold a government agency firearms licence which includes specific conditions and obligations on shooters operating under such a licence.

Firearm safety is critical, and personnel should refer to jurisdictional legislation and operator training materials, in addition to carefully considering the following aspects of firearm safety:

- All firearms are potentially hazardous and should be treated as if they are loaded: safety first.
- Firearms should only be loaded when ready to fire.
- Always wear eye and ear protection when shooting (electronic shooting earmuffs are preferred because they allow personnel to hear other sounds around them during operations, which improves safety).
- Ensure the barrel is clear of obstructions before loading and shooting.
- All firearm users require appropriate training, licensing and proof of expertise.
- When shooting at short range in stockyards, shooters should use relatively lower velocity with hollow-point or soft-point ammunition matched to the size of the animals. Solid-point ammunition should be avoided because solid projectiles can penetrate the skull and exit at high velocity, endangering personnel in the area. Hollow-point or soft-point ammunition deforms when entering the target, destroying brain tissue more effectively. If animals are to be shot unconfined in their paddocks, shooters should use high-velocity ammunition adequate to the task.

[4] https://pestsmart.org.au/

- People other than the shooters and their assistants should be cleared from the area or should stand well behind the shooters. The direction of fire must be chosen to prevent accidents or injury from stray bullets or ricochets. It may be necessary to construct a suitable backstop.
- For maximum impact and the least possibility of misdirection, the shooting distance should be as short as circumstances permit.
- The police should always be notified before firearms are used near populated areas.
- Sedation of animals before firearm use may allow more consistent outcomes and could allow conversion from free projectile to use of captive bolts in some circumstances as a risk control measure.
- Tranquilliser dart guns may be useful for unapproachable animals and/or when other methods (e.g. rifle or shotgun) may not be the preferred option. Tranquilisers must be held and used in accordance with legal requirements for restricted veterinary chemicals.
- Noise suppressors are available and may provide an engineering control for occupational exposure, minimise the welfare compromise to nearby livestock and reduce noise pollution to the local area. There are additional legal requirements for their possession and use. Jurisdictional requirements may vary.

3.4 Captive bolt devices

Captive bolt devices are an acceptable alternative to firearms when animals, especially ruminants, horses, pigs and poultry, can be adequately restrained. Firearms legislation may apply in some jurisdictions.

To be effective, captive bolt devices must be positioned correctly and held firmly against the skull. Animals require individual restraint and so the method is relatively slow, especially when large numbers of animals are to be destroyed. A secondary method should be readily available and applied promptly if the use of the captive bolt does not result in immediate death. Captive bolt devices can be either penetrating or non-penetrating and be powered by either spring, propane, compressed air or blank cartridges. Devices may be a pistol-shape or a cylinder. Cartridge-fired captive bolt devices tend to overheat with repeated use, and some models have daily firing rate restrictions as advised by the manufacturer. If repeated use of these devices is required, it may be necessary to have multiple devices and to rotate them. This rotation allows for optimal performance, because it allows time for the device to cool and provides designated device cleaning time.

For larger animals, penetrating captive-bolt devices are generally more suitable as a destruction method than non-penetrating devices, which typically result only in stunning rather than immediate death in these larger animals.

3.4.1 Penetrating captive bolt devices

Penetrating captive bolt devices are pressed firmly against the skull and when fired, drive a rod-shaped steel bolt with a concave penetrating-end through the skull into the brain. Penetrating bolts concuss and traumatise the cerebral hemispheres and brainstem, resulting in loss of consciousness and usually death. A terminal procedure may be required if death cannot be confirmed.

It is important to ensure that the type of captive bolt, bolt length and propulsive power are matched to the animal being destroyed. Operators should ensure that they follow manufacturer's instructions and that they use the correct stunning devices and cartridges (where applicable) for the specific species, type and age of animals being treated.

3.4.2 Non-penetrating captive bolt devices

A non-penetrating captive bolt device ejects a mallet or mushroom-shaped knocker that delivers a fatal percussive blow, resulting in fracturing of the skull at the site of application and causing considerable damage to the underlying soft tissues of the brain and the brainstem. It is suitable only for small animals, birds, and neonates. In larger animals such as sheep, goats and cattle, this device typically only stuns the animal, which is likely to be reversible. Therefore, it must be followed up by a terminal method, so may not be suitable in field conditions.

With an effective stun, the animal becomes immediately unconscious, collapses and exhibits tonic limb contractions followed by gradual relaxation and involuntary kicking movements.

3.5 Low and medium expansion water-based foam (‘wet’ foam)

Water-based foams are produced by mixing foam concentrate, water and atmospheric air and, less commonly, an alternative gas when gas-filled foams are being used. Refer to Section 3.10.6.

Foam is classified by expansion ratio, which is the ratio of the volume of finished foam produced relative to the volume of solution used to generate it. The three main expansion types are: low (20:1), medium (20:1-200:1) and high (>200:1). Foams with different expansion ratios vary in bubble size, stability, and consistency, which may impact welfare and efficacy outcomes. Therefore, systems must be carefully calibrated and operated within specifications to mitigate these risks.

Production of low- and medium-expansion foams requires a significant volume of suitable water. This necessitates securing contingency plans and an adequate supply before proceeding. Some jurisdictions have access to the required equipment, resources and trained staff, but availability and capacity are limited.

The method involves covering animals with a blanket of foam. The bubbles are small enough to enter the animals’ airways, causing death by mechanical suffocation (Nicol et al 2017, Hewitt 2023). Poor animal welfare outcomes are a risk when systems may not be calibrated appropriately (EFSA AHAW Panel 2008, EFSA AHAW Panel 2017).

The method is scalable and requires minimal contact between responders and potentially infectious animals. The foam confers the added benefit of reducing aerosolisation of viruses such as high pathogenicity avian influenza (HPAI).

Studies have concluded that the mechanism of action is highly aversive (Alphin et al 2010, EFSA AHAW Panel 2017, Nicol et al 2017). Occlusion of the airways caused by air-filled water-based foam is not recognised as a humane killing method in the guidelines for killing animals for disease control purposes by the World Organisation for Animal Health (WOAH, 2016) and more favourable options should be chosen whenever possible.

Additionally, the downside of foam is that there is poor visibility of the animals during application.

3.6 Dislocation of the neck and decapitation

Cervical dislocation and decapitation may be suitable for small numbers of birds but is not practicable as a mass destruction technique. This destruction method is only suitable for poultry weighing less than 5 kg (DAFF 2022), but other factors such as species and age should also be considered, as detailed in Section 4.7.2.1.

The method may be used as a secondary method for larger birds, such as ratites, if they are rendered unconscious with a stunning method first. See Section 4.7.

When performed correctly, cervical dislocation causes the vertebrae to dislocate from the cranium, which causes permanent damage to the blood vessels supplying the brain and spinal cord. This damage leads to loss of blood to the brain, and the destruction of the upper spinal cord causes cessation of breathing. Some sources state it results in immediate unconsciousness and death, while others suggest there may be a delay and raise concerns that birds may suffer pain and distress and die from asphyxiation (Hewitt 2023). Excessive effort during dislocation may lead to unintended decapitation and its associated risks of blood contamination.

Some mechanical aids (e.g. burdizzos) should not be used for cervical dislocation because they may increase the risk of crushing the neck rather than dislocating, which increases pain and time to loss of consciousness and death (Woolcott et al 2018, Jacobs et al 2019, Hernandez et al 2019, Baker-Cook et al 2021, Jacobs et al 2021, Bandara et al 2023). However recent developments of novel mechanical cervical dislocation devices are showing promise. Devices that are proven to cause dislocation of the cervical vertebrae and severing of the spinal cord may be suitable alternatives to manual cervical dislocation (Martin et al 2019).

Decapitation is effective for poultry (less than 5 kg) (DAFF 2022) and neonatal rodents provided that the blade or instrument is sharp and well maintained and that the head is removed in one swift cut. It is important to ensure the neck is cut and not crushed during the procedure. Decapitation is associated with blood loss which may pose additional biosecurity risks. Specially designed cones may be used to aid in the restraint of birds during decapitation. Some research suggests that unconsciousness following decapitation may not be immediate, and that animals may experience pain during this period. As such, decapitation is not recommended as a primary method of killing in conscious animals (EFSA 2019; WOAH 2024).

3.7 Electrical stunning or electrocution

Electrical stunning and electrocution are different and should not be confused with one another.

Electrical stunning serves only to temporarily stun an animal. Unless the animal is killed using a secondary terminal method, such as exsanguination within 15 seconds of the animal becoming unconscious, they will recover relatively quickly (usually within 30 to 90 seconds, depending on species, age and size).

Electrocution on the other hand is terminal and may be administered either as a single step or two-step method. Electrocution using a single step is typically undertaken by handheld devices which are applied to the head and back, simultaneously stunning the animal and causing cardiac arrest (Kramer et al 2022). Two-step systems work by first applying a head-only stun, which renders the animal unconscious, then, within 15 seconds of when the animal becomes unconscious, applying another electrode to the chest or side of the animal resulting in cardiac arrest (AVMA 2020). Electrocution may be hazardous to personnel and is not useful for dangerous, intractable animals. Dehydrated animals that have been off water for too long are poor conductors of electricity and electrical stunning failures are a significant risk. Other methods of euthanasia should be considered in these circumstances.

Electrical stunning (electronarcosis), followed by a terminal method, and electrocution are appropriate methods of destruction of cattle, sheep, goats, pigs, birds and rabbits, however use of this technique in a field setting in particular is contingent upon the availability of equipment specifically designed and manufactured for this purpose and operated by trained and experienced personnel. The Humane Slaughter Association (HSA 2016a) provides a detailed review of the principles of electrical stunning and electrocution of cattle, sheep, goats and pigs.

In August 2024 Animal Health Committee agreed that one-step and two-step electrocution are suitable as terminal methods for all classes of pigs over 1 week of age during an emergency animal disease outbreak (AHC45 OOS13).

3.8 Manual blunt force trauma

Manual blunt force trauma may be suitable for destruction of small numbers of animals in certain circumstances (see Section 4). Successful application of this method is dependent on the weight and size of animal and the skill of the operator. The percussive blow may not always be of a magnitude to produce death, in which case a secondary method should be applied.

There is a significant risk for animal welfare harm associated with blunt force trauma, due to inappropriate practice, lack of accuracy, issues with repeatability, and operator fatigue (Dalla Costa et al 2020, Hewitt 2023).

Assessments during actual emergency responses have shown concerning failure rates, and because of this, it is recommended that manual blunt force trauma only be used when no other method is available, and then be limited to small numbers of animals (Hewitt 2023).

Where possible, non-penetrating captive bolts (in neonates and some small species) can be used in preference to blunt trauma, achieving death via a very similar mechanism but allowing for more accuracy, which ensure greater effectiveness.

3.9 Immersion anaesthesia

Tricaine methane sulfonate (TMS, MS–222) can be used for destruction of amphibians and fish in an immersion solution (see Section 4.12).

Drowning or suffocation of any species is not acceptable (unacceptable techniques are listed in Appendix 1).

3.10 Modified atmosphere

Normal atmosphere is composed of nitrogen gas (N_2) 78%; oxygen gas (O_2) 21% and carbon dioxide (CO_2) 1%. The addition of inhalation agents alters atmospheric composition. When this altered atmosphere is inhaled it causes loss of consciousness followed by respiratory depression and death from hypoxia. The type and concentration of gases will affect the time it will take time to achieve equilibration of gas concentrations in the alveoli, blood and brain. Therefore, destruction will take some time. This also affects the level of distress an animal may experience before losing consciousness.

Inhalation agents come in a variety of forms and can be used in a range of species, however there are gas and species differences to be aware of. Neonatal animals appear to be relatively resistant to hypoxia; therefore, they take longer to die than adults and should receive a longer treatment or a terminal procedure once unconscious.

Working with modified atmosphere systems requires careful management and monitoring to prevent risks to personnel, including those from oxygen deprivation or exposure to hazardous gas concentrations, especially in confined or poorly ventilated areas. Other specific hazards with modified atmosphere systems include those from pressurised gas cylinders or systems, and cold exposure when modified atmosphere systems use cryogenic forms of gases (stored as liquids at extremely low temperatures).

3.10.1 Carbon dioxide gas

Carbon dioxide (CO_2) is one method for destroying poultry, pigs and laboratory animal species.

CO_2 is a colourless, nearly odourless gas, that is heavier than air and is easy to use and safe for personnel when used in well-ventilated areas. CO_2 should only be used in species for which it has been validated.

CO_2 has rapid depressant and anaesthetic effects. It depresses the central nervous system by lowering the pH in brain tissue and death is caused by hypercapnic hypoxia. Species that can control their respiration or hold their breath (e.g. ducks) may require a longer exposure. Animals may be exposed to the gas in several ways including containerised units, partial-house gassing, or whole-house gassing.

CO_2 at levels above 30% has been consistently shown to be aversive for all animals, although poultry may be more tolerant to higher concentrations than pigs. CO_2 irritates the mucous membranes and excites trigeminal nerve endings causing nociception. It also causes the buildup of blood CO_2 (hypercapnia), which causes breathlessness (including ‘air hunger’) which may result in distress before loss of consciousness (EFSA 2015, Verhoeven et al 2016). WOAH, the American Veterinary Medical Association (AVMA) and the European Food Safety Authority (EFSA) support gradual increases in CO_2 concentrations as being less aversive than immediate high concentration exposure and do not support immersion of conscious animals in concentrations of CO_2 above 40%. This, however, may increase the time to unconsciousness.

Conversely, high concentrations of CO_2 are initially more aversive but result in a shorter time to unconsciousness (Meyer et al 2014, Sutherland et al 2017, Walsh et al 2019). Therefore, consideration should be given to which is least aversive from a welfare standpoint, but on balance a gradual increase in CO_2 level is likely to result in better outcomes because it reduces distress prior to unconsciousness. This may be achieved through a gradual increase in concentration or a two-phase introduction of gas. In the latter, levels 40% or below are used to induce unconsciousness and then the concentration is increased to cause death.

CO_2 released from compressed air cylinders or compressed liquid vessels is cold and can freeze animals on direct contact. Highly compressed liquid CO_2 may also be used and allows for transport of large volumes of gas. It should ideally be vaporised and humidified before introduction into the container or shed.

In August 2024 Animal Health Committee agreed that gassing in containers with carbon dioxide is suitable as a terminal method for destruction of all classes of pigs during an emergency animal disease outbreak (AHC45 OOS13).

Note: CO_2 supplies in Australia are highly contingent on supply and demand and are typically seasonal. Excess volumes of CO_2 are not usually available in storage. The quantities required for partial or whole-shed gassing, especially for responses requiring the gassing of multiple sheds may not be available when required. Anticipated quantities and supply arrangements should be confirmed as soon as possible before use (especially when undertaking partial or whole-shed gassing – see Sections 3.10.3 and 3.10.4). Depopulation via CO_2 in the USA has encountered similar supply constraints, with gas supplies depleted after 2-4 days of operation, requiring further delivery which may not be locally available (McOrist et al 2020).

3.10.2 Containerised gassing

Mass destruction using containers filled with gas (e.g. CO_2, mix of CO_2 and argon, and nitrogen) is an effective method of killing animals in batches. This can result in rapid unconsciousness and death with minimal aversive effects, resulting in more favourable welfare outcomes. Gas levels are readily controllable, and so this method may be more economical in terms of gas usage. However, this depends on the system design because opening the container to remove carcasses may result in a complete loss of gas each time.

The major downside of containerised gassing is that for some species it involves manual handling of animals, which for some species may be slow, labour intensive and limit scalability. Handling may also risk injuring animals, exposing responders to zoonoses and increasing the possibility of disease spread. There is also the potential hazard of compression and suffocation of animals in containers. It is therefore important to consider animal density and positioning.

Containers may be built from materials available on farm and vary in size from small bins, large skips up to shipping containers. Containers constructed from hay bales and plastic sheeting have also been demonstrated to be effective. Additionally, there are purpose-built modified atmosphere killing (MAK) carts that may have features such as conveyer belts, viewing windows or cameras and advanced monitoring systems. There is a containerised gassing system that can be loaded with poultry transport crates or modules to minimise live bird handling. Modified tipper trucks have also been extensively studied and successfully used for depopulation of all classes of pigs using CO_2. Monitoring equipment to ensure adequate gas concentration and suitable temperatures and humidity should be used to ensure efficacy and welfare standards, especially when using non-purpose-built setups. Containers may be pre-filled with a specified concentration of gas to anaesthetise the animals and then filled with additional gas to cause death. Alternatively, gas may be introduced after the animals have been loaded into the container. The gas concentrations required for anaesthesia and death vary between species.

Animals may be left in the container until death is confirmed, or they may be removed once unconscious and killed using a terminal technique.

Where possible, operators should ensure they can view animals during the procedure so that signs typically associated with unconsciousness can be checked.

3.10.3 Whole-shed gassing or whole-house gassing

As the name implies, whole-shed gassing is when a gas, typically CO_2, is introduced directly into a shed containing animals. CO_2 is effective over a wide range of concentrations and has an acceptable workplace health and safety profile. This method is currently most applicable to poultry houses. Openings in sheds need to be sealed, for example with plastic sheets or tarps, to ensure the gas is contained. The seal does not have to be perfect, and some leakage of gas is expected. In fact, there must be venting to allow displaced air to escape the building.

Whole-shed gassing may not be as efficient, in terms of overall gas usage, or as readily controllable as gassing in containers but offers several key advantages. It allows rapid depopulation of an entire shed in a single step. It is especially useful in disease outbreaks that may pose a risk to human health—such as zoonotic diseases—and those affecting large numbers of animals. It is also significantly less labour intensive than containerised gassing. It has considerable welfare benefits because animals can be left in place with their companions and are not subjected to the distress of manual handling. Due to its many advantages, whole-house gassing has been subject to extensive research. More recently, trials have shown that whole-house gassing with nitrogen can be used for poultry and pigs (see Section 3.10.5).

3.10.4 Partial-shed gassing

Partial-shed gassing fits somewhere in between whole-shed gassing and gassing in containers. It may be considered in open sheds or old facilities that cannot be sufficiently sealed. It involves creating a gassing enclosure within a shed—for example using panels and plastic sheeting as walls. It is most suited to floor-reared poultry that can be driven into the enclosure in groups.

3.10.5 Inert gases: argon and nitrogen

For the purposes of this manual, inert gases refer to argon (Ar) and nitrogen (N_2). These gases are considered physiologically inert and do not induce the aversive response and 'air hunger' seen with CO_2. They may be used alone or in mixtures with CO_2. There is evidence in pigs that the combination of inert gases with CO_2 leads to better welfare outcomes compared with CO_2 alone (Llonch et al 2013, Kells et al 2018). Use of 100% argon or nitrogen is likely to result in better welfare outcomes than combining with CO_2 (Kells et al 2018). Inert gases offer advantages for the destruction of waterfowl that may be more resistant to induction of unconsciousness with CO_2. In addition to the welfare advantages, nitrogen is also readily available and can be extracted from the air. Inert gases may require a greater degree of precision because high gas concentrations need to be held within a relatively tight range. They may also need to be used in the correct state if they are to be fit for purpose. For example, nitrogen may be vaporised from its liquid state but held at low temperatures so that it is heavier than air and behaves in a similar way to CO_2.

For depopulation of pigs and poultry, nitrogen may be delivered into containers or sheds using a specialised manifold system. This method has been used successfully in trials in the USA and Canada. Nitrogen may also be delivered in a high-expansion gas foam, which has been shown to be humane and suitable for poultry and pigs in EAD depopulation field situations in both containers and sheds, including open-sided sheds (see Section 3.10.6 on high-expansion gas-filled foam).

Argon mixed with 20 to 30% CO_2 (available as welding gas) has been used extensively in the UK for containerised gassing of poultry during EAD responses, and is the primary gas used for stunning of birds in abattoirs in the UK. It is economical on a quantity basis but when used in containers there is a total loss of gas every time the doors are opened.

3.10.6 High-expansion gas-filled foam ('dry' foam)

High-expansion gas-filled foam is sometimes referred to as 'dry' foam due to its relatively low water content. It has an expansion ratio of >200:1 with an optimal range of 250:1 to 350:1. It has a different mechanism of action from wet foam, offering better welfare outcomes. It is functionally a modified atmospheric killing method in which inhalant gas is delivered using a foam medium. It is scalable and, where it can be conducted in place, requires minimal contact between responders and potentially infectious animals. The foam confers the added benefit of reducing aerosolisation of viruses such as high pathogenicity avian influenza. It has application to poultry, including waterfowl, and pigs. It can be used in containers or open-sided sheds to depopulate entire poultry sheds (Hewitt 2023). It forms a blanket over the animals and may be employed in open environments because the foam stays in place in contrast with gaseous delivery systems. The production capacity must, however, exceed the rate of breakdown of the bubbles and atmospheric dilution. The downside of foam is that there is poor visibility of the animals during application.

High-expansion foam is filled with 100% nitrogen or CO_2. The former is more widely used and commercial units are available from a few manufacturers globally. Nitrogen is highly effective at displacing oxygen and creates an anoxic environment that renders animals rapidly unconscious.

The bubbles are large compared with wet foams and consequently do not occlude airways causing suffocation and drowning. Instead, they burst on contact with surfaces and through movement of animals release nitrogen into the atmosphere causing a concomitant drop in oxygen to less than 1%. Bubbles greater than 10mm in diameter facilitate rising of gas above the heads of the animals. Nitrogen is a physiologically inert gas and is not aversive—it causes smooth loss of consciousness and avoiding the 'air hunger' associated with hypercapnia. Death is rapid and humane due to the anoxic conditions (Benson et al 2007, Alphin et al 2010, Benson et al 2018, Gurung et al 2018, EFSA 2019, Lindahl et al 2020).

This is a rapidly evolving technology[5] that warrants further investigation and research into the availability and practicality for use in Australia for mass depopulation of poultry and pigs. High-expansion gas foam as a delivery method for nitrogen gas is being used in the UK (EFSA AHAW Panel 2024), Europe and USA in a

[5] https://heftinternational.com/technology/ and https://www.livetecsystems.co.uk/resource_hub/nitrogen-foam-delivery-system-nfds-product-guide/

limited way at present for depopulation of poultry and pigs in container and open-shed settings. Research is occurring for application to tiered layer cage sheds as well.

3.10.7 Carbon monoxide

Commercially supplied carbon monoxide (CO) is effective for killing a range of animals as an inhalant method; however, it is not recommended for on-farm use as it is a colourless, highly flammable, odourless gas with cumulative effects (AVMA 2020), and can be lethal for humans in low concentrations. It therefore presents significant safety concerns for operators and is not recommended for this reason. AVMA (2020) provides guidance on its safe use.

CO is a cumulative poison that produces a fatal hypoxaemia, by blocking uptake of oxygen by haemoglobin. CO gas in its pure form is a humane and highly effective method of destroying poultry and other small animals. It produces loss of consciousness without pain and is highly toxic at low concentrations (4–6%).

CO was successfully used in six poultry farms in the 2003 avian influenza outbreak in the Netherlands. Reports indicate that it took up to one hour for the sheds to reach the desired concentration of CO. Results suggest it does not have improved welfare outcomes compared to carbon dioxide but has a significantly higher human health risk (Gerritzen et al 2006).

3.10.8 Hydrogen cyanide gas

Hydrogen cyanide gas is a humane and highly effective method of destroying poultry and other small animals. However, human safety considerations restrict its use.[6]

3.10.9 Methyl bromide

Methyl bromide is effective for killing poultry but is now regarded as unacceptable because of operator safety requirements and environmental concerns.

3.10.10 Other gaseous agents

Nitrous oxide (N_2O) used alone does not induce anaesthesia and is not suitable as a primary destruction method. If used, it is best utilised as the first step in a two-step method in which the secondary method induces death once the animal is unconscious.

3.11 Gaseous anaesthetic agents

Gaseous anaesthetic agents, which include halothane, enflurane, isoflurane, sevoflurane and methoxyflurane, can be used to produce anaesthesia and death in small animals (<7 kg).

These agents can be used in exactly the same way as CO_2, but there should be no direct contact between the animal and the anaesthetic in its liquid form. Animals may be left in the anaesthetic chamber until

[6] https://www.woah.org/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Contingency_Manual.pdf

dead, or may be removed once unconscious and destroyed by one of the physical terminal methods or even by injection of an overdose of barbiturate euthanasia solution (see Section 3.13).

The major disadvantage of these agents is that they are expensive and restricted (Schedule 4) drugs that should be delivered via a closed system (e.g. gaseous anaesthetic machine) or used in a well-ventilated room or fume cupboard. Prolonged exposure, even at low concentrations, may harm the health of personnel.

3.12 Low atmospheric pressure stunning (hypobaric hypoxia)

Low atmospheric pressure stunning (LAPS) has been shown to be effective and humane for broilers (Martin et al 2016, Mackie and McKeegan 2016, Gent et al 2020) and has been validated in male layer chicks and rodents (Clarkson et al 2022, 2023). It is approved in the EU as a method of commercial slaughter for broilers under 4 kg (EFSA 2017). Currently, the technology is not available in Australia. The method involves removal of oxygen from the air inside a chamber resulting in death from hypoxia (hypobaric hypoxia). It provides a possible on-farm method of killing large numbers of poultry and rodents in disease situations. It appears to have an excellent welfare profile for certain classes of poultry, and lower environmental costs compared to gaseous systems.

Low atmospheric pressure stunning has also been evaluated in pigs but at this stage is considered inappropriate. Reduction of atmospheric pressure results in expansion of gases in enclosed spaces (Boyle's Law). Observations during LAPS in pigs have found prolonged behaviours indicative of pain and distress as a consequence of gas expansion causing pain—especially ear pain (barotrauma) and ear drum rupture (Martin et al 2022, Baxter et al 2022).

The unique anatomical structure of the avian respiratory system and lack of a diaphragm reduces the likelihood of gas trapping during LAPS. Thus, there is no evidence of pain, distress or organ pathology as described in mammals (EFSA AHAW Panel 2019). The consequences associated with the presence of shelled eggs within the reproductive tract of laying birds have not been adequately studied (EFSA AHAW Panel 2017). At this time, LAPS has not been validated in egg-laying birds (EFSA AHAW Panel 2017), and more research is required.

Note that LAPS (hypobaric hypoxia) is a gradual decompression method that results in reduction in the partial pressure of oxygen. It uses gradual decompression (a 280-second cycle) according to a set of prescribed pressure curves (Martin et al 2020). It should be distinguished from rapid decompression, which is considered an unacceptable method (see Appendix 1).

3.13 Injectable agents

Injectable euthanasia solutions (hypertonic solutions of barbiturates) are a rapid and reliable way to destroy individually handled animals. An overdose can be used as a primary means for destruction, ideally by the intravenous (IV) route, but other routes may be more practical in small animals provided the animals are already anaesthetised or unconscious. These agents are restricted by law and must only be used by a veterinarian or under direct veterinary supervision. Expertise and anatomical knowledge are required to successfully inject at the different sites. Care is needed to avoid needlestick injuries and self-injection.

Barbiturates depress the central nervous system, beginning with the cerebral cortex, with loss of consciousness progressing to general anaesthesia. With an overdose, deep anaesthesia progresses to apnoea, followed by cardiac arrest. Commercial euthanasia solutions (sodium pentobarbitone 170–400 mg/mL; 18% = 200 mg/mL) are usually administered intravenously at dose rates greater than 100 mg/kg. Sodium pentobarbitone, which is packaged and labelled for use as a general anaesthetic at the lower dose of (60 mg/mL), may be used, but larger volumes will be required. Alternate routes of administration (intraperitoneal, intracardiac, intrahepatic and intrapleural) can be used on unconscious animals, but prior insensibility should be confirmed. The high pH (11–12) of sodium pentobarbitone causes tissue irritation (Suckow et al 2019).

A partial dose may cause excitement, and this can be dangerous to personnel, especially if working with large animals. Destruction of cats, rabbits and some birds by intraperitoneal sodium pentobarbitone, at normal anaesthetic concentrations, may be accompanied by an excitement phase, and animals should be confined and handled with extreme care in such circumstances. Prior deep sedation must be used because intraperitoneal injection of barbiturate solutions is painful. It will also help to avoid the excitement phase.

Consideration should be given to disposal of animals destroyed using barbiturates to prevent environmental contamination and secondary poisoning of wildlife and other scavenging animals.

Specific jurisdictional requirements must be adhered to with respect to storage, use and administration of restricted drugs (i.e. drugs and poisons legislation).

3.14 Sedation/anaesthesia and other techniques combined

A combination of sedation, captive bolt and pithing, or some other terminal technique, is suitable for a variety of situations. These situations may include those in which free projectiles are undesirable; where it is desirable to move animals to an alternative, adjacent destruction site; where facilities are inadequate for individual restraint; and/or where access to the available destruction site is compromised. Reasonably large numbers of animals can be handled in a day. If no other machinery is needed to move animals immediately from the destruction site, destruction can usually proceed soon after disease is detected and may be completed before disposal arrangements are finalised.

In practice, animals are worked through a race or otherwise confined and injected with a suitable sedative drug, such as xylazine, using a dose at which they will remain standing. For animals over 100 kg, 10% xylazine is recommended. For younger stock, 2% is more appropriate (a dose of 10% xylazine is very small and difficult to measure accurately; overdosage leads to calves going down too quickly). Animals are then moved directly from the race or enclosure to the destruction site, which could be an adjacent paddock, a pit, another yard or a single-deck livestock transport. Sedation should take effect within 3–5 minutes of injection.

As sedation deepens, the animals lie down. An appropriate technique such as captive bolt or firearm would then be used. The captive bolt operator moves among them and stuns each animal. Immediately the captive bolt operator moves away from a stunned animal, another operator moves in and confirms insensibility (loss of consciousness) before a terminal procedure. Alternatively, the sedated animals can be shot at close range with an appropriate firearm.

When this process is completed for one batch, the next batch can be injected with sedative and let into the destruction area. Alternating between two destruction sites can speed up the operation, by allowing for one group of animals to be destroyed whilst the other group is waiting for the sedation to take effect.

Note that sedative supplies may limit the use of this method, especially given the large volume of xylazine required for sedation of adult cattle.

3.15 Oral agents

Oral agents fall into three general categories: poisons, sedatives, and anaesthetics. In some controlled circumstances, an oral sedative agent may reduce animal distress and allow better delivery of an effective destruction method. Oral anaesthetic agents and poisons may achieve destruction with or without an additional terminal method. To protect animal welfare, close supervision is required. Agents include sedatives such as diazepam for mammals, anaesthetic agents such as alpha-choralose for birds (licences or permits are required) and poisons such as sodium nitrite for pigs. See species-specific sections for more detail on oral agents.

3.15.1 Sodium nitrite

Pigs are highly susceptible to sodium nitrite poisoning because they have low levels of a protective enzyme, methaemoglobin reductase, that is present in most other species (Cowled et al 2008). Sodium nitrite causes death by converting haemoglobin in the red blood cells to methaemoglobin. The formation of methaemoglobin results in a reduction in the capacity of red blood cells to carry oxygen therefore causing oxygen depletion to the brain and tissues leading to unconsciousness and death (Lower 2020). Methaemoglobin levels in the blood are usually around 1% of total haemoglobin. Levels above 70% are usually fatal due to lack of oxygen supply to vital organs.

Sodium nitrite in a microencapsulated (meSN) form is registered and routinely used for the control of feral pigs by oral intoxication in Australia. It may only be used in specified classes of domestic pigs for a declared EAD and with approval from the jurisdictional Chief Veterinary Officer, as outlined in Section 4.3.9. The method has in principle support from the Animal Health Committee but has not been used in Australia at the time of writing. It would also require an emergency use permit from Australian Pesticides and Veterinary Medicines Authority (APVMA) which, at the time of writing, is not yet available.

Sodium nitrite is volatile and hygroscopic and will rapidly degrade to non-toxic derivatives. It is also unpalatable and will not readily be consumed by pigs unless coated. It is important that formulations of sodium nitrite used for depopulation purposes are appropriately encapsulated or coated to mitigate these outcomes—for example, by administering microencapsulated sodium nitrite.

Sodium nitrite is toxic to aquatic life. Care must be taken to not contaminate dams, rivers, streams, waterways or drains with the product or used containers.[7]

While the risk of secondary intoxication is low due to low residual concentrations in carcasses and rapid toxin deterioration, care should still be taken to ensure carcasses are disposed of using an approved

[7] Hoggone meSN Feral Pig Bait

method and in accordance with any APVMA requirements. Where applicable, appropriate measures to prevent access to sodium nitrite by non-target species should be applied.

3.15.2 Para-aminopropiophenone

Para-aminopropiophenone (PAPP) works similarly to sodium nitrite, which induces the formation of methaemoglobin. It is considered to be a more humane mechanism of action than that of 1080 poisoning and may be used in preference for feral animal control.

Dog and cat species are more prone to PAPP toxicity than many other species, including native Australian mammals and birds. Nonetheless, the dosage levels in some commercial baits pose a threat to some native animals such as quolls and bandicoots, along with crows and large reptiles, especially lizards and goannas. Measures should be implemented to lessen the risk to non-target species before the start of baiting. These measures may include refraining from baiting if these species are present. Buried baits are expected to present a lower risk to birds and small mammals. PAPP breaks down relatively quickly in the environment and is not considered a secondary poisoning risk to animals that consume poisoned animals.

3.16 Terminal procedures

Terminal procedures cause death but are not acceptable methods of destruction without prior stunning or anaesthesia. The procedures below must only be used on unconscious (stunned or anaesthetised) animals.

3.16.1 Pithing

Pithing is the practice of manually destroying the brain tissue in and around the brainstem to ensure death. It is typically performed by physically inserting a light, flexible metal or plastic rod through a hole made with a penetrating captive bolt device in the animal's skull towards the base of the skull, inserting it into the spinal canal. The spinal cord is then macerated by moving the rod up and down several times. Rods are suitable for cattle, sheep or pigs. Some commercially available pithing rods are designed to remain inside the skulls and spinal cords and include plugs to prevent the escape of blood and brain material.

Pithing must only be performed on animals that have been confirmed to be unconscious and insensible following stunning. For cattle, pithing should occur within 60 seconds of stunning by penetrating captive bolt of sedated animals or within 30 seconds of stunning non-sedated animals. For sheep, pithing should occur within 30 seconds of stunning.

Pithing stimulates violent involuntary movements of the animal's legs and head. Therefore, the operator should stand in a safe position to avoid injury. A set of nose pliers and a short rope may be used if needed to restrain the head to allow for easier insertion of the rod.

3.16.2 Exsanguination

Exsanguination ('bleeding out') is a useful procedure to ensure death after stunning or loss of consciousness. However, it is undesirable in-field because of the potential release of infectious material and because the destruction site becomes slippery, making work dangerous. Following stunning, exsanguination can be achieved by cutting the jugular veins and carotid arteries ('neck cut'), or cutting the vessels at the top of the heart via the thoracic inlet ('chest stick') to evacuate over 40% of blood volume

(Walcott 1945). Note that cattle will require a secondary thoracic stick following a neck cut, as they typically won't exsanguinate effectively after just a neck cut. If necessary, large animals that have been rendered unconscious can be exsanguinated by severing the abdominal aorta per rectum; appropriate care is required.

Exsanguination should be used only after an effective stun and after the animal has been assessed to be unconscious. The use of bleeding-out as a primary method of destruction is not acceptable.

3.16.3 Injectable terminal agents

The death of a stunned or anaesthetised animal may be caused by an injected overdose of anaesthetic agent or other specific chemical.

Barbiturate euthanasia solutions are acceptable as a primary destruction agent and terminal procedure (see Section 3.13).

Potassium chloride and magnesium sulfate, as supersaturated solutions, may be injected intravenously on sedated or anaesthetised animals. Neuromuscular blocking agents (e.g. nicotine and succinyl choline) are acceptable for use on anaesthetised or unconscious animals as a terminal procedure only. They produce cardiac arrest and hypoxia without loss of consciousness first and are not acceptable as a primary killing method.

3.17 Ventilation shut down (VSD) and ventilation shut down plus (VSD+)

VSD is characterised by closing and sealing the inlets and outlets of a shed and turning off ventilation fans. Body heat from the animals raises the temperature of the shed and the animals ultimately die of hyperthermia. VSD+ primarily refers to the addition of supplementary heat. The American Veterinary Medical Association describes VSD+ as the addition of CO_2 and/or heat (AVMA 2019).

Research indicates that death results from severe, environmental heatstroke, and that this is associated with prolonged animal suffering (Reyes-Illg et al 2022).

The time to death is dependent on a range of factors including:

- the ability to adequately seal the inlets and outlets
- the number of animals, and therefore the density, within the shed
- the health status of the animals
- the ambient temperature
- the time taken to reach the desired temperature.

VSD and VSD+ are unable to achieve immediate unconsciousness or death without distress (Arruda et al 2020). Reported average times to death with VSD are 2.25 hours in meat chickens (Anderson 2019), 3.75 hours in laying hens Eberle-Krish (2018) and 4.5–6 hours in turkeys (Anderson 2019). Research conducted by Eberle-Krish 2018 demonstrated that by adding heat, the average time to death is reduced—for example VSD+ (heat) in laying hens reduced time to death from 3.75 to 2 hours. Estimates of time to loss of consciousness suggest that birds are conscious for 50–95% of this time (Anderson 2019). In pigs, times to death of up to 106 minutes have been reported (Baysinger et al 2021) and a case study in the UK of pigs during ventilation failure showed that 100% mortality was not produced after 16 hours (AVMA 2019).

VSD and VSD+ are not included in the WOAH Terrestrial Animal Health Code as methods of killing for disease control purposes and are not acceptable destruction methods internationally, except for consideration in very exceptional circumstances. In the United States, VSD+ is used under constrained conditions for poultry in accordance with the USDA HPAI Response VSD+ Policy[8], while VSD without supplemental heat is not recommended. These methods are the subject of much debate due to the aversive nature of the mechanism of death. VSD and VSD+ remain unapproved methods of destruction in Australia.

See also Section 4.7.3.11.

3.18 Movement to abattoir

Abattoirs have trained staff and infrastructure already in place to destroy animals on a large scale. Therefore, destroying animals through an abattoir may be an acceptable method of destruction. This would be subject to meeting biosecurity requirements, and also ensuring agreement with and capacity of the abattoir to handle the number of animals involved. The use of an abattoir for destruction is best suited to animals with a low likelihood of disease transmission. However, in some circumstances, it may be appropriate to consider using an abattoir for higher biosecurity risk animals, subject to risk assessment.

3.19 Other methods of destruction

Other methods of animal destruction not mentioned or not recommended in this manual may be considered on a case-by-case basis. The person in charge of destruction activities must adhere to the standards for humane destruction, except in a declared EAD response, when the jurisdictional Chief Veterinary Officer (or equivalent) must be satisfied that a welfare assessment has been conducted, and all alternative destruction methods have been explored and found impractical or not feasible.

[8] HPAI Response: Ventilation Shutdown Plus Policy

4 Destruction of specific species

This section outlines methods of destruction for various domestic species in managed situations, along with the factors influencing the choice of method.

Some guidance is also given on preferred methods of destruction for various wild species. Further discussion can be found in the **AUSVETPLAN *Operational manual: Wild animal response strategy*** or the current edition of the *Model Code of Practice for the Welfare of Animals–Feral Livestock Animals: Destruction or Capture, Handling and Marketing*. The distinction between wild and domestic animals may be unclear in some extensive production systems.

4.1 Cattle and water buffalo

Acceptable methods for the destruction of cattle include gunshot, penetrating captive bolt, electrocution, intravenous (IV) injection of supersaturated solutions, and overdose of an anaesthetic.

Methods of destruction suitable for cattle are typically also suitable for water buffalo, although the anatomical differences of the skull and head should be accounted for.

The choice of method will depend on human safety risk assessments, age or class of animal, capacity to restrain animals and implications for the disposal of carcasses (e.g. when using barbiturates).

A well-placed headshot using an appropriate calibre rifle and ammunition is considered the most humane method for destroying individual animals (Andrews et al 1993). However, this method may also be associated with distress and fear if several or more animals are penned together and shot individually. It is therefore important to consider the context and circumstances surrounding the choice of destruction method, and to choose the most appropriate method based not just on individual animals but also of animals in groups.

Note: headshots are not appropriate when brain tissue may be required for diagnostic purposes—for example, in cases of suspected BSE.

If animals can be safely restrained, and carcasses can be easily removed, the use of appropriate penetrating captive bolt devices offers significant benefits over the use of firearms. Penetrating captive bolt devices are generally safer than firearms and animals can be destroyed out of sight of other members of the herd.

Use of sedative agents in conjunction with destruction via gunshot or captive bolt may also be considered, as it may reduce the level of individual animal restraint required (see Section 4.1.4).

Electrocution should only be considered in instances when there are appropriately trained personnel with specialised equipment specifically designed for this purpose.

The overdose of an anaesthetic drug can be used as a single-step method to kill cattle and buffalo of all ages and weight groups. However, this method must only be performed by registered veterinarians or approved persons. This method limits carcass disposal options because of environmental residue risks and should therefore be carefully considered before use.

4.1.1 Background considerations (intensive production)

When planning the destruction of feedlot and dairy cattle, the below factors should be considered. For further information, refer to the **AUSVETPLAN enterprise manuals *Beef cattle feedlots* and *Dairy (cattle) industry***.

4.1.1.1 Both feedlots and dairies

- External farm staff (e.g. herders and milkers) may not be available to assist with daily farm duties, resulting in under resourcing of farm activities and adverse animal welfare outcomes.
- Supplementary feed or feed sourced from other premises is usually needed. Movement controls on feed, premises access and on farm biosecurity controls may result in delays to obtaining feed, or substitution of feed, resulting in potential adverse animal welfare impacts.
- Financial impacts from the EAD on the animal owner may reduce the ability for the animal owner to care for animals (e.g. to provide of feed, water, treatment/pain relief of sick animals).
- Large numbers of animals destroyed may create disposal issues in terms of volume, timeliness and unsightly processes.
- The facilities and human resources available may not allow timely and humane destruction of animals on farm.

4.1.1.2 Feedlots

- A large proportion of beef from feedlot animals is exported. Access to export and potentially domestic markets may be affected by the EAD outbreak, with export processing facilities closing or taking considerably less stock for slaughter.
- Movement controls may result in restricted or no access to export processing facilities. Sending cattle over jurisdictional borders for processing may not be possible.
- Livestock welfare issues can arise. Capacity to hold long-fed cattle at slaughter weights and to hold animals beyond their planned 'on feed' time may be limited, thereby resulting in overcrowding and other welfare concerns.
- Destruction of large numbers of animals in feedlots or other confined facilities may result in significant challenges with respect to carcass removal. Ideally, animals should be moved to a place on the premises where both destruction and the subsequent removal of carcasses is feasible and practicable.

4.1.1.3 Dairies

- Lactating animals will need to be prioritised for destruction to avoid the need for ongoing milking and subsequent milk management (e.g. collection, denaturing, disposal, decontamination of equipment etc). Failing to milk animals will lead to painful udder distention, mastitis, and possibly death.
- Rapid drying off of lactating cattle can also create animal welfare issues, and should be undertaken gradually with careful monitoring.
- During the calving season, movement controls preventing or slowing the movement of stock (e.g. calves) to other destinations, including abattoirs, may lead to overcrowding.

- If the dairy mechanism (e.g. rotary dairy platform) is being used in the destruction process trained farm staff will be required to ensure its safe operation.

4.1.2 Firearms

This method requires the selection of an appropriate firearm, cartridge and bullet with sufficient velocity, energy and size to penetrate the skull (enter the brain) and cause massive brain destruction.

With more than 81 calibres to choose from it is important to select the most appropriate calibre, cartridge load and bullet type for the circumstances. Considerations for the choice of calibre and bullet type to use include:

- skull thickness, which depends on the age and class of animal
- risk of projectile exiting the skull and the subsequent risk to humans and other cattle standing close by
- shooting distance
- terrain.

The ideal calibre and bullet type will ensure penetration of the skull and destruction of brain tissue without exiting the skull. This can be achieved by ensuring the calibre, cartridge load and bullet type (e.g. full metal jacket, soft point, hollow point) are appropriately matched.

It is impractical to list all the available calibres in this document and their suitability for use in all situations and for all classes and ages of animal. Seek the advice of an expert to select the appropriate calibre, cartridge load and bullet type based on the age and class of animals and site-specific circumstances. See Section 3.3 for general recommendations on firearm calibre.

Notwithstanding the above, for buffalo, high calibre rifles (.30 or larger) are recommended, and hard-point or jacketed ammunition is preferable.

4.1.2.1 Shot placement

The preferred shot placement for both firearms and penetrating captive bolts is the frontal method.

Frontal shot

The target in cattle for a frontal shot is the midpoint of the forehead (Figure 4.1 – position ‘A’). This position coincides with the intersection of two imaginary lines each drawn from the rear corner (outside corner) of the eye to the base of the opposite horn (or for polled or dehorned cattle where the horns would be).

The frontal short may require a higher shot placement for dairy cattle with a long-face phenotype (e.g. Holsteins) as compared to beef cattle (Gilliam et al 2018).

If buffalo are to be shot from the frontal position, operators should keep the angle of impact in mind, because the animals will often lift their noses.

Poll shot

Poll shooting (Figure 4.1 – position ‘B’) should only be used in situations where it is difficult to get a good frontal shot. For example, when an animal puts it head down, and the forehead cannot be reached. The poll shot in cattle should enter a point in the middle of a horizontal line drawn between the base of the horns (or where they would be) (Figure 4.1 – position 'B'). The direction of aim should be perpendicular, midway between the ears and aiming towards the base of the tongue. Poll shots should never be aimed at the nose as these will miss the brainstem.

Temporal shot

Temporal shots (Figure 4.1 – position 'C') (aimed at the side of the head between the eye and ear canal) may be less reliable than other shot placements. Temporal shots should therefore only be used when frontal or poll shots are not possible or feasible. Temporal shots using captive bolt devices are not appropriate and should not be used.

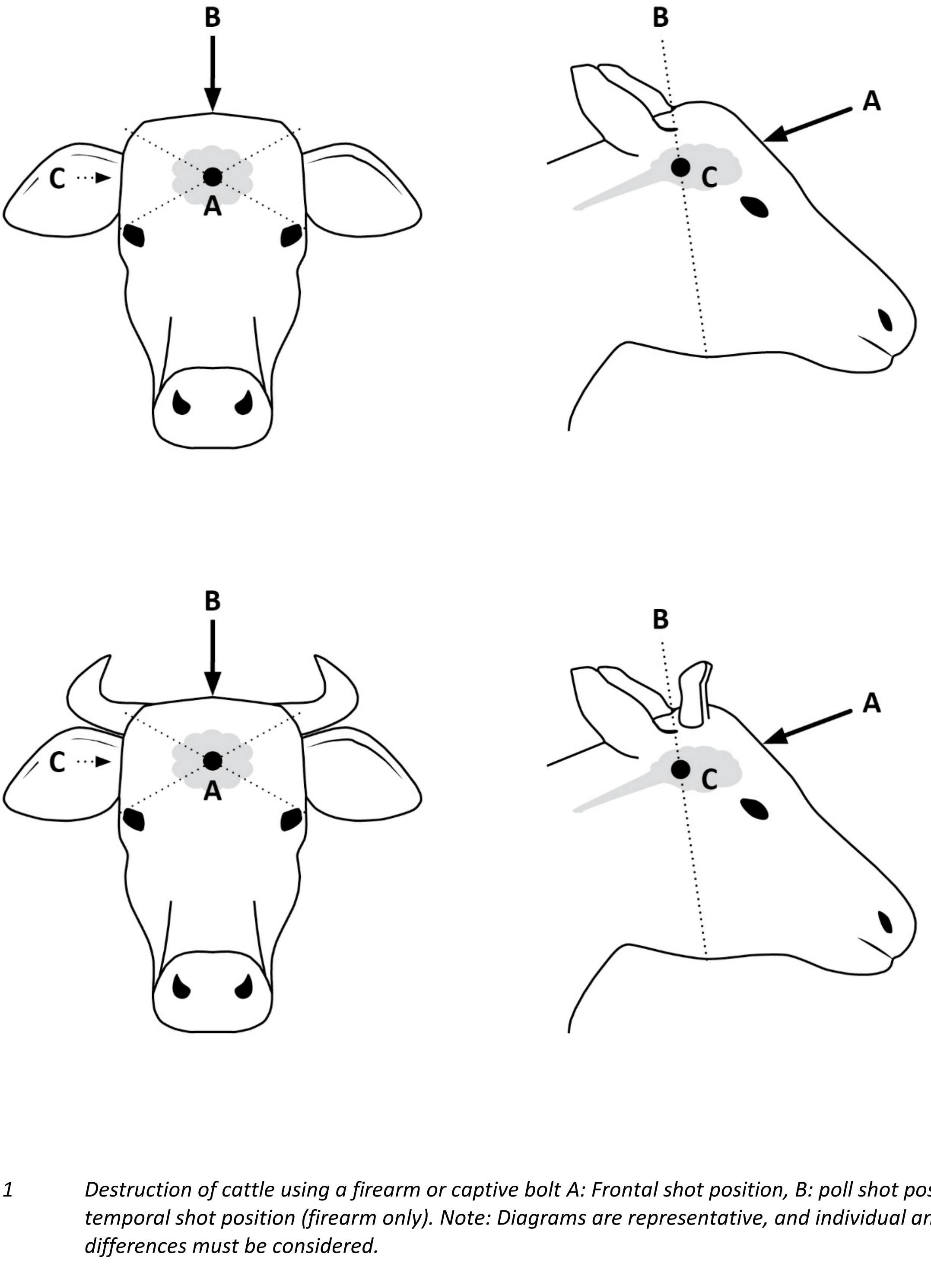


Figure 4.1 *Destruction of cattle using a firearm or captive bolt A: Frontal shot position, B: poll shot position, C: temporal shot position (firearm only). Note: Diagrams are representative, and individual anatomical differences must be considered.*

4.1.3 Penetrating captive bolt devices

Penetrating captive bolt devices (see Section 3.4) are most suitable when animals can be adequately restrained. Operators should assess the feasibility of removing carcasses before using this method. For instance, cattle crushes may be a suitable method of restraint but may be impractical because of the difficulty of removing carcasses after destruction.

As with firearms, there are a variety of devices available on the market, and careful consideration is required to ensure the chosen device is matched with the size and ages of animals being destroyed. If restraint of buffalo is feasible, captive bolt devices that are approved by the manufacturer for use on buffalo may be considered.

Shot placement with captive bolts is exactly as described above for firearms, except for the temporal shot, which should not be used with captive bolt devices. Poll shots with captive bolts are generally not recommended and should be limited to where frontal shots are awkward or where cattle are best approached from behind such as a downer cow in a pen with the head in the corner.

Some penetrating captive bolt devices are suitable as a single step method of destruction, but most will require a follow-up terminal procedure to ensure death, for example pithing or exsanguination. Studies have shown that where the mean bolt penetration depth is greater than 14cm, penetrating captive bolts can be an effective single step method (Shearer et al 2017) however, confirmation of death must always be performed. For depths less than 14cm, pithing is recommended to ensure animals do not regain consciousness.

4.1.4 Sedation before destruction

Dairy and some beef properties have yarding facilities that enable the restraint of groups animals. This allows for the administration of sedation before destruction by gunshot or captive bolt.

This can be achieved by restraining a group of cows via the dairy platform, artificial insemination race or cattle yard race, and administering sedative (usually xylazine). The sedative will take approximately 5–10 minutes to take effect, allowing time for cattle to be moved to yards or a proximal paddock while still walking. Once the cows are recumbent, destruction can be undertaken.

On dairy farms, calves are mostly artificially raised in sheds or small yards. A similar technique can be employed. Calves can be sedated (typically also using xylazine) while feeding at milk feeders, allowing them to become recumbent before destruction.

The volume of xylazine required for this method may, however, limit its application. It also prolongs the time needed for destruction. However, it reduces the overall distress to the cattle and handlers, and therefore may be applied in some circumstances.

4.1.5 Injectable agents

Injectable agents such as barbiturates and barbituric acid derivatives may be suitable for small numbers of cattle, such as on hobby farms, with well-handled small herds (e.g. stud and pet cattle) or in urban situations.

Animals should be restrained to guarantee effective administration. For animals that are difficult to handle, prior sedation may be useful to prevent movement during administration of the barbiturate.

Intravenous (IV) administration is preferred. Doses that cause rapid loss of consciousness followed by death should be used. Other routes of administration (e.g. intraperitoneal, intrahepatic, intrathoracic) are not suitable for use in conscious animals as a primary method of destruction and may only be used if the animal is first rendered unconscious or is under general anaesthesia. Animals should be monitored throughout the administration and the following period to ensure the drugs have been effectively administered and death is confirmed.

When an animal is killed by lethal injection there may be restrictions on how the carcass can be disposed of.

See also Section 3.13.

4.1.6 Electrical stunning and electrocution

Electrical stunning (electronarcosis)9 followed by a secondary procedure to cause death, and electrocution as a sole method of destruction, are conditionally acceptable methods for the destruction of cattle. However, the feasibility of using these methods in the field is yet to be demonstrated.

Electrical stunning and/or electrocution should only be undertaken on cattle that have been appropriately restrained and with equipment specifically designed for this purpose. The equipment should only be used by personnel trained and experienced in the use of electrical stunning and electrocution.

The methods of electrical stunning and electrocution are very similar for pigs, sheep, goats and cattle.

4.1.7 Paddock or extensive-area destruction

Shooting in paddocks or over extensive areas may be required in instances where animals cannot be mustered into pens or other suitable enclosures. This will typically require shooting over longer distances by skilled and experienced marksmen.

The shooter must aim either at the head, to destroy the major centres at the back of the brain near the spinal cord, or at the chest, to destroy the heart, lungs and large blood vessels.

While headshots are always preferable, they may not always be possible or even recommended. At long distances chest shots provide a much larger target area than the head kill zone, which reduces the likelihood of wounding rather than killing the animal rapidly. The aim of the chest shot is to destroy the heart and cause rapid death through loss of blood flow to the brain and massive shock to animal. The ideal target zone is essentially about a third of the distance up from the bottom of the chest, directly between the front legs. Alternatively, if shooting from the side, the point of impact is behind the foreleg, slightly above and immediately behind the elbow joint. Only large calibre rifles should be used when opting for chest shots.

[9] www.hsa.org.uk/electrical-stunning-of-red-meat-animals-introduction/introduction-1

The target animals in a group should be checked to ensure they are dead before moving on to the next group of animals. Always approach the recumbent (down) animal from the dorsal (or spinal) side to prevent injury from kicking legs.

Shooting from helicopters is another effective and humane method of destroying unmusterable cattle and buffalo in extensive and difficult terrain. Aerial shooting is a highly specialised skill and, depending on the jurisdiction, is subject to stringent regulations, accreditation requirements and operational guidelines

Aerial shooting programs must comply with relevant Commonwealth, state, and territory legislation, policy, and guidelines, specifically the Civil Aviation Safety Regulations and subordinate documents.

4.1.8 Specific methods for calves

The recommended techniques for killing calves are an intravenous dose of barbiturates, electrocution, penetrating captive bolt with terminal procedure if required, or head shooting with a firearm in the frontal position (Figure 4.1, position 'A'). Small calves may also be shot with a firearm or penetrating captive bolt device just behind the nuchal crest (poll) in the mid-line, aiming directly at the base of the tongue (Figure 4.1, position 'B').

Use of sedatives may be considered in some circumstances to sedate the calf before use of other means of destruction.

The *Australian Animal Welfare Standards and Guidelines for Cattle* state that calves less than 24 hours old may be killed by a blow to the forehead if no other humane methods are reasonably available. However, blunt force trauma is generally not considered an appropriate method of destruction for calves.

4.2 Sheep and goats

Acceptable methods for the destruction of sheep and goats include gunshot, penetrating and non-penetrating captive bolt, electrocution, and overdose of an anaesthetic.

The choice of method will be determined by risk assessments which include a range of factors including, but not limited to; animal species, age, size and weight; site specific considerations, available resources and infrastructure, training and experience of personnel, work health and safety and public perception.

Table 4.1 lists various methods of terminal destruction of sheep and goats. Constraints to the various methods are described in subsequent text.

Table 4.1 Destruction methods for sheep and goats, by age and class

	Polled		Horned	
Method	**Neonates**	**Adults**	**Neonates**	**Adults**
Firearms	Used with constraint	Suitable	Used with constraint	Used with constraint
Penetrating captive bolt	Used with constraint	Suitable	Used with constraint	Suitable
Non-penetrating captive bolt	Used with constraint	Not acceptable	Used with constraint	Not acceptable
Electrocution	Used with constraint	Used with constraint	Used with constraint	Used with constraint
Injectable agent	Suitable	Suitable	Suitable	Suitable

4.2.1 Background / considerations (intensive production)

The destruction of feedlot sheep and dairy goats would have similar considerations as for cattle (see Section 4.1.1).

Furthermore, wool-producing sheep require regular shearing and crutching to maintain sheep health and welfare. Regular shearing and crutching help to prevent flystrike, reduce the impact of grass seeds, and enhance sheep mobility and thermal regulation. While a slight delay in shearing or crutching may have little to no impact on sheep health and welfare, an extended delay is likely to have a negative impact. Sheep that are adversely impacted by flystrike, reduced mobility or heat stress should be considered for prioritisation of destruction.

For further information, refer to the **AUSVETPLAN *Enterprise manual: Wool industry***.

4.2.2 Firearms or penetrating captive bolt devices

4.2.2.2 Polled (hornless) sheep

Poll method

The poll position is the preferred approach, when possible. The shot is directed through the skull just behind the base of the horns, directed slightly forward of the angle of the jaw. Figure 4.2 – position ‘B’.

Crown method

The shot should be directed straight down from the highest point of the skull, midway between the base of the ears, aiming towards the centre of the brain or spinal cord to target the brainstem. Figure 4.2 – position 'D'.

Frontal method

The shot should be directed at a point midway across the forehead where two imaginary lines from the topside of the base of the ears and top of the eyes intersect, aiming down the spine. Figure 4.2 – position 'A'.

Temporal method (firearm only)

This is the least preferred method but may be necessary if sheep are positioned so that neither the frontal method nor poll method are accessible. The shot should be aimed perpendicular to the side of the head and placed midway between the base of the ear and the eye as shown in Figure 4.2 – position 'C'.

4.2.2.3 Horned sheep and all goats

In younger animals with less developed horn structures the frontal aiming position as described for polled sheep may be used. However, heavily horned sheep and goats can present a problem when using firearms. The mass of horn over the forehead may limit the target area and reduce the likelihood of a clean shot.

The optimum shooting position for heavily horned sheep and mature goats is behind the poll aiming towards the base of the tongue. With a captive bolt device, 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, using a heavy-duty cartridge (Figure 4.3).

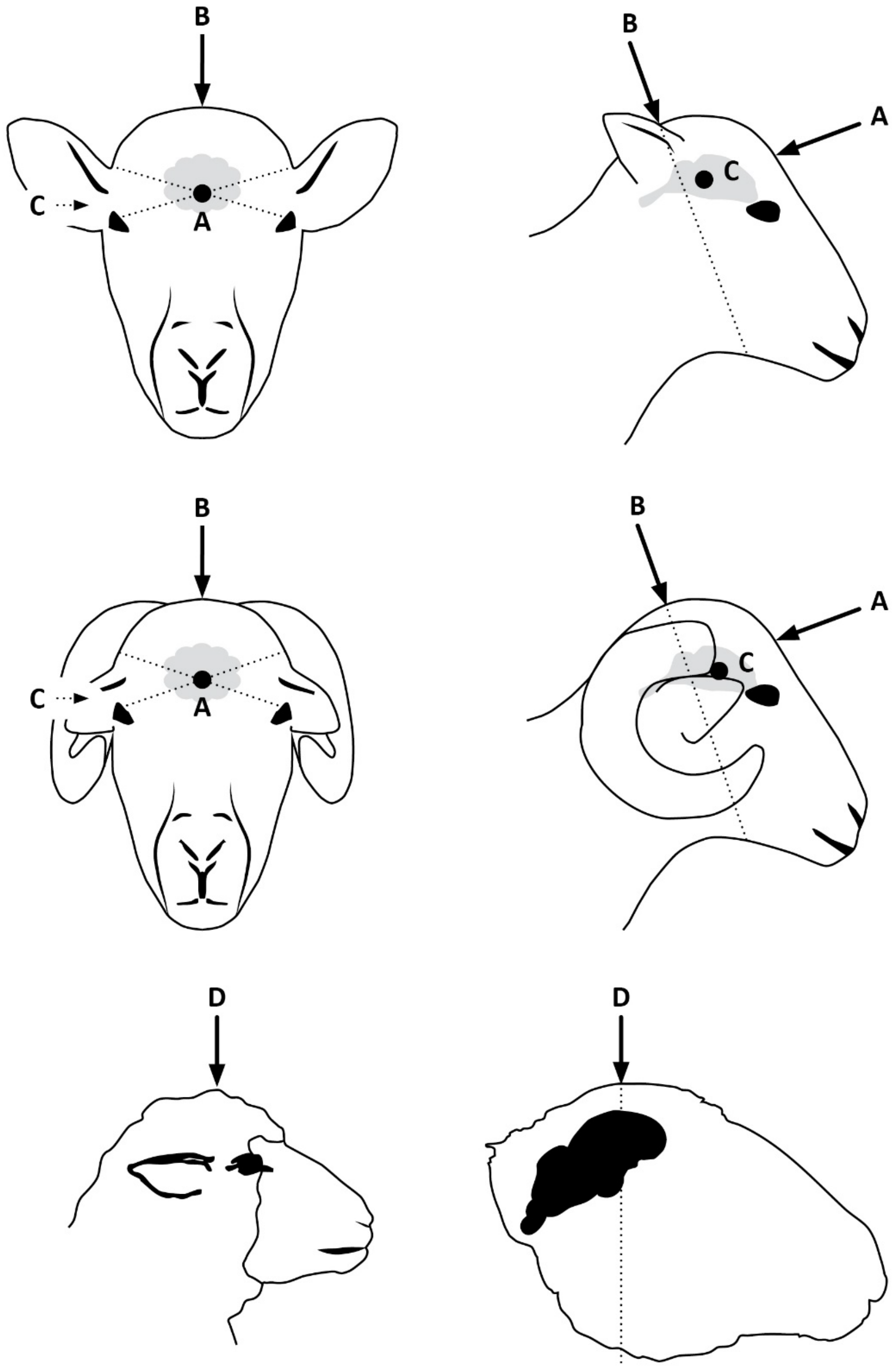


Figure 4.2 *Destruction of sheep using a firearm or captive bolt A: frontal shot position, B: poll shot position, C: temporal shot position (firearm only), D: crown shot position. Note: Diagrams are representative, and individual anatomical differences must be taken into account.*

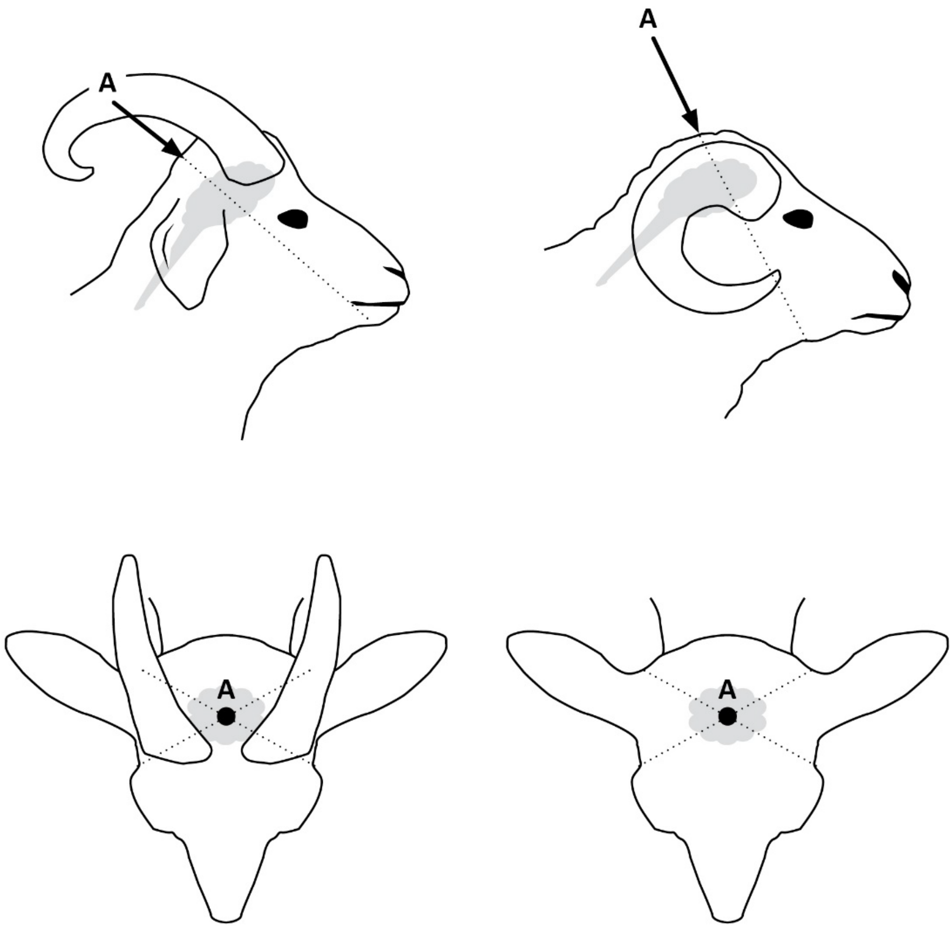


Figure 4.3 *Destruction of horned goats using a firearm or captive bolt A: frontal shot position. Note: Diagrams are representative, and individual anatomical differences must be taken into account.*

4.2.3 Electrical stunning and electrocution

Electrical stunning and electrocution may be suitable in sheep and goats if undertaken with equipment specifically designed for this purpose and class of animals, and operated by skilled and experienced personnel.[10]

However, it should be noted that this method may be unsuitable for unshorn sheep and sheep with high wool cover on the head. The fleece may prevent adequate contact and the required voltage from being administered. If necessary, a saline solution may be applied to aid conduction but should only be considered where adequate contact is consistently and reliably achieved (EFSA AHAW Panel 2021, HSA 2016a).

Commercial head-to-back stunners for sheep can be used for stun-killing as a sole method of destruction (electrocution). These head-to-back stunners have a system for passing water through the electrodes to wet the skin and achieve adequate contact and delivery of the required voltage in unshorn sheep or sheep with high wool coverage on the head.

4.2.4 Injectable agents

Barbiturate overdose by the jugular vein is the recommended option for injectables. Parting or removal of the wool may be necessary at the injection site. Other routes (e.g. intraperitoneal, intrahepatic) may only be used if the animal is first rendered unconscious or under general anaesthesia.

Sedation with xylazine followed by a terminal procedure may be the preferred approach for pet animals.

4.2.5 Specific methods for lambs and kids

Non-penetrating captive bolt devices may be suitable for very young lambs (<6 kg) and kids (<4 kg). This method will usually both stun and kill neonatal animals with a single well-placed shot. Adequate restraint of the animals is still required to ensure the method is effective.

Lambs are more difficult to stun-kill than kids when using a non-penetrating captive bolt device. The energy required to produce an effective stun-kill on lambs up to 6 kg was found to be greater than, or equal to, 107 joules. Operators should ensure both the device and selected charge can deliver the energy required (Grist et al 2018, HSA and University of Bristol 2022).

Shot position is also critical with lambs. The shot should be applied behind the poll, between the ears, with the neck bent and the chin touching the chest.

The application of a percussive blow with energy of greater than, or equal to, 27.8 joules will produce an effective stun-kill on kids up to 4 kg (Grist et al 2018). The energy developed by individual devices can be determined from the manufacturer’s website.

Shot position and confirmation of an effective stun-kill is as for lambs (see above). Larger lambs or kids may be subjected to the penetrating captive bolt in the frontal position.

[10] https://www.grandin.com/humane/elec.stun.html)

Alternatively, neonatal lambs/kids can be drafted off and administered sodium pentobarbitone euthanasia solution IV (or in the anaesthetised or unconscious animal, intracardiac) through automatic syringes.

4.3 Pigs

4.3.1 Background considerations

There are many factors that need to be considered in an EAD response requiring pig depopulation.

- Piggeries usually have pigs on site at all stages of the production cycle (pregnant sows, lactating sows and piglets, weaners, growers, finishers).
- Approximately 90% of domestic pigs in Australia are housed indoors in small (<10) to very large (>100) groups, in infrastructure that may be naturally or artificially ventilated, and which have solid, slatted or straw-based flooring.
- Many smallholders and pig keepers house pigs outdoors.
- Australian pork abattoirs and commercial piggeries operate at or close to capacity, with full asset utilisation. The maximum time that market pigs can be held over at most commercial piggeries is 7–10 days. After this time, overcrowding would occur, leading to unacceptable animal welfare impacts. Each week of further disruption to flow into abattoirs will take 4–5 weeks to catch up. Disruption to pig movements to abattoirs or to epidemiologically related premises (e.g. breeder to weaner site) in an EAD response may therefore lead to significant, time-sensitive impacts on pig welfare that may necessitate their destruction on-farm.
- It is estimated that between 20,000 and 35,000 pigs per week, per state, need to be moved to either an abattoir or another property (i.e. property-to-property movement), and as such, would be at risk of welfare-driven, on-farm destruction if movement to an abattoir or epidemiologically related premises is not possible.
- Unlike grazing livestock, pigs require commercially formulated and delivered feed, which may be adversely impacted by movement controls during an EAD outbreak.
- Farms may have a workable destruction (and disposal) plan in place that is customised and takes consideration of farm-specific factors including accessible resources, capability and equipment.

It is therefore likely that requirements for on-site pig destruction may be high and not limited to infected premises. It is also likely that multiple methods and tools will be required to humanely destroy pigs at any given site. Consideration should be given to the order of destruction depending on factors such as disease progression, the class and number of pigs, availability of feed and available progeny space.

Personnel undertaking the planning and operational tasks associated with the depopulation of piggeries need to consider carcass removal and disposal options before commencing depopulation to ensure the method and location of depopulation does not compromise carcass removal and disposal. For example, movement of pigs 'under their own steam' to destruction pens outside their sheds may assist the process of carcass removal considerably.

For more details about the various production systems and their potential implications for the choice of destruction methods see the **AUSVETPLAN** ***Enterprise manual: Pork industry***.

Although the most recent version of the *Model Code of Practice for the Welfare of Animals: Pigs,* published in 2008, has been considered in the development of this manual, more contemporary research and reviews have since become available and have informed the inclusion of the methods below.

Certain methods of destruction are more appropriate than others for pigs of certain ages, sizes and weights. Table 4.2 lists various terminal methods of destruction of pigs together with the ages and/or size of pigs for which they are appropriate. The choice of method(s) will likely depend on a range of factors including, but not limited to, human safety, resource or technology availability, competency and experience of personnel (e.g. government, farm staff and/or contractors), animal welfare, environmental considerations, efficiency of use and urgency of destruction.

With respect to Table 4.2, ‘suitable’ methods should be given priority and used preferentially if feasible and reasonable to do so. Suitable methods are those that have been endorsed through Animal Health Committee, are supported by the literature (including relevant guidelines for euthanasia and slaughter), are typically widely used or tested in the field, for which effectiveness is well-established and/or the potential risks are understood.

‘Used with constraint’ methods may be used where the circumstances of the response are such that these methods become necessary and in some cases with conditions on use (such as the use of a secondary terminal method; or methods that are appropriate only in animals based on number, size or age). Circumstances may include, but are not limited to, zoonosis, human safety, deployable resources, disease transmission risk and depopulation efficiency.

Technology under development / needs further research (written as ‘developing / needs research’ in the Table 4.2) refers to methods that may be suitable but are not yet well-established, for which research is ongoing, or for which the literature is ambiguous. It may also include circumstances in which the technology is proven but is either unavailable or impractical to deploy during a response.

‘Not acceptable’ methods have been consistently demonstrated to be inappropriate for all animals or for a subset of animals by virtue of their size, weight or other characteristics. Risks to human safety may also preclude them from use.

Irrespective of the method used, attention must be paid to confirmation of death and provision must be available to perform a secondary method if death cannot be confirmed.

Table 4.2 Destruction methods for pigs, by age and class

Method	**Class of pig**						
	Foetus	**Sucker (<5 kg)**	**Weaner (5-30 kg)**	**Grower (30-70 kg)**	**Finisher (70-110 kg)**	**Sow/gilt (>110 kg)**	**Boar (>110 kg)**
Carbon dioxide	N/A	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
Injectable agent	N/A	Suitable [a]	Suitable [a]	Suitable [a]	Suitable [a]	Suitable [a]	Suitable [a]
Penetrating captive bolt	N/A	Not acceptable	Used with constraint	Suitable	Suitable	Suitable	Suitable
Non-penetrating captive bolt	N/A	Suitable	Used with constraint [b]	Not acceptable	Not acceptable	Not acceptable	Not acceptable
Sodium nitrite	N/A	Not acceptable	Used with constraint	Suitable	Suitable	Suitable	Suitable
Firearm (free bullet)	N/A	Not acceptable	Used with constraint	Suitable	Suitable	Suitable	Suitable
Movement to slaughter	N/A	Not acceptable	Not acceptable	Used with constraint	Suitable	Suitable	Suitable
Electrocution one step	N/A	Used with constraint	Suitable	Suitable	Suitable	Suitable	Suitable
Electrocution two step	N/A	Used with constraint	Suitable	Suitable	Suitable	Suitable	Suitable
Nitrogen or inert gas	N/A	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
High-expansion (‘dry foam’)	N/A	Developing / needs research	Developing / needs research	Developing / needs research	Developing / needs research	Developing / needs research	Developing / needs research
Manual blunt force trauma	N/A	Used with constraint [a]	Not acceptable	Not acceptable	Not acceptable	Not acceptable	Not acceptable
Induction of abortion	Suitable	N/A	N/A	N/A	N/A	N/A	N/A

Note: Suitability of a method does not indicate whether specialised equipment (if required) is available in Australia. Destruction methods may be deemed suitable but require specialised equipment to be used in a field setting, which may or may not be available.

a. Small number of individuals only
b. Piglets <10 kg only (see Section 4.3.8)

4.3.2 Sedation or anaesthesia

Sedative or anaesthetic drugs may assist pig restraint or depopulation in difficult circumstances, where small numbers of pigs must be destroyed. Sedatives include intramuscular azaperone, and anaesthetic agents include combinations of agents such as xylazine and ketamine.

4.3.3 Carbon dioxide

Gassing in containers with carbon dioxide (CO_2) is considered suitable as a terminal method for destruction of all classes of pigs during an EAD outbreak.[11] CO_2 has been used in all classes of pigs overseas, and successful research trials have been conducted in Australia (Meyer and Morrow 2005, Stikeleather et al 2013, Rice et al 2014, Kinsey et al 2016, Pepin et al 2020, Lorbach et al 2021, Rotolo 2021). The method has been used in the USA to depopulate large numbers of pigs in emergency situations (Mayes pers. com) using modified transport trucks.

CO_2 gassing offers a few advantages over mechanical and electrocution methods. Although it does not cause an immediate loss of consciousness, it does minimise animal handling and allows pigs to remain with their companions, which reduces distress. These animal welfare advantages are also described in other literature (Meyer et al 2013, EFSA 2019, Hewitt and Small 2022). Additionally, it allows many animals to be killed at one time, which is a key consideration when faced with a sizeable response.

Immersion in containers pre-filled with CO_2 should be avoided in the field. To minimize distress to pigs, pigs should be exposed to CO_2 by first placing pigs in the container and displacing ambient gases with CO_2. Further research is being done to determine appropriate CO_2 administration rates for best outcomes. Pigs may vocalise and move involuntarily even when CO_2 is used correctly.

Unlike for some poultry production systems, whole-shed gassing with CO_2 is unlikely to be feasible on most piggeries. The use of appropriate on-farm containment units may be suitable. These may include temporary structures such as pens made using straw bales and sealed with tarpaulins. The use of tipper trucks as gassing containers facilitates disposal of carcasses.

On completion of gassing, the container will be opened to evacuate the gas. All animals should be checked for signs of life and a terminal method applied to any individuals if required, or the container may be closed again to repeat the gassing protocol (EFSA 2019).

4.3.4 Inert gases

Gassing in containers with inert gasses (nitrogen (N_2) or argon (Ar))—either alone or mixed with carbon dioxide—is suitable as a terminal method for destruction of all classes of pigs during an EAD outbreak. As with CO_2 gassing, it offers the welfare advantages of reducing handling and allowing pigs to move in a group and stay with their cohorts. Inert gases are not used as commonly as carbon dioxide for gassing pigs in containers, but may be applied similarly. They displace atmospheric air and so create an anoxic or hypercapnic environment, depending on the concentrations used. Higher levels of inert gases may reduce aversive responses.

[11] Animal Health Committee (AHC45 OOS13)

A mixture of 30% N2 and 70% CO_2 was shown to be effective in pigs of different ages (Gerritzen et al 2012). In this study pigs collapsed on average 145 seconds after exposure to the gas and showed a suppressed electroencephalogram (EEG) followed by cardiac arrest with a 100% mortality rate. A sophisticated containerised system was also developed for on-farm use in the Netherlands using the same mixture of 70% N2 and 30% CO_2. In this system, pigs are loaded into transport units that are moved by forklift into gassing containers, which accommodate up to six transport units. Preheated gases are injected into the container and continuously monitored at the head height of the pigs (EFSA 2020b). Pure nitrogen has also been trialled in pigs in both containers and small sheds in the USA and Canada with promising results (see Section 3.10.5).

Further investigation is warranted for feasibility and operationalisation within an Australian context.

4.3.5 High-expansion ('dry') foam

This method is being used in a limited capacity in Europe, the USA and Canada to deliver nitrogen gas in containerised and open-air settings for pig destruction.

Further investigation is warranted for feasibility and operationalisation within an Australian context. See also Section 3.10.6.

4.3.6 Injectable agents

Use of barbiturates as an injectable agent is an acceptable method suitable for all classes of pig. This method is typically only suitable for small numbers of pigs because it must be performed by a skilled person authorised to handle and administer the agent, and individual restraint is required for each animal, which is stressful for pigs.

Barbiturates can be administered intravenously or intracardiac. Intracardiac should only be performed on unconscious or anaesthetised animals.

Disposal of carcasses is problematic due to the risk of secondary poisoning of scavenging animals.

4.3.7 Penetrating captive bolt devices

Use of penetrating captive bolt devices is an acceptable method for restrained pigs over 15 kg. The application of captive bolt devices should only be undertaken by trained and experienced personnel. It is recommended that the most experienced personnel are used for the captive bolting of pigs greater than 120 kg because of the increased risks associated with these animals.

Optimal shot placement will vary depending on the size of the animal; however, Figure 4.5 and the following provides guidance (T Jubb, pers comm, 2024):

- Captive bolt shots must target the brainstem to achieve brain death. The brainstem in pigs lies midway along an imaginary line connecting the base of the two ears (as it does in all vertebrate species).
- In pigs, the skull is thinnest just above the eyes (the low frontal position) and behind the ears. Hence there are two recommended methods in pigs, the low frontal shot, and the behind-the-ear shot.
- With captive bolt devices, the device must be pressed firmly against the skull.

- In the low frontal shot the penetrating captive bolt device is placed firmly against the lower aspect of the forehead just above the level of the eyes and aimed precisely between the base of the ears towards the tail.
- In a behind-the-ear shot the device is firmly pressed immediately behind and level with the base of the ear and precisely aimed at the eye on the opposite side of the head.
- The temporal approach should not be used (Primary Industries Standing Committee, 2008).
- If there is any uncertainty about the effectiveness of the shot, it should be repeated using a different placement position 1–2 cm above or to the side of the first hole, then precisely aim at the brainstem (which lies midway along an imaginary line connecting the base of the two ears).

Penetrating captive bolt devices using the appropriate strength charges are required to consistently achieve death. This method is typically effective for smaller pigs, and pithing is not required. However, based on their review of the literature, Hewitt and Small (2021b) recommended using a secondary (or terminal) method in larger pigs to ensure death. Pithing in pigs can be dangerous to the operator because of the violent post death reflexes that occur almost immediately after the shot, and which can continue for several minutes. In healthy pigs, post death reflex tonic/clonic movements are immediate and violent. These factors may influence the suitability of this method depending on the class and size of pigs to be destroyed.

When operated by skilled and experienced personnel, penetrating captive bolt devices using the appropriate strength charges can result in death without the need for a secondary method. However, access to tools and equipment should be immediately available for the application of a secondary method in case of poor shot placement, misfires or equipment failure. A secondary (terminal) method is particularly recommended for larger pigs, as the size and structure of their skull can impact the ability of the bolt to penetrate the skull (AVMA 2020, Hewitt and Small 2021).

4.3.8 Non-penetrating captive bolt devices

Non-penetrating captive bolt is considered acceptable as a one-step method for pigs less than 10 kg liveweight (Hewitt and Small 2021b, HAS and University of Bristol 2022). For pigs up to 30 kg, a non-penetrating captive bolt may be suitable as a stunning method in a two-step destruction process (requiring a terminal method) (Anderson et al. 2022). However, there is limited research on the effectiveness of concussive stunning in pigs of this size. Non-penetrating captive bolts are not considered effective for slaughter-weight or breeding pigs (Hewitt and Small 2021b).

Correct placement of the captive bolt is critical to effectively stun/destroy the animal. All animals will require individual restraint.

Only the frontal method should be used in pigs (Primary Industries Standing Committee Model Code of Practice for the Welfare of Animals Pigs, 2008). The ideal shot placement is at a point midway along an imaginary line connecting the base of the two ears (Figure 4.4).

The muzzle of the stunner must be placed firmly against the head. Following an effective shot, pigs will demonstrate tonic/clonic movements (e.g. kicking, paddling movements) indicating that the stun was effective. These movements may last a minute or two.

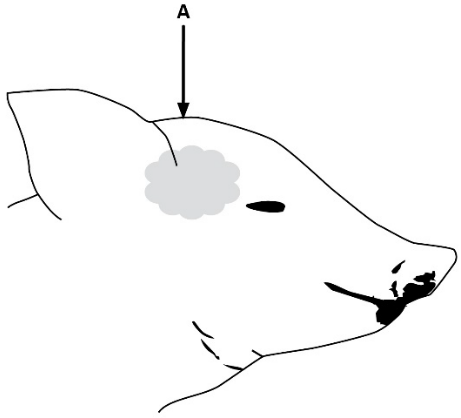


Figure 4.4 *Destruction of piglets using a captive bolt device (A=direction of fire). Note: Diagram is representative, and individual anatomical differences must be considered.*

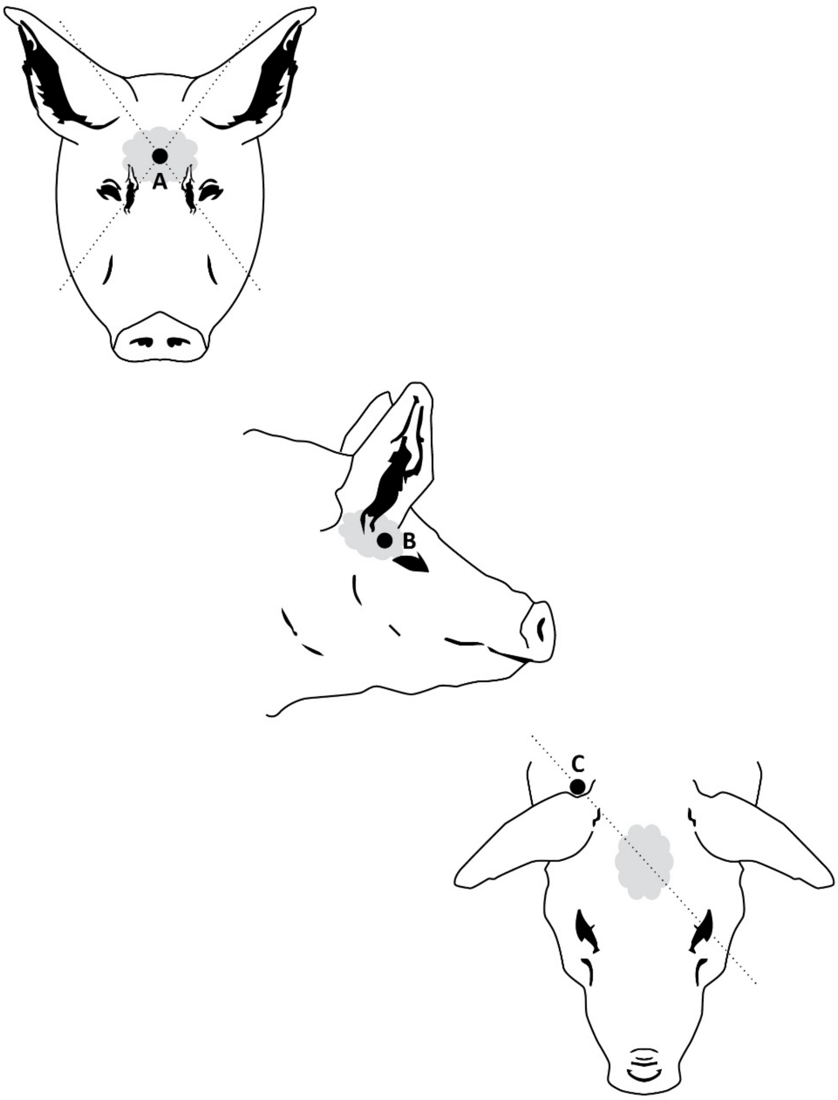


Figure 4.5 *Destruction of larger pigs using a firearm or captive bolt A: frontal shot position, B: temporal shot position (firearm only), C: behind-the-ear shot position. Note: Diagrams are representative, and individual anatomical differences must be considered.*

4.3.9 Oral agent – microencapsulated sodium nitrite

Microencapsulated sodium nitrite has Animal Health Committee (AHC) in-principle agreement[12] as an acceptable method for all pigs, excluding suckling pigs, newly weaned pigs and any pig that is not reliably consuming food orally (e.g. ill or injured pigs).

Microencapsulated sodium nitrite may only be administered to domestic pigs in the event of a declared EAD response and for the purposes of destruction under permit from the APVMA and with jurisdictional Chief Veterinary Officer (CVO) approval. This may include destruction in circumstances outlined in various AUSVETPLAN response strategies, and to mitigate adverse welfare outcomes in instances of supply chain interruptions that may occur due to a response to a declared emergency animal disease.

To be effective, bolus dosing is required. Before delivery of microencapsulated sodium nitrite, pigs to be treated must be consuming 90% of the feed in which the required dose of microencapsulated sodium nitrite is to be delivered, within 20–30 minutes. To achieve this condition if this is not already the case—for example in ad libitum fed progeny pigs—a pre-feeding program, which may include a feed withholding period of no more than 24 hours, should be undertaken in consultation with a qualified animal nutritionist and a veterinarian experienced with pigs. Individual oral drenching may be a suitable alternative depending on the situation. Consideration should be given to the class of pig and its nutritional requirements, existing feed formulation, method of feeding, and the intended microencapsulated sodium nitrite formulation to be administered (paste or top dress). Pigs may be treated in groups, if appropriate measures are taken to ensure all pigs to be treated have access to sufficient treated feed to ensure intoxication (e.g. by ensuring sufficient feeding space and that shy feeders are not prevented from accessing feed treated with microencapsulated sodium nitrite).

Unconsciousness and death are not immediate, with preceding ataxia and lateral recumbency (Lower 2020). Where pigs do not rapidly consume a fatal dose but show signs of distress, an alternative destruction method should immediately be implemented.

4.3.10 Firearms

The use of a firearm (free bullet) is an acceptable method for all classes of pig greater than 15 kg (i.e. nursery/weaner pigs greater than 15 kg, growers, finishers, and mature pigs).

The use of firearms is generally preferable for pigs housed in non-traditional sheds (e.g. ecosheds) and free range paddocks. Pigs housed indoors should be moved outdoors prior to use of a firearm. Sound suppression (silencer) should be considered to reduce distress to pigs and facilitate best depopulation outcomes with this method.

When using the frontal method, for pigs between 15 and 120 kg, the ideal shot placement is one finger's width above eye level, on the mid-line of the forehead, aiming towards the tail (Figure 4.5). For adult sows and boars, shot placement should be off-center with a higher placement 3–4 cm above the eyes, aiming into the centre of the head. Because of the challenges associated with older pigs, where possible, use a higher calibre rifle (>.30) or shotgun (12, 16 or 20 bore). In addition to the same shot placement as above, the animal can be shot using a shotgun through an eye, or from behind an ear, aiming toward the middle of

[12] Animal Health Committee (AHC43 OOS16)

the head. When using a shotgun, the muzzle should be held 5–25cm away from the animal's head (HSA 2016b).

When using the temporal method, the pig is shot from the side so that the bullet enters the skull at a point midway between the eye and the base of the ear. The bullet should be directed horizontally into the skull and at ninety degrees to the side of the head. With adult pigs, this method has some advantages because the bone structure at the front of the skull is heavier.

4.3.11 Movement to abattoir

Destroying animals through an abattoir may be an acceptable method of destruction, subject to meeting biosecurity requirements, and agreement with and capacity of the abattoir to handle the numbers and sizes of pigs involved. Further information on abattoir biosecurity controls can be found in the **AUSVETPLAN *Guidance document: African swine fever response operational guidelines for pig abattoirs***.

Abattoirs have the trained staff and required infrastructure already in place, and the potential capability to destroy thousands of suitably sized pigs per day. It may be possible to use existing rendering capabilities to assist disposal. Abattoirs may also have the capacity to hold limited carcasses pending disposal.

The use of an abattoir for destruction best suits pigs with low likelihood of disease transmission. However, in some circumstances—for example where large numbers of pigs are involved—it may be appropriate to consider using an abattoir for higher biosecurity risk pigs. In this case, movement to an abattoir may increase the risk of disease spread. Therefore, the movement to an abattoir requires the relevant authorisation after an appropriate risk assessment has been conducted.

4.3.12 Electrical stunning and electrocution

Electrocution is suitable for all classes of pigs over 1 week of age. Electrocution requires specialised equipment, correct amperage and voltage, and a skilled operator to ensure the appropriate placement of electrodes. Work, health and safety considerations for operators must be afforded the highest consideration with respect to electrocution, as the method does carry risk to human safety. This method requires a reliable supply of electricity. The electrodes must be applied and held in the correct positions to ensure that an effective stun and subsequent death occurs. The two-step method is considered to be physically demanding, and can result in operator fatigue leading to the risk of poor electrode placement.

Head-to-heart electrocution is a one step process and does not require a terminal method. Head-only electrical stunning requires application of a terminal procedure as well.

EFSA (2020b) describes both handheld systems and mobile electrocution units for mass depopulation based on a conveyer (negative electrode) and curtains of chains (positive electrode) as being commercially available in Europe. These items are held in the veterinary stockpiles of some European nations, and are being developed in North America. Handheld units have not been practically used with pigs in Australia in the field and mobile electrocution units are not available.

4.3.13 Manual blunt force trauma

In an emergency response, manual blunt force trauma should only be used when an alternative appropriate method is not available. Due to the risk of misapplication and reduced effectiveness, it should be undertaken only by a skilled operator and its use strictly limited to pigs <5 kg liveweight and to situations where only small numbers of pigs need to be destroyed (Hewitt and Small 2021b). In addition, the method is considered aesthetically unpleasant for operators and bystanders. Strict attention should be paid to confirming death in each pig. Where this cannot be achieved, a secondary method should be applied. When performed correctly, the pig will usually exhibit tonic-clonic movements.

4.3.14 Induction of abortion

Consideration can be given to inducing abortion in late-gestation sows when there is a delay in destruction, particularly on non-infected premises. This will reduce the time and space pressure on the flow of pigs, creating a gap or buffer in new pigs entering the system. Decreasing the need for further pig space in this way may be of assistance if the EAD response becomes protracted, impacting normal production activities. It may also facilitate a faster return to normal production when mass depopulation is required for welfare outcomes alone. Induction of abortion, however, should be strictly under the supervision of a veterinarian with pig experience because sows may become distressed and increased cannibalism can occur.

Prostaglandin F2 alpha and its analogues are registered for use in pigs as luteolytic agents and will induce abortions at any time after embryos are implanted (Pressing et al 1987). Evidence suggests a double dose or repeated dose may be needed to achieve a 100% success rate.

Work, health and safety considerations for female workers of childbearing years and asthmatics must be afforded the highest consideration with respect to handling and using prostaglandins.

4.4 Horses, donkeys and mules

Horses and other equids are powerful and athletic, and have a prey animal disposition. They are inclined to show panic and flight responses, which may be exacerbated during a destruction event. They derive safety from being part of a herd and are generally more secure in the company of their companions. They should be handled calmly by personnel experienced in equine handling and restraint. When equids are destroyed from a standing position, they will fall suddenly upon loss of consciousness and may continue to thrash on the ground because of result of involuntary muscular excitation. It is important that responders are safely positioned, and the area is cleared of potential hazards.

4.4.1 Sedation

Any destruction method may be preceded by a sedative, which provides animal welfare and human safety benefits because it reduces excitation. Appropriate agents include alpha-2 agonists, xylazine, butorphanol and acepromazine. The latter may prolong time to unconsciousness due to its effects on the circulatory system. Ketamine, with or without benzodiazepines, may be used to induce anaesthesia.

4.4.2 Injectable agents

The most widely accepted terminal method for equine euthanasia is intravenous injection of barbiturates such as sodium pentobarbitone. Use of a jugular catheter is recommended to secure intravenous access and accommodate the large volume of solution required. The full label dose should be given undiluted. Neuromuscular blocking agents (e.g. succinyl choline) should not be used alone or in combination with sodium pentobarbitone because their use may induce paralysis before loss of consciousness. If a horse is difficult to restrain and this is hindering catheter placement, prior use of sedation is recommended (AVMA 2020) (see Section 4.4.1).

The following chemicals may also be used to invoke cardiac arrest and death in an anaesthetised animal:

- intravenous saturated solution of potassium chloride or magnesium sulphate
- intrathecal injection of 2% lidocaine.

4.4.3 Firearms

The brain is positioned high in the head of equids, so, like other livestock species, when shooting using the frontal method, the bullet must enter above, and not between, the eyes. The target is the intersection of diagonal lines extending from the outside corner of one eye to the inner margin of the opposite ear (Figure 4.6). The shot should be directed to follow the angle of the brainstem and spine. The firearm should not be held directly against the animal's head, because it may result in severe recoil or explosion of the barrel.

The frontal method is the position of choice for shooting equines. However, if the frontal position cannot be accessed (e.g. the horse is down in a position which makes access impossible) then a temporal shot can be used as a last resort. This should only be done with an appropriate high calibre rifle, because lighter calibre (rifles eg .22/.22 magnum) will not be sufficient because the petrous temporal bone is very hard and angulated, and the ramus of the mandible and zygomatic arch can get in the way (T Jubb, pers comm, 2024).

The temporal position is not appropriate for captive bolt.

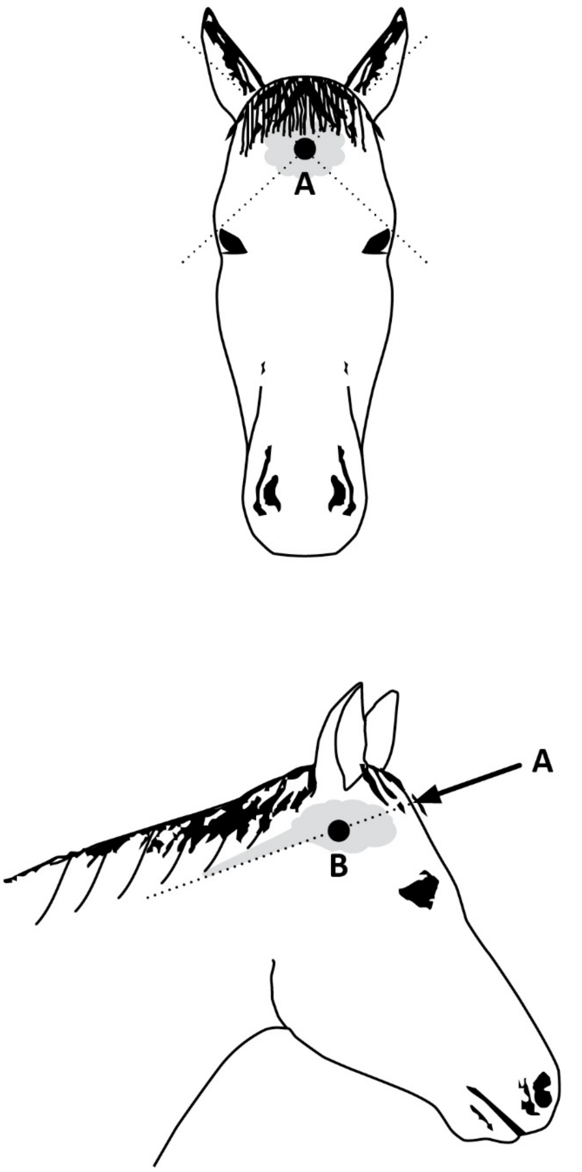


Figure 4.6 *Destruction of horses using a firearm or captive bolt A: frontal shot position, B: temporal shot position (firearm only). Note: Diagrams are representative, and individual anatomical differences must be considered.*

4.4.4 Paddock or extensive area destruction

Paddock destruction of equines is like that of cattle and buffalo (see Section 4.1) but should consider the nature of equids, especially those that are unhandled. All activities should be conducted in a manner that minimises distress.

An example method to destroy groups of horses is to muster them using long hessian wings, herding them into portable yards covered in hessian curtains, and then up a race lined with hessian curtains. A team of operators can then safely and unobtrusively inject the horses in the neck or rump through the gaps in the race rails with a sedative, such as a high dose of xylazine and ketamine, using pole syringes. After injecting, the horses are let out of the race in small numbers into a hessian curtained yard where they cannot see the injection team operating. When the horses lie down, a team quietly destroys them using captive bolt devices. Panels are then removed to allow machinery access to remove the carcases for disposal. Only penetrating captive bolts should be used in this larger scale mass yard destruction approach, not rifles, which are too loud, will disturb the animals, and can ricochet, which is a risk to human health (T Jubb, pers comm, 2024).

For feral horses, refer to Section 4.14 and the **AUSVETPLAN *Operational manual: Wild animal response strategy***.

4.4.5 Penetrating captive bolt device

The use of penetrating captive bolt devices in field situations can be a high-risk method because of the likelihood of horses moving suddenly, and the operator may not be able to withdraw the bolt or move out of danger. Equids must be appropriately restrained and/or sedated when using a penetrating captive bolt device.[13] Standing horses should always be sedated, not just to still the head, but to lower the head for ease of access and accurate placement of the captive bolt in the high frontal position. Once the shot is fired the horse drops straight down so the operator needs to know to take a step back the instant the shot is taken.

The target with a penetrating captive bolt is the brainstem which lies midway along an imaginary line connecting the base of the two ears. The high frontal position uses a point of entry high on the forehead—above not between the eyes—with the device held perpendicularly and pressed gently to the skull so as to target the brainstem (T Jubb, pers comm, 2024) (Figure 4.6). Captive bolts must not be used in the temporal position in equines.

Checking for absence of heartbeat and pulse can be misleading after shooting or captive bolt use in equines. This is because the heart can continue to beat for many minutes after brain death and in shocked horses may be weak, fluttering and difficult to detect especially if the horse is fat, hairy or there is a lot of background noise.

However, if anaesthetic overdose is used, checking for absence of heartbeat or pulse will be necessary (T Jubb, pers comm, 2024).

[13] www.hsa.org.uk/positioning/horses

4.5 Camelids

Camelids include a wide range of domesticated and feral species and most commonly include camels, llamas and alpacas. As with other species, operators should take steps to minimise operator injury, and animal excitement, fear and pain during handling and restraint. Animals should be handled calmly by personnel experienced in camelid handling and restraint. When larger individuals such as adult camels are being destroyed from a standing position, it is important that responders are safely positioned, and the area is cleared of potential hazards.

4.5.1 Sedation

Any destruction method may be preceded by a sedative, which provides animal welfare and human safety benefits because it reduces induction of excitation. Agents for South American camelids include xylazine, benzodiazepines, butorphanol and ketamine. Doses vary by species and their selection, alone or in combination, should be informed by expert advice, such as Riebold (2004).

4.5.2 Restraint of South American camelids: llamas, guanacos, vicunas, alpacas

To access the jugular vein, farmed camelids may be restrained manually by placing in a small yard, standing at the left shoulder of the animal and placing an arm around the animal's neck. Larger and/or less tractable camelids can be placed into a narrow race, haltered and cross-tied in a chute or crush.

4.5.3 Restraint of camels

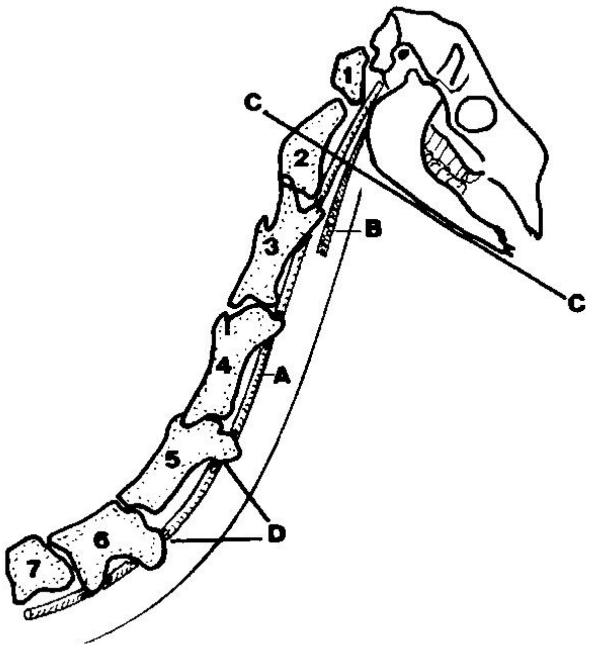
Halter-trained camels can be placed in sternal recumbency ('hooshed') to access the jugular vein. Less tractable camels should be run into cattle yards, along the race and into the crush. If there is no suitable animal handling infrastructure, camels can be humanely destroyed using firearms at a distance in the paddock.

4.5.4 Injectable agents

The dose of sodium pentobarbitone for destruction in camelids is 100 mg/kg by intravenous (IV) injection. Adult alpacas weigh approximately 60–80 kg, and adult llamas weigh 140–160 kg.

In South American camelids, it is essential that an assistant restrains the camelid in a relaxed manner, or the animal is cross-tied in a chute so that the neck is upright, not rotated, and held on the midline, thus allowing the jugular vein to fill with blood. The jugular vein is always difficult to visualise but may be accessed high near the ramus of the mandible or low nearer the thoracic inlet (Figure 4.7), South American camelids do not have an obvious jugular furrow (the vein is covered by the sternotrachealis muscle), but the vein lies just medial to the ventral projection of the transverse process of the cervical vertebrae. Neck fibre may be clipped to allow easier palpation of landmarks. The needle should be inserted upwards and at an angle of 30 degrees to the skin.

In camelids, the jugular vein has its largest diameter, is easiest to see and is most accessible high on the neck. The specific positions for South American camelids are shown in Figure 4.7.



Source: Fowler (1998)

Figure 4.7 *Sites for accessing the jugular vein in South American camelids: (A) jugular vein; (B) tendon of sternotrachealis muscle; (C) site for upper access; (D) sites for lower access.*

4.5.5 Penetrating captive bolt device

When using a penetrating captive bolt device in camelids, use the poll shot in well restrained animals. Place the captive bolt firmly on the midline of the caudal skull and direct the bolt through an imaginary line drawn between the horizontal ear canals, directed slightly forward of the angle of the jaw, to ensure rapid loss of consciousness and disruption of the brainstem (Figure 4.8). If the animal blinks, vocalises or tries to stand, repeat the shot through a different entry point (Gibson et al 2015). The strength of the blank needed depends on the type of captive bolt and the body weight of the camelid. Follow manufacturer's directions.

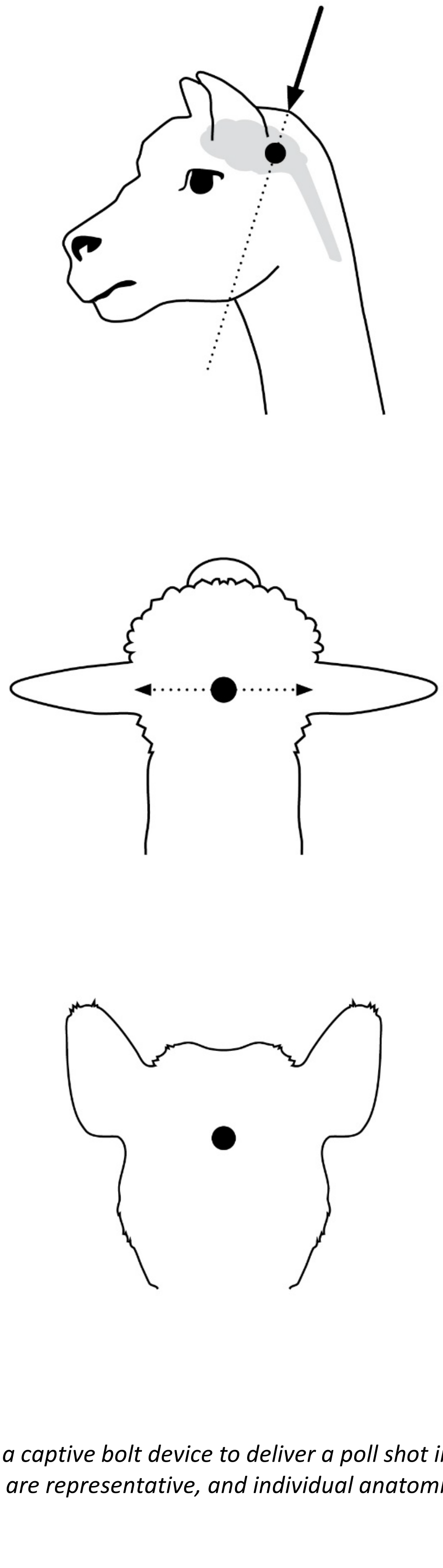


Figure 4.8 *Site of placement of a captive bolt device to deliver a poll shot in South American camelids (position 'A'). Note: Diagrams are representative, and individual anatomical differences must be taken into account.*

4.5.6 Firearms

If camelids can be placed in sternal recumbency (South American camelids 'kushed' and camels 'hooshed') or placed into a race, crush or chute, then a poll shot can be used as with a captive bolt (Figure 4.8).

To maximise the impact of the shot and to minimise the risk of misdirection, the range should be as short as possible (e.g. 5–20 cm from the stationary head using a rifle). In South American camelids, a .22 calibre rifle with soft nose or hollow point ammunition is adequate. For camels, at least a .22 magnum calibre rifle should be used.

Ground and aerial shooting of feral camels is covered by Sharp et al (2022a) and Sharp et al (2022b) respectively. Culling programs for feral camels should comply with the Australian Model Code of Practice for the humane control of feral camels.[14]

4.5.7 Blunt force trauma

This method can only be used in camelids less than 24 hours of age, and only when there is no firearm, captive bolt or lethal injection reasonably available. The neonatal camelid should be placed in sternal recumbency with its head placed on a solid surface, before striking the central skull bones with a single sharp blow to ensure rapid loss of consciousness and disruption of the brainstem (AAV 2016).

[14] https://pestsmart.org.au/toolkit-resource/model-code-of-practice-for-the-humane-control-of-feral-camels/

4.6 Cervids (deer)

Cervids are generally highly distressed when handled and/or restrained. Capture myopathy may occur during trapping, capture, transport and even simple restraint. This leads to rapid physiological imbalances that result in severe muscle damage and hyperthermia. Handling should be avoided if possible. If handling is necessary, additional care should be taken. This is especially true of unhandled cervids. In these cases, firearms are preferable if restraint facilities (e.g. appropriate crush and visual blockers, like blinds) are unavailable or where capture myopathy is considered likely. When penetrating captive bolts or injectable agents are used as a terminal procedure, heavy sedation may precede their use.

4.6.1 Injectable agents

Use of barbiturates as an intravenous injectable agent is an acceptable method suitable for all classes of cervids.

Use of injectable agents is typically only suitable for small numbers of cervids because it requires individual handling and restraint of animals. Sedation before barbiturate injection is likely to be required.

In farmed herds, gentle handling and restraint using a suitable crush and intramuscular administration of a sedative such as xylazine can precede release of animals into a small enclosure. Heavy sedation is recommended. After animals are sedated and recumbent, further restraint may need to be applied before to jugular vein injection of the barbiturate.

4.6.2 Firearms and penetrating captive bolt devices

Firearms and/or penetrating captive bolt devices are acceptable methods for destruction of cervids. Herd flight response is a limiting factor for humane destruction of cervids. Therefore, it may be necessary to draw upon both recommendations for farmed deer, such as those in the *Model Code of Practice for the Welfare of Animals: The Farming of Deer,* and/or those for feral deer such as the *National Standard Operating Procedure: Ground Shooting for Feral and Wild Deer*.

Dependant fawns or calves and juveniles should be destroyed first to minimise the risk of negative welfare outcomes. When destroying trapped cervids or cervids in urban or peri-urban locations, tranquilisers can be administered via dart guns.

When using firearms, only head shots and chest shots are acceptable, although chest shots are preferred for mature animals. Death from chest shots occurs because of blood loss due to damage to tissues and major blood vessels. If death does not occur, a chest shot must be followed up with a head shot. For small cervids (e.g. hog, fallow, chital), the minimum firearm and ammunition requirements are .243 calibre with 80 grain bullets. For large cervids (e.g. red, rusa, sambar and wapiti), the minimum firearm and ammunition requirements are .308 calibre with 150 grain bullets.

The following describes shot placement for firearms and penetrating captive bolts for cervids (Terrestrial Vertebrate Working Group 2023).

See also Figure 4.9.

4.6.2.1 Fawns and calves

Frontal position (front view)

The preferred method of destruction for fawns and calves is the frontal shot, in which the firearm or captive bolt device is aimed centrally on the forehead. This position is located by drawing imaginary lines from the medial aspect of the eye to the medial aspect of the base of the opposite ear. The bullet should be directed horizontally into the skull.

4.6.2.2 Other classes of deer (excluding fawns and calves)

The frontal position (as preferred for fawns and calves) should not be used in larger adult deer due to the heavier bone structure of the front of the skull.

Poll shot

The poll shot is the preferred method when mature animals cannot be approached from the side. The firearm or captive bolt device should be positioned centrally, at the back of the skull, between the base of the ears, or, for stags, at a point just behind the antler base, with the bullet or bolt directed towards the mouth.

Temporal shot (firearm only)

The shot should be aimed between the base of the ear and the eye on the same side of the head. The bullet should be directed across the skull to exit between the eye and base of the ear on the opposite side of the head.

Chest shot — side (firearm only)

The firearm should be aimed horizontally at the base of the chest just behind the elbow. The aim of shot should be taken at an angle slightly behind the scapula (aiming towards the opposite shoulder) and not as a direct side on shot because of the location of the humerus and scapula, which partially shield the heart.

Chest shot — front (firearm only)

The frontal chest shot should only be taken when the animal has its head in a high position and as such is not recommended for routine use. The firearm is aimed horizontally and centrally between the front legs and immediately below the base of the throat.

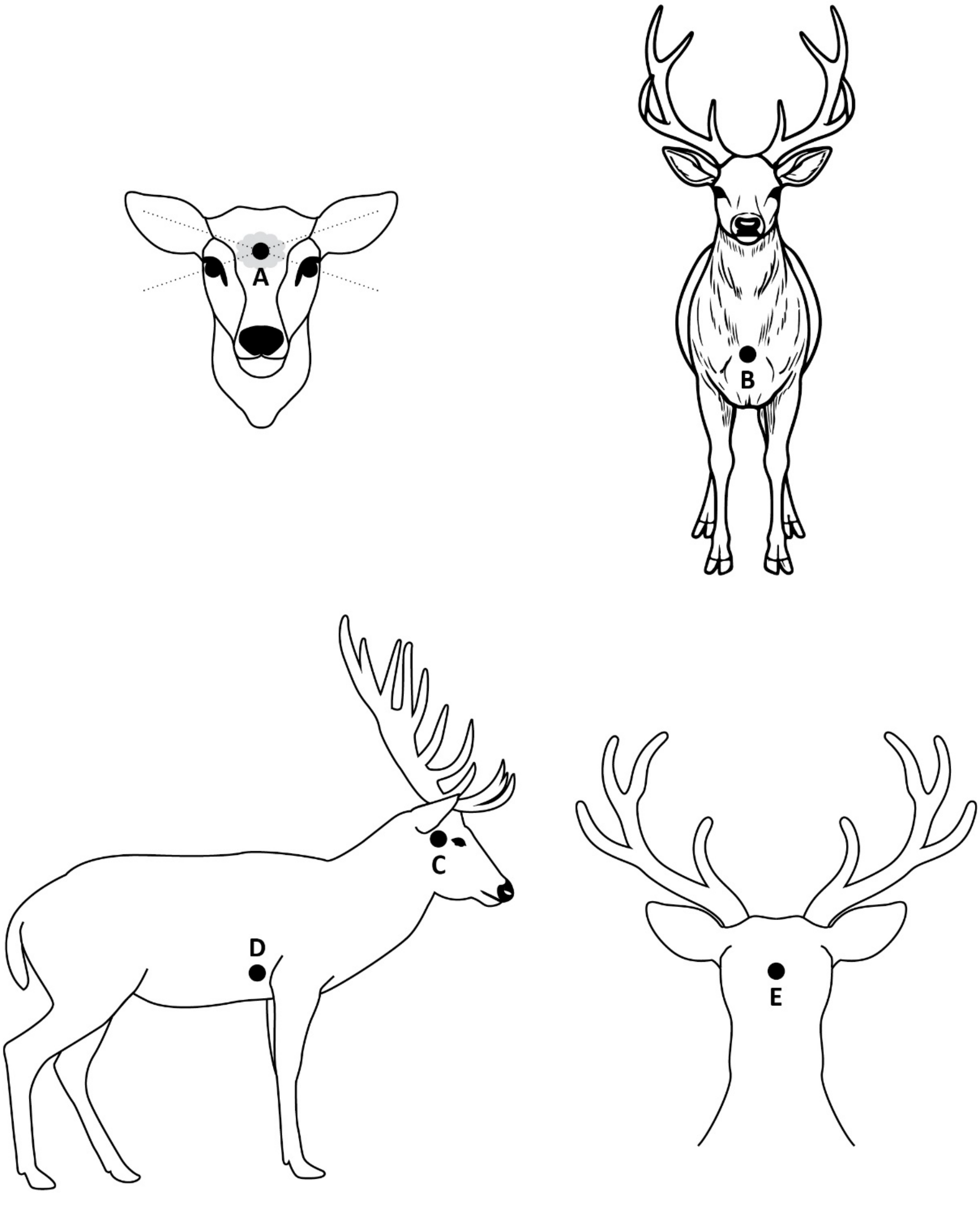


Figure 4.9 *Destruction of deer using a firearm or captive bolt. A: frontal shot position (fawns or calves only), B: chest shot—front position (firearm only), C: temporal shot (firearm only), D: chest shot—side (firearm only), E: poll shot position. Note: Diagrams are representative, and individual anatomical differences must be taken into account.*

4.7 Poultry, including ratites (birds)

Tables 4.3 and 4.4 list various methods of destruction of poultry, ratites and other birds. Further details are described in subsequent text.

With respect to Tables 4.3 and 4.4, 'suitable' methods should be given priority and used preferentially if feasible and reasonable to do so. Suitable methods are those that have been endorsed through Animal Health Committee, are supported by the literature (including relevant guidelines for euthanasia and slaughter), are typically widely used or tested in the field, for which effectiveness is well-established and/or the potential risks are understood.

'Used with constraint' methods may be used where the circumstances of the response are such that these methods become necessary and in some cases with conditions on use (such as the use of a secondary terminal method; or methods that are appropriate only in animals based on number, size or age). Circumstances may include, but are not limited to, zoonosis, human safety, deployable resources, disease transmission risk and depopulation efficiency.

Technology under development / needs further research (written as 'developing / needs research' in the table refers to methods that may be suitable but are not yet well-established, for which research is ongoing, or for which the literature is ambiguous. It may also include circumstances in which the technology is proven but is either unavailable or impractical to deploy during a response.

'Not acceptable' methods have been consistently demonstrated to be inappropriate for all animals or for a subset of animals by virtue of their size, weight or other characteristics. Risks to human safety may also preclude them from use.

Irrespective of the method used, attention must be paid to confirmation of death and provision must be available to perform a secondary method if death cannot be confirmed.

4.7.1 Background considerations (intensive production)

The commercial poultry industry can be broadly divided into a poultry meat sector and an egg production (layer) sector. This is an important distinction because there are fundamental differences between the two that need consideration during the preparation and planning for EAD responses. There are also several production systems (e.g. barn, free range) within these two sectors, and the production system used will dictate what destruction methods may be most feasible, or even possible, and has a significant bearing on resources and technologies required to undertake mass destruction.

4.7.1.1 Poultry — meat

Large commercial poultry meat (broiler) farms may house chickens, turkeys, ducks or game birds. Chicken meat is by far the largest sector, representing over 90% of poultry meat, followed by turkeys and ducks. There is also a small game bird sector.

Chicken meat farms typically have stocking capacities ranging from 100,000 birds (2 sheds) to over 2 million birds (20 sheds) per farm. However, a production unit may be made up of several farms, and therefore there may be up to approximately 6 million birds within a production unit. Turkey farms generally have much lower stocking densities but produce significantly heavier and larger birds. Duck farms tend to have much lower stocking densities than either chicken meat or turkey farms.

Chickens, turkeys and ducks produced for poultry meat are exclusively produced in shed production systems and never in cages. Sheds may be naturally ventilated or tunnel ventilated. In free range production systems, the birds have access to an outdoor range during daylight hours. However, breeder farms include housing with nest boxes and perches which pose some challenges in terms of undertaking mass destruction in sheds.

4.7.1.2 Poultry — egg

The poultry egg industry is far more diverse than the meat industry and is characterised by the presence of a wide range of producers—small, medium and large. In 2021 the largest four egg companies accounted for 80% of national production, by market share.[15] Backyard and micro-commercial enterprises account for 1.2–3.8 million hens, estimated to produce between 174–591 million eggs, which would account for approximately between 3.0–8.6% of Australia's total egg production (Graham et al 2021).

There are three distinct types of production systems:

- Cage systems: Differences in these types of systems are limited mainly to the number of cage tiers, which can range from one to eight. Multi-tier sheds have higher levels of automation.
- Free-range systems: There are distinct types of free-range systems—paddock-based, with moveable laying sheds, and barn-based, with access to a fixed outdoor range.
- Barn production systems: Birds can freely roam throughout the shed but do not have access to the outdoors. Sheds often have slatted floors. Nest boxes are provided for birds to lay their eggs in.

[15] https://www.ibisworld.com/au/industry/egg-farming/22/#IndustryStatisticsAndTrends

Table 4.3 Destruction methods by classes of commercial poultry (chickens, ducks and turkeys)

		Chickens			**Ducks**	**Turkeys**
METHOD	**Embryonated eggs**	**Chicks (day old[16])**	**Cage-based housed birds**	**Floor-based housed birds**		
Cooling	Suitable [f]	Not acceptable	Not acceptable	Not acceptable	Not acceptable	Not acceptable
Macerated	Suitable [f]	Suitable	Not acceptable	Not acceptable	Not acceptable	Not acceptable
Carbon dioxide (CO_2) gassing—whole-shed and containerised[17]	Suitable [f]	Suitable	Suitable	Suitable	Suitable	Suitable
Water based foam[18]	N/A	Suitable	Developing / needs research [a]	Suitable	Used with constraint	Suitable
High-expansion gas foam	N/A	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]
Nitrogen/inert gas in containers and sheds	N/A	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]
Non-penetrating captive bolts	N/A	Not acceptable	Suitable	Suitable	Suitable	Suitable
Dislocation of the neck by hand or with novel mechanical cervical dislocation devices	N/A	Suitable [b]	Used with constraint [c]	Used with constraint [c]	Used with constraint [c]	Used with constraint [c]
Dislocation of the neck by crushing mechanical aids of conscious birds	N/A	Not acceptable	Not acceptable	Not acceptable	Not acceptable	Not acceptable
Lethal injection (e.g. sodium pentobarbitone or anaesthetic overdose)	N/A	Not acceptable	Suitable	Suitable	Suitable	Suitable
Firearms	N/A	Not acceptable	Not acceptable	Not acceptable	Not acceptable	Not acceptable
Hypobaric hypoxia (LAPS)	N/A	Developing / needs research [d, e]	Developing / needs research [d, e]	Developing / needs research [d, e]	Developing / needs research [d, e]	Developing / needs research [d, e]
Electrical methods (stun-to-kill)	N/A	Developing / needs research	Suitable [d]	Suitable [d]	Suitable [d]	Suitable [d]
Ventilation shut down (VSD) + heat	N/A	Not acceptable	Not acceptable	Not acceptable	Not acceptable	Not acceptable

a) Birds to be removed from cages; b) By hand but not stretching device; c) Depends on age or size of bird; d) Technology not yet available in Australia; e) Not validated in egg bearing/laying birds; f) Embryonated eggs or neonates should preferably be destroyed by containerised gassing, cooling, freezing or maceration. Bird embryos that have attained more than 80% incubation should be destroyed by methods similar to those used in avian neonates. Eggs at less than 80% incubation may be destroyed by exposure (> 20 minutes) to CO2, cooling (< 4°C for 4 hours), or freezing. Anaesthesia can be used before destruction and is most easily accomplished with exposure to inhaled anaesthetics via entry into the air cell at the large end of the egg (AVMA 2019).

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[16] 'Day old' chicks are 1-3 days old. Maceration is only suitable at hatcheries.
[17] Refer to Animal Health Committee (AHC39 OOS17)
[18] Refer to AHC39 OOS18 for water-based foam in containers

Table 4.4 Destruction method for fancy poultry breeds and ratites

		Bird type		
METHOD	**Embryonated eggs**	**Fancy poultry breeds, pigeons**	**Ratite chicks (<26 weeks of age)**	**Ratites (managed birds >26 weeks)**
Cooling	Suitable	Not acceptable	Not acceptable	Not acceptable
Macerated	Suitable	Not acceptable	Not acceptable	Not acceptable
Water based foams	N/A	Suitable	Used with constraint [a]	Not acceptable
Carbon dioxide (CO_2) gassing – whole-shed and containerised	N/A	Suitable	Suitable	Suitable
Electrical stunning, followed by cervical dislocation or bleeding out	N/A	Suitable	Suitable	Suitable
High-expansion gas foams	N/A	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]
Nitrogen/inert gas in containers and sheds	N/A	Developing / needs research [d]	Developing / needs research [d]	Developing / needs research [d]
Non-penetrating captive bolts	N/A	Suitable	Suitable	Suitable
Dislocation of the neck by hand or with novel mechanical cervical dislocation devices	N/A	Used with constraint [c]	Not acceptable	Not acceptable
Dislocation of the neck by crushing mechanical aids of conscious birds	N/A	Not acceptable	Not acceptable	Not acceptable
Lethal injection (e.g. sodium pentobarbitone or anaesthetic overdose)	N/A	Suitable	Suitable	Suitable
Firearms	N/A	Not acceptable	Not acceptable	Suitable
Hypobaric hypoxia (LAPS)	N/A	Developing / needs research [b, d]	Developing / needs research [b, d]	Developing / needs research [b, d]

a) Method was used in 2020 Victorian avian influenza outbreak for emu chicks less than 6 weeks of age; b) Not validated in egg bearing/laying birds; c) Depends on age or size of bird; d) Technology not yet available in Australia

4.7.2 Small numbers of birds or large bird species

4.7.2.1 Dislocation of the neck or decapitation

For the destruction of small numbers of birds, cervical dislocation (separating the skull from the spine by hand) and decapitation are acceptable methods of destruction. The WOAH Terrestrial Animal Health Code (Chapter 7.6) outlines an upper limit of 3 kg for conscious birds, which is supported by the review by Hewitt (2023). The Australian Animal Welfare Standards and Guidelines for Poultry (DAFF 2022) allow for a maximum weight limit of 5 kg; however, in addition to weight, other factors should be considered before attempting cervical dislocation. These include age, stage of development and species. For example, broilers and commercial layers are routinely destroyed by using this method despite significant age differences. However, ducks over 3 weeks of age (approximately 1.2 kg) have very well-developed neck muscles, making them less suitable for destruction using cervical dislocation. Similarly, the roosters of some fancy breeds that weigh less than 5 kg have exceptionally strong neck muscles and are similarly unsuitable for cervical dislocation. Cervical dislocation should only be undertaken by competent and experienced personnel.

The use of mechanical aids that reliably cause the dislocation of the cervical vertebrae and severing of the spine may be considered (Martin et al 2019). If used as a primary destruction method, these methods may be suitable for birds up to 5 kg, provided strict conditions can be met, including that the animal is held firmly in place and is the correct size for the apparatus. Mechanical aids can be used in larger birds (>5 kg) provided they are unconscious first (i.e. stunned or sedated). Mechanical cervical dislocation should be performed with care. For example, Burdizzos and forceps have been associated with neck crushing rather than dislocation and should not be used. However, novel mechanical cervical dislocation devices that reliably cause the dislocation of the cervical vertebrae and severing of the spine may be considered (Martin et al 2019).

Ratites larger than 5 kg can be destroyed by cervical dislocation provided they are stunned first (see Section 4.7.4).

4.7.2.2 Non-penetrating and penetrating captive bolts – chickens, ducks, turkeys

Captive bolt devices may be suitable for small numbers of birds but are unlikely to be practicable for mass destruction. Both penetrating and non-penetrating devices are typically powered by a blank cartridge, spring, compressed air or gas. Captive bolt guns designed specifically for poultry are commercially available.

Captive bolt devices are intended to deliver sufficient force and energy to the head to result in immediate insensibility and brain death (Hewitt 2000, Raj and O'Callaghan 2001, Erasmus et al 2010, Gibson et al 2018). Raj and O'Callaghan (2001) suggested that a bolt diameter of at least 6mm driven at an air pressure of 827kPa was necessary to kill chickens. Other researchers corroborated these parameters when using similar equipment to kill turkeys, ducks and geese (Erasmus et al 2010a, Erasmus et al 2010b, Sparrey et al 2014, Gibson et al 2018).

Placement of the captive bolt device is applied to the top of the head between the back of the eye and centre of the ear. For small birds, such as chickens, either a flat or convex head is suitable. For larger birds (duck, goose, and turkey) a convex head is recommended.

Birds must be well restrained before administering the shot from the device. For adult turkeys it is recommended to place the birds on their keels on a sold surface before discharging the shot. A bin with a slot cut out for the head of the bird can be used to effectively restrain large birds such as turkeys, geese and ducks. Cones may be suitable restraints for chickens and younger birds of other species.

4.7.2.3 Injectable agents

Intravenous, injection of sodium pentobarbitone into either the jugular, brachial or tarsal vein is a suitable destruction method for small numbers of birds or large bird species.

Most commercially available formulations of sodium pentobarbitone have very high concentrations of drug which may cause pain or distress if administered incorrectly (e.g. extravasation). In instances in which a veterinarian or authorised person is not familiar with intravenous administration, a dilution of 1:5 in saline is recommended.

Intracardiac, intracoelomic or intraosseous route for injections of sodium pentobarbitone should only be used in anaesthetised or unconscious birds (AVMA 2020).

An anaesthetic overdose is also a suitable method of destruction.

The use of potassium chloride (KCl) as an injectable agent for destruction should be avoided.

4.7.2.4 Carbon dioxide (CO_2) gassing

Small portable CO_2 units, such as a wheelie bin and CO_2 bottle, may be used for small numbers of birds. Principles of use are as per Sections 3.10.1, 3.10.2 and 4.7.3.3.

4.7.2.5 Firearms

Firearms are typically suitable for juvenile and adult ratites. See Section 4.7.4.2.

4.7.3 Large numbers of birds

4.7.3.1 Cooling

Embryonated eggs at less than 80% incubation can be destroyed by cooling them to less than 4 °C for four hours. Bird embryos that have attained more than 80% incubation should be destroyed by methods similar to those used in avian neonates.

4.7.3.2 Maceration

Day-old chicks (up to 72 hours old) and eggs can be macerated using commercial macerators.

4.7.3.3 Carbon dioxide (CO_2) gassing

CO_2 is a method with proven efficacy in large-scale destruction of most poultry species. Used appropriately, it meets acceptable animal welfare standards and can be scaled to accommodate the size of the response, especially when delivered to entire sheds. It is colourless, heavier than air and nearly odourless, and is easy to use and safe in well-ventilated areas.

4.7.3.4 Whole-shed and whole-house gassing with carbon dioxide

The advantages of whole-shed gassing is that it is scalable, requires minimal animal contact and labour and has acceptable animal welfare outcomes. Birds can remain in familiar surroundings with their companions and are not subjected to the distress of manual handling. The gas levels may not be as easily controllable as in containerised systems and higher volumes may be required.

Whole-shed gassing is suitable for both floor-reared and caged poultry. The method requires buildings to be sealable—although this does not need to be absolute—and some leaking of gas is expected. Ventilation systems should be turned off and gas concentrations must reach effective levels before the birds experience heat stress.

The aim is to achieve a minimum of 40–45% CO_2 at a level above the birds' heads. In a caged system, this will apply to birds on the uppermost tier (Gerritzen et al 2006). Concomitantly, oxygen levels should fall to under 10%. The gradual increase in CO_2 that occurs during whole-shed gassing minimises aversive responses in birds. Death occurs in 2–3 minutes in chickens, but the shed dwell time is typically 20–30 minutes. Ducks and geese require lower residual oxygen concentration to cause death (EFSA 2019), which may cause longer times to unconsciousness. Field experience shows that birds are rapidly rendered unconscious when shed CO_2 levels reach 30% and are dead by the time it climbs to 40%. In two Australian trials, between 3.88 kg/m3 and 6.78 kg/m3 of liquid CO2 was required to achieve a minimum 40% CO2 concentration (AHA 2006, Exercise Gallus 2013).

There needs to be some shed openings above the birds to allow displaced air to escape while the space is filling with CO_2. Oscillating fans may be used in lower parts of the shed to move settled CO_2 upwards. It is expected that the process will take longer in caged facilities, requiring more time for gas application and increasing the risk that satisfactory gas concentrations will not be reached at higher tiers. Regardless of production system, CO_2 and oxygen levels should be measured at critical points in the shed and remotely accessible cameras are strongly recommended to monitor bird behaviour during gas deployment.

CO_2 can be transported in higher volumes in highly compressed liquid form. Specially designed delivery systems such as bespoke CO_2 lances or specialised manifolds are required to inject the CO2 into the sheds where the liquid CO_2 is converted into its gaseous form at ambient pressure and temperatures. Vaporisers and humidifiers may also be used to minimise the risk of cold stress and reduce airway irritability caused by dry gases. Liquid CO_2 may vaporise immediately on contact with the warm air of a poultry house without the use of a vaporiser (EFSA 2020). Ready-to-go whole-shed gassing trailers exist in the USA. They contain all necessary equipment—for example plastic sealing materials; a distribution box and dosing manifolds for gas delivery into the sheds; hoses and polyethylene tubing; and monitoring and calibration devices.

Personnel should be equipped with personal CO_2 monitors to detect any leaks and potential risks to personnel on site.

4.7.3.5 Containerised CO_2 gassing

Containerised gassing can result in rapid unconsciousness and death in a way that meets acceptable animal welfare standards. Gas levels can be more tightly controlled compared with whole-house gassing and are likely to require lower gas input.

The downside of containerised gassing is that it necessitates individual animal handling, which risks injury to birds when they are caught, carried by the legs and placed through the small entrance of a container. There is also the risk of responders being exposed to infectious animals and materials—for example in the case of high pathogenicity avian influenza, and increased opportunities for contamination and disease spread. There is a potential hazard of birds dying from compression and suffocation in the container. This is especially a concern in systems in which new batches of birds are added to a container before disposing of previous ones. Death must be confirmed in each batch and sufficient time allowed between treatments. This method is labour intensive and to be feasible it requires at least 10–15 personnel to collect and carry birds to each unit.

Containerised gassing units (CGU), also known as modified atmosphere killing (MAK) units, are routinely used by the layer industry to euthanase spent hens (a hen that has passed its prime egg laying period).

The units are essentially large metal or plastic containers that are pre-filled with CO_2 into which birds are placed. Containers vary in size from small metal or plastic bins to shipping containers.

MAK units have been deployed overseas and in Australia to depopulate poultry farms impacted by disease.

Given adequate exposure time, 40% CO_2 in air is sufficient to kill chickens (Gerritzen et al 2004) but concentrations above 55% will kill birds quickly (Raj and Gregory 1990). Prefilling of the container before introducing the birds is recommended, followed by supplementation of CO_2 until death is confirmed. Immersion of conscious animals in concentrations above 40% is not recommended due to aversive responses (EFSA AHAW Panel 2019). If compressed gases are used, they must be vaporised or heated before admission into the container to prevent freezing at the outlets.

Estimates for the number of birds that can be destroyed per hour per MAK unit are between 300 to 500 birds, based on the experience of NSW DPI officers depopulating farms infected with *Salmonella* Enteritidis in 2020 and as reported by Scott (2015). However, this is highly dependent on production system (cage versus non-cage systems), availability of suitable labour, site accessibility (both within the sheds and externally) and the type of MAK unit or equipment used.

Traditional MAK units are not suitable for ratites. However, shipping containers may be suitable if sufficient volumes of CO_2 or other suitable gasses can be secured.

4.7.3.6 Inert gases

Containerised gassing with physiologically inert gases is a well-established method for destruction of groups of poultry. It has an excellent welfare profile because it induces unconsciousness rapidly with minimal aversive reactions. A mixture of 20–30% argon with CO_2 has been extensively used overseas because of its high availability as welding gas. This method requires manual handling of poultry, including catching birds, carrying them by the legs and placing them through the narrow opening of a container. Manual handling of birds increases the exposure of humans to potentially zoonotic diseases, presenting a work health and safety risk. Containerised gassing systems minimise handling, because birds are loaded into transport crates and then the entire crates are gassed within containers.

Nitrogen is an emerging method of gassing poultry both in containers and sheds and has been shown to be both highly effective and humane.

Inert gases may offer additional benefits to waterfowl which are more resistant to the effects of CO_2.

4.7.3.7 Water-based foam

Water-based foam has been used in Australia since 2012 for emergency depopulation of poultry. This method offers rapid large-scale destruction of most poultry species. It is scalable but is limited by the location and availability of the foaming units. It reduces human exposure to floor-based birds by reducing or eliminating handling of live poultry. However, the resultant high water content can cause rapid carcass autolysis, which may affect disposal methods and necessitate prompt disposal.

Water-based foam is generated and delivered to floor-based birds in a confined space so that a blanket of foam covers the birds. Time to death is 3 minutes from birds being covered in foam (Benson et al 2009, 2012). For caged birds, the birds must be removed from the cages and placed into enclosures before application of the foam. It should not be applied in containers and is not the preferred method for use on ducks because of their breath-holding ability. The method also has welfare concerns (see Section 3.5 regarding mechanism of action and relative humaneness).

More information on the use of the foam depopulation unit, including *Standard Operating Procedure: Depopulating Poultry with a Foam Depopulation Unit*, is available from the Victorian Department of Energy, Environment, and Climate Action.

4.7.3.8 High-expansion dry nitrogen filled foam

High-expansion gas foam shares the advantages of water-based foam: it is scalable, requires minimal animal handling, may be used in open environments and possibly limits aerosolisation of viruses and other pathogens. Importantly it offers superior animal welfare outcomes over water-based foam because it causes death using a different mechanism of action. It creates a modified atmosphere when the high-expansion bubbles, which are too large to occlude airways, burst on contact with surfaces and through movement of birds. The nitrogen released is highly effective at displacing oxygen from the air surrounding the animals, causing death due to lack of oxygen. Use of nitrogen causes a smooth loss of consciousness due to anoxia, which avoids the 'air hunger' associated with use of CO_2 (hypercapnia).

High-expansion gas foam is used overseas for depopulation of poultry (and also pigs), including in Europe, the UK, the USA and Canada, but at the time of publication is not available in Australia.

4.7.3.9 Electrical stunning and electrocution

Waterbath and head-to-body stunning can be used as effective stun-to-kill methods. Head- only stunning requires a secondary terminal method such as cervical dislocation or neck cutting (exsanguination).

Waterbath stunning-to-kill is the only method that has previously been used for on-farm mass depopulation purposes overseas. For waterbath stunning-to-kill, the minimum current necessary to induce cardiac arrest varies according to the species, as well as depth of immersion, cleanliness of shackles and tightness of contact between the legs and the metal shackle.

If mobile waterbath stunners are used in Australia, they should comply with the minimum specifications described in *Scientific Opinion on the killing for purposes other than slaughter: poultry* (EFSA AHAW Panel 2019).

Head-to-body electrocution using dry electrodes is an alternative option to induce immediate unconsciousness followed or accompanied by cardiac arrest resulting in death. This method however requires the individual handling of birds and is therefore unlikely to be suitable for the mass destruction of poultry. Poultry head-to-body electrical killing devices are available overseas commercially.

Other methods include systems in which birds are placed into a hopper, whereupon they are destroyed by an electric current. Birds are killed immediately and within a second they are dropped onto a conveyor belt leading to a rendering bin (Crossan 2014).

Effective stunning-to-kill requires specific electrical currents and application times. If used, operators must ensure the equipment has been specifically designed and approved for use in poultry and is used according to manufacturer directions.

There are work health and safety considerations when working with electrical devices that are developed to kill animals. Strong safety precautions and the presence of qualified personnel is therefore a precondition.

4.7.3.10 Hypobaric hypoxia or low atmospheric pressure stunning (LAPS)

Low atmospheric pressure stunning (LAPS) is a novel technology that has been applied to broilers under 4 kg overseas and validated for culling of male layer chicks. Birds are placed in a hypobaric chamber and exposed to gradual decompression until the available oxygen is below 5%. There a degree of uncertainty around the effects of gas expansion within body cavities during treatment, although intestinal rupture has now been ruled out. This procedure has not been extended to layers and questions remain around the effects on intra-abdominal shell eggs. LAPS is mostly being used commercially in abattoirs, but a mobile LAPS system has been developed for on-farm killing of poultry in the US (EFSA AHAW Panel 2019, Jongman and Fisher 2021, Hewitt 2023).

LAPS involves a two-phase gradual decompression process. In the first phase, the pressure is reduced from standard sea level atmospheric pressure (760 Torr) to no lower than 250 Torr over at least 50 seconds. In the second phase, the pressure continues to drop to a minimum of 160 Torr, which should be reached within 210 seconds from the start of decompression. The pressure-time curve must be carefully managed to ensure that all birds are irreversibly stunned and killed within the cycle (EFSA AHAW Panel, 2017).

Research on the suitability of LAPS for avian species, other than broiler chickens is limited and therefore there is little understanding of its appropriateness across the entire poultry industry. Further, the Australian Animal Welfare Standards and Guidelines for Poultry suggest that although LAPS may be a suitable method of destruction, further research is needed to determine its practicality for use on-farm.

4.7.3.11 Ventilation shut down and ventilation shut down plus

Ventilation shutdown (VSD) and VSD+ remain unapproved methods of destruction for poultry in Australia. VSD alone is not permitted for use. However, circumstances may arise when the use of VSD+ is considered within or across jurisdictions, where the number of infected or at-risk animals requiring rapid culling to control an emergency animal disease outbreak, or to minimise human health risks, would overwhelm industries and jurisdictions' capacity using the currently approved methods. As per the *Australian Animal Welfare Standards and Guidelines for Poultry*, a person in charge must adhere to the standards for humane killing during emergency depopulation, except where the Chief Veterinary Officer (or their delegate) is satisfied that a welfare assessment has been conducted, and all alternative destruction methods have been explored and found impractical or not feasible (see Section 4.7.3.12).

4.7.3.12 Other methods

The person in charge of destruction must adhere to the standards for humane destruction, except in a declared EAD response, when the Chief Veterinary Officer (or delegate) must be satisfied that a welfare assessment has been conducted, and all alternative destruction methods have been explored and found impractical or not feasible. This is consistent with Standard 10.7 of the Australian Animal Welfare Standards and Guidelines for Poultry which states "a person in charge must adhere to the standards for humane killing (SA 10.1 to SA 10.6) during emergency depopulation, except in a declared emergency animal disease situation where the Chief Veterinary Officer (or equivalent) is satisfied that a welfare assessment has been conducted and all permitted killing methods have been explored and found impractical" (DAFF 2022).

4.7.4 Ratites

Destruction of emus, ostriches and other unusual birds requires expert assistance. Depopulation of large numbers of ratites can be a difficult process because of the challenges in moving, handling and restraining birds. Ratites, unlike other stock, cannot be herded so should be coaxed to the required destination with feed or by appealing to the birds' natural curiosity about unfamiliar objects or human activity. The type of birds (e.g. age, size, temperament), equipment/facilities, safety and staff experience all influence the method that is appropriate to euthanase birds in a safe and humane manner.

Emus can kick in all directions, unlike ostriches which are reported to only be able to kick forward. Adult emus and ostriches have a powerful kick that can causing bruising and muscular soreness and have reportedly broken bones in people. Care should be taken by response staff when handling birds, especially adults. Personal protective equipment (PPE) such as leather/chainsaw chaps or a 'cricketer's abdominal guard ('box') may be considered for some activities that require close-contact handling.

Unlike ostriches, 'hooding', (e.g. a sock over the head of the animal) does not calm emus.

4.7.4.1 Electrical stunning followed by destruction

Electrical stunning followed promptly by cervical dislocation or exsanguination is recommended for juvenile and adult birds.

Experienced contractors should be sourced from ratite abattoirs to conduct the electrical stunning. Stunning equipment can be relocated to a site on-farm if necessary. Consideration should be given to providing shelter for the electrical stunning equipment in the event of rain and having clearly marked exclusion zones around the stunning equipment for safety.

To ensure an effective stun, the electrodes must be placed so that the applied current spans the brain. This is commonly done by placing the electrodes (e.g. callipers) laterally across the head. Dipping of the calliper tips, in water or dilute saline, immediately before stunning may improve conductivity. In a commercial abattoir setting, effective stunning in emus usually takes 10–12 seconds, with exsanguination required within 20 seconds of an effective stun.

'VE-machine' conveyor systems work well to restrain birds for electrical stunning; however, the size of the birds and set-up of the conveyor system must be checked to ensure restraint is effective. There is no 'one-size fits all' option. Birds will need to be manually handled onto the conveyor belts which requires PPE (long pants or overalls, cricket abdominal guards, etc) to protect handlers from animal kicks.

A gantry can be used to hang birds after stunning (as per the process in an abattoir) however this requires significant manual handling. A better system utilises steel rollers and a high-sided tray placed at the end of the VE-machine so that stunned birds roll off the conveyor belts onto the steel rollers for immediate cervical dislocation. Dead birds are then pushed along the rollers to the end and collected for carcass disposal.

Pneumatic garden shears on a long pole work well for cervical dislocation after electrical stunning. They can be driven by a portable air compressor. This reduces operator fatigue to ensure the dislocation process is fast and effective every time, so that animal welfare standards are met and maintained. The best location to apply the pneumatic shears in emus, for an effective cervical dislocation was found to be at the junction where the darker head feathers met the lighter neck feathers. It is unknown if a similar location is appropriate for ostriches.

Figure 4.10 Indicative point to target for cervical dislocation using mechanical shears in emus.

Exsanguination can be an effective method of destruction after electrical stunning. However, it presents the added complication of containing and disposing of the blood, the health and safety risk of slips and falls, and the odour being a possible deterrent to other birds. Abattoir studies of ostrich slaughter suggest exsanguination should be undertaken within 20–30 seconds of stun, severing both the carotid arteries and jugular veins, using a complete ventral neck cut, high up close to the head (Wotton and Sparrey 2002).

A captive bolt should be on hand, as a secondary method, in the event the stunning or cervical dislocation has not been 100% effective.

4.7.4.2 Firearms

For ratites that are mobile and cannot be effectively restrained, a headshot from a 12-gauge shotgun is preferred when the bird is within 30 m of the shooter. For distances greater than 30m, a shot to the centre of the chest using a centre-fire rifle and ammunition appropriate for the size of the bird (such as .22 magnum for smaller birds and .243 calibre for larger birds) should be used (Victorian Government 2007).

4.7.4.3 Wet foam depopulation

Wet foam depopulation is a method that has been used for emu chicks and juvenile birds up to 25 weeks. At the time of writing, this technique has not been field tested in ostriches in Australia. However, note comments in section 3.5 about the aversive nature of the wet foam mechanism of action (mechanical hypoxia). More humane options should be considered and used if available. See Section 3.5.

Emus are around 1 m tall at 25 weeks and do jump vertically so consideration must be given to the space and height of the foam. Their tracheal diameter is similar to chickens and turkeys, so similar foam settings can be used to formulate a bubble size that is appropriate for effective destruction. Emu chicks have a propensity to smother, so keep batch sizes small to minimise the risk of smothering. Staff can be placed at the end of intended 'foam runs' to discourage birds from clustering in the corners.

Emus experience a 'flightier' behaviour towards the foam than has been noted in chickens. In each foam run ensure there is an area of clear space (i.e. no birds) so that the foam can be introduced away from the birds at the start of foaming. Then allow the foam to naturally flow (‘bump and roll’) towards the birds rather than directing the foam generators right next to where the birds are standing.

4.7.4.4 Injectable agents

Physically or chemically restrained captive birds may be destroyed by intravenous injection of a barbiturate.

4.8 Dogs and cats

Acceptable methods for destruction of dogs and cats include injectable agents, modified atmosphere (overdose of a gaseous anaesthetic) and firearms. The choice of method will depend on human safety risk assessments, age and size of animal, and capacity to catch and restrain the animal. Rarely will a situation arise where large numbers of domesticated or semi-domesticated dogs and/or cats require destruction. For direction regarding wild dogs and feral cats see the **AUSVETPLAN *Operational manual: Wild animal response strategy***.

4.8.1 Injectable agents

Injectable agents are the preferred method of destruction for dogs and cats that can be handled. Intravenous (IV) sodium pentobarbitone should be administered via the cephalic, jugular, or other accessible vein. In unconscious or anesthetised animals, intra-organ injections (e.g. intracardiac, intrahepatic, or intrarenal) may be used as an alternative if IV is inaccessible (Rhoades 2002, Fakkema 2010, AVMA 2020). Intracardiac injections are favoured for puppies, kittens and small dogs and cats but only if they are already anaesthetised or unconscious.

4.8.2 Sedation or anaesthesia

Sedative drugs may be given parenterally, via a tranquilliser gun or pole syringe if necessary, before intravenous barbiturate destruction.

A lasso on a pole may be useful to help catch and control animals to allow parental injection. Additionally, dogs may require muzzling to ensure personnel safety. Cats that are not easy to handle may have to be put in a hessian bag or cat restrainer cage and injected with a sedative agent through the bag or cage. Tranquilliser guns are less suitable for cats, which are small and fast-moving targets.

Without a tranquilliser gun or pole syringe, injection by any route may be too dangerous for some unmanageable animals, and for suspect rabid animals. Including a sedative in the animal's food may be an appropriate adjunct before using an injectable agent.

Gassing unmanageable cats with an anaesthetic agent in a suitable cage or enclosure may be required. When the animal is unconscious, it may be removed and destroyed with an overdose of barbiturate.

4.8.3 Oral agents

For application of the following oral agents, refer to the **AUSVETPLAN *Operational manual: Wild animal response strategy***.

4.8.3.1 Para-aminopropiophenone (PAPP)

Para-aminopropiophenone (PAPP) is used for the control of feral dogs and cats (Johnston et al 2020). The time from bait ingestion to first signs is about 30 minutes with death occurring within 1–2 hours. Before death, some animals might feel anxiety and distress due to their inability to move despite being aware.

4.8.3.2 1080

1080 poisoning is used for control of feral dogs.

4.8.4 Firearm

Some free-ranging, unmanageable or aggressive dogs and cats may have to be shot through the head or the heart. Gut shots are not acceptable.

4.8.5 Penetrating captive bolt

Although highly unlikely, penetrating captive bolt may be used in exceptional circumstances.

See also **AUSVETPLAN *Operational manual: Wild animal response strategy***.

4.9 Rats, mice and guinea pigs

The preferred method for the euthanasia of rodents is injectable barbiturates. Other acceptable methods include modified atmosphere (including hypobaric hypoxia), cervical dislocation, and captive bolt in guinea pigs. The choice of method depends on age, size and number of animals. Rodents should be removed from the main group before destruction to minimise distress. Rarely will a situation arise, outside of the research facility, in which large numbers of captive rodents require destruction. In such circumstances, the assistance of a veterinarian with experience in handling (and destroying) laboratory rodents should be sought.

4.9.1 Injectable agents

As with other species, concentrated sodium pentobarbitone can be used for destruction. Intravenous access can be difficult in these small species. Therefore, the intraperitoneal (IP) route is often used but ideally only after the animal is unconscious. The minimum accepted dose rate is 100 mg/ kg for rats and guinea pigs (Reilly 2001), and 150 mg/ kg for mice. Increasing the dose of sodium pentobarbitone increases predictability and speed of effect when administering IP sodium pentobarbitone in rats and mice (Laferriere and Pang 2020).

4.9.2 Modified atmosphere

A common method of destruction is CO_2 gassing due to practicality, minimal need for restraint and handling, and ability to destroy large numbers quickly (Brunt et al 2021). However, some literature indicates a wide range of behavioural and physical responses in rodents that suggest negative welfare outcomes (Niel and Weary 2007, Améndola and Weary 2020) during the conscious phase of CO_2 destruction (Hickman et al 2016).

Altricial rats and mice neonates are tolerant to hypoxia and hypercapnia, and require prolonged time to death when using CO_2 (Pritchett et al 2005, Pritchett-Corning 2009). Adequate exposure time (e.g. up to 50 minutes) and concentration should be provided, or an adjunct method (e.g. cervical dislocation, or decapitation) should be performed after a neonate is nonresponsive to painful stimuli (AVMA 2020).

4.9.3 Physical

For the destruction of small numbers of rodents, dislocation of the neck should be performed by experienced, competent personnel. Cervical dislocation is not permitted in rats over 150 g in weight (ANU Research Ethics Office Animal Experimentation Ethics Committee Approved Document, 2021).

Neonatal mice (<10 days of age) and neonatal rats (<5 days of age) may be destroyed by decapitation (AVMA 2020, ANU Research Ethics Office Animal Experimentation Ethics Committee Approved Document 2021).

Captive bolt devices have been used on guinea pigs with success when performed correctly (Limon et al 2016, Cohen et al 2020, Hewitt and Small 2021).

4.9.4 Hypobaric hypoxia

Early studies suggest low atmospheric pressure stunning (LAPS) is a high-throughput, humane destruction method for mice. When compared to CO2, there are fewer behavioural indicators of pain and anxiety (Clarkson et al 2023). Further studies are required to validate these findings and its application to other rodent species.

4.10 Rabbits

The preferred method for the euthanasia of farmed and laboratory rabbits is injectable barbiturates, following deep sedation. Acceptable methods include cervical dislocation, non-penetrating captive bolt, injectable agents, and modified atmosphere (overdose of an anaesthetic). The choice of method depends on age, size and number of animals.

4.10.1 Physical

Physical methods such as manual cervical dislocation should only be used by experienced, competent personnel and only on rabbits weighing less than 1 kg (CCAC 2010). The use of commercial mechanical cervical luxators allow this method to be humanely used in larger animals (Walsh et al 2017).

Nonpenetrative captive bolt devices have been successfully demonstrated on rabbits of weight 150– 3500 g (Walsh et al 2017). The device was routinely used at Canadian abattoirs, being twice discharged in rapid succession, resulting in immediate insensibility of 100% of animals. The captive bolt device should be placed against the rabbit's head on the midline and at the intersection of lines drawn from the outside edge of the eye to the base of the opposite ear. It is recommended to follow with a terminal method to ensure death (European Commission Directorate-General for Health and Food Safety 2018, Hewitt and Small 2021).

4.10.2 Injectable agents

The preferred method for laboratory rabbits is intravenous or intracardiac sodium pentobarbitone in unconscious or heavily sedated rabbits. Prior sedation is recommended to overcome typical handling and injection pain and distress (Flecknell 2023) associated with intravenous injections.

4.10.3 Modified atmosphere

Induction of anaesthesia with CO_2, is not recommended due to pain and distress (Hewitt and Small 2021a). Inhalational anaesthetic agents may be used in overdose or as a primary method followed by a terminal procedure.

4.10.4 Electrical stunning

The predominant method employed in commercial abattoirs is electrical stunning; however, there is not enough scientific research to establish optimal stun parameters (Hewitt and Small 2021a). The feasibility of using these methods in the field is yet to be demonstrated.

4.11 Primates

The preferred method for the euthanasia of primates is injectable barbiturates. The assistance of a veterinarian with experience in handling (and destroying) laboratory or captive primates should be sought.

Injectable chemical sedation, followed by an overdose of barbiturate given by the intravenous route, is recommended. Animals should be appropriately physically and/or chemically restrained before attempting intravenous route. The intracardiac route may be used if the animal is anaesthetised (Reilly 2001).

4.12 Fish

A detailed description of destruction methods suitable for marine species (including molluscs and crustaceans) is part of the AQUAVETPLAN series of operational manuals.[19]

4.13 Circus and zoo animals

The assistance of a veterinarian with experience in handling (and destroying) circus and zoo animals should be sought.

4.14 Wild animals

Wild animals in this context are defined as animals that is found in the natural environment and do not live under human supervision and control. Wild species may be native to Australia or introduced. Destruction of free-roaming animals is especially challenging and may, in some instances, increase the risk of spreading disease. A multi-agency approach will be required to determine the appropriate method of controlling disease in wild animals. This may or may not include destruction or local extirpation (complete removal from an area).

Assistance of a veterinarian with experience in handling (and destroying) native wildlife, or feral animal management specialists (whichever is relevant) should be sought when planning destruction response activities.

For further information on the destruction of wild animals see:

- the **AUSVETPLAN *Operational manual: Wild animal response strategy***
- the relevant AUSVETPLAN response strategy
- *National Wildlife Biosecurity Guidelines*
- *National Guidelines for Management of Disease in Free-ranging Australian Wildlife*
- *Guidelines for Management of an Emergency Wildlife Disease Response*
- relevant jurisdictional legislation
- the *Australian Model Code of Practice for the Welfare of Animals: Feral livestock animals*[20].

[19] https://www.agriculture.gov.au/agriculture-land/animal/aquatic/aquavetplan/destruction
[20] https://www.publishing.csiro.au/book/370/

Appendix 1 Unacceptable primary methods of destruction

The following historical or more commonly identified primary destruction methods should never be used under any circumstance.

Note: This will never be a complete list. Refer to relevant sections of the manual for additional information, if available.

- Air embolism
- Beating or wounding an animal to death
- Burning (chemical or thermal)
- Decompression
- Drowning (in any liquid)
- Formalin injection
- Freezing (excluding altricious mice)
- Low atmospheric pressure stunning (LAPS) in pigs
- Microwave oven
- Modified atmosphere: car exhaust gas
- Neuromuscular blocking agents
- Perishing (denial of feed and water)
- Poisoning (using unapproved agents)
- Smothering
- Strangulation
- Suffocation (excluding currently approved methods)
- Ventilation shut down (VSD)

Glossary

Terms and definitions

Standard AUSVETPLAN terms

For definitions of standard AUSVETPLAN terms, see the **AUSVETPLAN *Glossary***.

Document-specific terms

Term	Definition
Anoxia	Complete lack of oxygen delivery to an organ
Asphyxia	Inadequate oxygen supply to the body
Extravasation	the unintentional leakage of vesicant fluids or medications from the vein into the surrounding tissue.
Hypercapnia	the increase in partial pressure of carbon dioxide ($PaCO_2$) above 45 mm Hg[21]
Hypoxia	A state in which oxygen is not available in sufficient amounts at the tissue level to maintain adequate homeostasis[22]
Inert gas	A gas that does not readily undergo chemical reactions with other chemical substances and therefore does not readily form chemical compounds. An inert gas is a stable and nonreactive gas. There are six primary inert gases which include helium, neon, argon, xenon, radon, and krypton. Nitrogen gas has similar properties and is often referred to as an inert gas.
Poultry	For the purposes of this manual, 'poultry' means chickens, turkeys, guineafowl, ducks, geese, quail, pigeons, pheasants, partridges, emus and ostriches reared or kept in captivity, including commercial and backyard.
Suffocation	Air supply is blocked from entering the body
Vesicant	Agents capable of causing blistering, tissue sloughing or necrosis[23]

[21] https://pubmed.ncbi.nlm.nih.gov/29763188/
[22] www.ncbi.nlm.nih.gov/books/NBK482316/
[23] Clinical Practice Guidelines: Peripheral extravasation injuries: Initial management and washout procedure

Abbreviations

Standard AUSVETPLAN abbreviations

For standard AUSVETPLAN abbreviations, see the **AUSVETPLAN *Glossary***.

Manual specific abbreviations

Abbreviation	Full title
ANZCCART	Australian and New Zealand Council for the Care of Animals in Research and Teaching
DAFF	Department of Agriculture, Fisheries and Forestry (Australian Government)
IM	intramuscular
IV	intravenous
NOTAM	notice to airmen
NTSESP	National Transmissible Spongiform Encephalopathy Surveillance Program
TMS	tricaine methane sulfonate

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