

Recommendations for the Depopulation of Swine



This series of fact sheets provide guidance for veterinarians and producers about available swine depopulation methods, the limitations of each method and how they can be applied under various circumstances, and plan development for how depopulation could be deployed in emergency situations.

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Development of Recommendations for the Depopulation of Swine was funded by
USDA's Animal and Plant Health Inspection Service through the
National Animal Disease Preparedness and Response Program.

(Information adapted from AVMA Guidelines for the Depopulation of Animals, 2019)

Depopulation defined

The American Veterinary Medical Association (AVMA) has defined depopulation as the rapid and efficient destruction of a complete population of animals in response to urgent circumstances with as much consideration given to the welfare of the animals as practical.

The AVMA Guidelines for the Euthanasia of Animals, AASV On-Farm Euthanasia of Swine brochure, or the AVMA Guidelines for the Humane Slaughter of Animals should be referred to in circumstances necessitating prophylactic culling or precautionary killing.

Conditions necessitating depopulation

Urgent circumstances that may require the rapid and efficient destruction of a population of swine include, but are not limited to:

- **Regulatory diseases:** Depopulation may be used by state and federal animal health officials as the first line of defense to quickly eradicate the disease by preventing further disease replication in infected, exposed, or at-risk swine. Stop movements may be implemented in disease control areas and result in the need for depopulation of swine on noninfected farms.
- **Nonregulatory highly pathogenic diseases:** Depopulation of infected and susceptible swine may be required to prevent further agent replication, support herd health stabilization to mitigate further losses and prevent or relieve animal suffering due to (potential) exposure to the pathogen.
- **Emerging swine production diseases:** Depopulation may be required to prevent a nonregulated disease from spreading from the index case or early cases to the rest of the national herd or to prevent or relieve animal suffering due to (potential) exposure to the pathogen.
- **Zoonotic diseases:** Depopulation may be required because of real or perceived public health threats or food safety concerns, such that swine can no longer be moved or marketed. Zoonotic diseases may complicate or increase the burden of accomplishing depopulation owing to the level of personal protection required to prevent human exposure.
- **Intoxications and adulterations:** Depopulation of swine exposed to adulterants or intoxicants (eg, oral exposure to dioxin) may be required to prevent real or perceived threats to food safety or immediate or impending danger to swine welfare from the toxicant exposure (eg, kidney failure).
- **Radiologic exposures:** Depopulation may be required in a radiologic emergency, such as a nuclear power plant incident, to prevent or relieve animal suffering and protect worker and public health.
- **Natural disasters:** Depopulation may be required when swine cannot be removed from harm's way to prevent or relieve animal suffering. Following a natural disaster, farms may be damaged to an extent that is hazardous for workers to enter buildings. Farms may also remain intact but basic services, including animal care and feeding, are unable to be restored in time to prevent suffering.
- **Market disruption:** Any eventuality that reduces or eliminates the marketability of swine could have a negative impact on animal welfare in a short period due to the limited flexibility in the current marketing channel. This puts a high level of importance on the speed at which a decision can be made for swine that cannot be moved or marketed because of regulatory issues, natural or manmade disasters, food safety, and other public health issues.

Depopulation Method Options



LAST UPDATED:
September 30, 2021

(Information adapted from AVMA Guidelines for the Depopulation of Animals, 2019)

The American Veterinary Medical Association lists possible depopulation methods in three categories (AVMA, 2019):		
Preferred	Permitted in constrained circumstances	Not recommended
Carbon dioxide (CO ₂)	Ventilation shutdown plus	None listed
Carbon monoxide (CO)	Sodium nitrite	
Gunshot	Water-based foam*	
Nonpenetrating captive bolt	Compounded or nonpharmaceutical-grade injectable anesthetics and euthanasia agents	
Penetrating captive bolt		
Electrocution		
High-expansion foam plus gas*		
Manual blunt force trauma		
Movement to slaughter		
Anesthetic overdose		

* This method is not included for swine in the AVMA Guidelines for the Depopulation of Animals, 2019.

Preferred methods are given the highest priority and should be used preferentially when circumstances allow reasonable implementation during emergencies. The methods may correspond to those outlined in the AVMA Guidelines for the Euthanasia of Animals or the Guidelines for the Humane Slaughter of Animals, but techniques may be adjusted for situation considerations.

Permitted in constrained circumstances methods are permitted only when the circumstances of the emergency are deemed to constrain the ability to reasonably implement a preferred method. Potential constraints include, but are not limited to, constraints on zoonotic disease response time, human safety, depopulation efficiency, deployable resources, equipment, animal access, disruption of infrastructure, and disease transmission risk.

Not recommended methods should be considered only when the circumstances preclude the reasonable implementation of any of the preferred or permitted in constrained circumstances methods and when the risk of doing nothing is deemed likely to have a reasonable chance of resulting in significantly more animal suffering than that associated with the proposed depopulation technique. Examples include, but are not limited to, structural collapse or compromise of buildings housing animals, large-scale radiologic events, complete inability to safely access animals for a prolonged period, or any circumstance that poses a severe threat to human life.

The methods listed above have been shown to be appropriate for depopulation based on available scientific literature and experience. However, this list may not be all-inclusive. The appropriateness of alternative options should be assessed using the following criteria:

- Ability to induce loss of consciousness followed by death in a timely manner with a minimum of pain or distress.
- Reliability and irreversibility of the method to result in death of the animal.
- Compatibility with the safety of humans, animals, and the environment.
- Potential psychological or emotional impacts on personnel and sensitivity to public sentiment regarding the destruction of large numbers of animals.
- Availability of agents and carcass-processing and disposal venues to handle the volume.
- Ability to maintain equipment needed for depopulation in proper working order.
- Compliance with legal requirements.

We want to hear from you!

Do you have first-hand experience using any of these depopulation methods?
Please submit your feedback on the content of these recommendations to aasv@aasv.org

Every situation where depopulation is considered will be unique due to the limitations and constraints imposed by the type of the emergency, resource availability, geography, site variation, local regulations, etc. When choosing a depopulation method, the factors highlighted here must be considered. Producers should work with their herd veterinarian to discuss these factors and use the **Depopulation Decision Tool and Depopulation and Disposal Summary Form** to document the details of the situation and justification for choosing the depopulation method used.

Legal requirements

- Become familiar with state laws that may influence the depopulation process. This includes laws related to animal abuse and neglect, firearm usage, mortality management, or restrictions on access to needed resources.

Animal disease characteristics

- The scope of the outbreak will impact the number of animals to be depopulated and resource availability.
- Understand how the epidemiology, transmission route, and pathogenesis of the disease-causing agent will impact the timeline for depopulation, labor needs and worker safety precautions, the physical condition of swine, scope of depopulation, carcass disposal method, and cleaning and disinfection. Information about current pathogens of interest has been published by the Swine Health Information Center (swinehealth.org/fact-sheets/) and the Center for Food Security and Public Health (cfsph.iastate.edu/Species/swine.php).
- Evaluate the current and ongoing disease status (eg, infected, contact, or clean) of the site which will help define the timeline and scope of depopulation.

Time constraints

- Select a method with the ability to achieve the necessary throughput to accomplish depopulation within the established time constraint.
- State or federal regulatory authorities will establish the timeline for depopulation during a regulatory disease outbreak.

Ownership and indemnity

- Depopulation planning and coordination is essential when the owner of the pigs differs from the owner of the barn.
- Approval before depopulation occurs must be factored into any plan where there is an appraisal and indemnity process to offset the financial losses to owners. For example, insurance company or government authority approval may be required.

Personnel availability

- Determine the number of personnel needed and the training required to perform the chosen depopulation method.
- Appropriately trained personnel should be available to provide backup depopulation methods in the event such methods are needed.
- Consider the amount of downtime required if personnel are moving between sites to perform depopulation.
- Create work/shift schedules that allow for some downtime to protect human well-being and safety.

Worker health and safety

- The cause for depopulation will pose varying risks for worker health and safety, which should be a primary consideration when choosing a depopulation method.
- Responders will need to wear appropriate personal protective equipment, which may impact how a depopulation method is performed.
- Designate an individual to address and ensure worker health and safety during all phases of the depopulation process.

Operator and observer impact

- Consider the aesthetics of the chosen depopulation method and the impact the depopulation process will have on observers, operators, and producers.
- Make appropriate social services and mental health support resources available to all participants in the depopulation process, regardless of method used.

Public perception

- The scope of depopulation and the chosen depopulation method should be proportional to the scope and urgency of the of the situation.
- Consider how and where the method can be performed to limit the number of observers and protect public safety.

Animal environment

- Environmental conditions, including weather conditions and temperature, can impact equipment functionality and worker safety.
- Evaluate the facility's infrastructure for safety after a natural disaster or fire before personnel enter. Safety of the barn structure and environment will impact where depopulation can be performed.
- The type and layout of facility or outdoor housing will impact the depopulation procedure including how and where animals can be accessed to apply the depopulation method, which depopulation method can be used, and what type of ancillary equipment may be needed to facilitate animal movement and handling.
- If animals can be moved from the farm, consider developing regional depopulation strategies that use a centralized location and resources to increase throughput and facilitate carcass disposal strategies.

Choosing a Depopulation Method

Number of swine and phase of production

- The number of swine to be depopulated will influence the method used for depopulation, as the method throughput should be able to accomplish depopulation within the established time constraint.
- The phases of production housed on a site will impact the depopulation method used and the resources needed to successfully perform the depopulation.
- Multiple phases of production or sizes of pigs on one site may necessitate the use of multiple methods for depopulation.

Animal handling and condition

- Identify the location for depopulation, the route to that location from the area the animals are housed, and who is responsible for gaining access and moving pigs.
- Identify the type of animal restraint needed during the depopulation process.
- If pigs are depopulated in a barn, consider moving pigs closer to egress points to save on the distance a carcass needs to move for extraction from the barn.
- Consider the physical condition of the animals when developing a depopulation plan. Have a plan for how to handle non-ambulatory animals.

Equipment availability

- Identify the key resources needed for each method and calculate how much of the resource is needed, where the resource can be sourced, timeliness of acquisition, limitations on resource availability, and limitations on storage of the resource.
- Identify key ancillary resources needed for animal handling and carcass extraction and movement.
- Understand capacity limitations of equipment such as weight limits, battery life, gas/diesel needs, and durability of equipment.
- Understand and anticipate maintenance requirements of equipment.
- During a regulatory disease outbreak, state or federal regulatory authorities may require specific methods be used and resources may be available through the US Department of Agriculture's National Veterinary Stockpile.

Confirming insensibility and death

- Make every effort to confirm insensibility and death of the animals, provided the effort does not pose a risk to human health or safety.

Carcass removal and disposal

- Ensure that the throughput of the depopulation method does not outpace the ability to remove and dispose of carcasses.
- The cause for depopulation and the method of depopulation will impact the options for carcass disposal. For example, adulterants or intoxicants may limit disposal options to protect environmental health.
- Understand how depopulation and carcass disposal may impact the fallow period required for the site before it can be repopulated.
- Always refer to local and state regulations on appropriate and legal methods of carcass disposal.

Mass depopulation is a heavy emotional and physical burden on personnel carrying out the tasks. There is a high risk for physical injuries and psychological effects such as compassion fatigue or acute or prolonged traumatic stress. Each depopulation method has its own risks; however, depopulation in general can be very stressful and draining. The physical and psychological wellbeing of responders should be a top priority in the event of depopulation. It is important that responders are prepared and cared for during depopulation events to minimize any negative effects.

Who should be a responder?

Responders should be supervisors or veterinarians. Daily caretakers should only be involved if no one else is available.

Responder responsibilities

- Follow health and safety procedures.
- Report all injuries and accidents.
- Report safety concerns to supervisor.
- Be aware of surroundings.
- Wear all personal protective equipment correctly.

Preparing responders

Preparation is key for minimizing stress and injuries during depopulation events. Training and resources should be provided for staff.

- **Mentally:** Explain to the team why depopulation is necessary and assure individuals that they are playing a critical role in protecting health. Inform responders on how the pigs may physiologically respond to the method of choice. Responders should be given the opportunity to share concerns, share ideas, ask questions, and not participate if the task becomes too much.
- **Depopulation method:** Training (explanation, demonstration, hands-on walk through) should be provided on the method of choice. Safety precautions should be emphasized. Proper animal handling and equipment operation should also be demonstrated.
- **Extra resources:** Before the depopulation event, providing articles and handouts is suggested especially if an unfamiliar method is being used. Videos of methods and animal reactions can help prepare responders for what they will experience. Laminated standard operating procedure posters throughout the work area can be beneficial for responders to reference during the process. Locate available mental health resources and share this information with responders before the depopulation event. Inform responders of the insurance benefits available to them, including access to behavioral health resources.

Caring for responders

Minimizing physical and emotional stress on responders will create a better work environment for everyone involved. It is important for everyone to look out for one another. Listen to verbal feedback but also observe non-verbal communication. Check in with the group but also check in individually because some responders might not want to speak up in a group setting.

- **Physically:** Minimize extended shifts and allow frequent breaks to prevent fatigue. Provide sources of hydration and energy to avoid dehydration or physical exhaustion: ie, water, sports drinks, snacks. Portable bathrooms should be easily accessible to responders. Rotating jobs between workers will also be beneficial.
- **Emotionally:** Before and after depopulation events, debrief the team and allow responders to share concerns or thoughts on improving procedures. Encourage responders to communicate with loved ones and coworkers; practice stress and relaxation techniques; maintain a sleeping, eating, and exercise schedule; and seek formal mental health support if needed.

Indicators of stress

If signs of stress are observed in responders, provide some of the resources previously listed. Knowing these indicators can prevent a problem before it progresses.

- **Physical:** nausea, dizziness, headaches, changes in sleep patterns
- **Cognitive:** disorientation, memory
- **Emotional:** anxiety, guilt, grief, irritability
- **Behavioral:** anger, withdrawal, depression, drug or alcohol abuse

Preventing physical injuries

Physical injuries can occur in many forms such as musculoskeletal (sprains, strains, ergonomic), slipping and falling, animal encounters, or fatigue. Permanent hearing damage from gunshot, power tools, and animal vocalizations also are a risk especially for prolonged time periods.

- Be aware of surroundings: ie, animals, flooring.
- Practice safe lifting: lift using legs, not the back.
- Take breaks in the shade or air and away from work area.
- Maintain hydration with water/sports drinks.
- Increase intake of complex carbohydrates (muffins, granola bars).
- Rotate jobs.
- Ear protection.

Method classification

Preferred.

Suitable for

All phases of production.

Procedure

Carbon dioxide (CO₂) causes rapid onset of anesthesia with subsequent death due to severe respiratory acidosis and subsequent respiratory arrest. Pigs require a constant exposure to > 60% carbon dioxide concentration for at least 10 minutes. The total time needed to achieve effective concentration is a function of the flow rate and container volume. Fill container with approximately 20% to 30% chamber displacement rate of CO₂. Total time will then be a 5-minute fill of CO₂ followed by a minimum of a 10-minute hold time.

Biosecurity risk

Negligible risk due to minimal blood contamination.

Labor needs and throughput estimates

Labor needs and throughput estimates can be calculated here: ncagr.gov/oep/documents/MultiFarmStartMacro7.xlsm

Safety considerations

Carbon dioxide poses a moderate risk to human safety. Personnel should be cautious of CO₂ exposure (fsis.usda.gov/wps/wcm/connect/bf97edac-77be-4442-aea4-9d2615f376e0/Carbon-Dioxide.pdf?MOD=AJPERES). Risks can be mitigated by using wearable gas monitors and allowing complete ventilation of the container before entry for carcass inspection or removal. Cryogenic gloves and goggles should be worn by personnel working around the vaporizer chamber. If CO₂ exposure occurs, remove the exposed person from the vicinity to fresh air and provide oxygen if necessary.

Seasonality impacts

Extra energy may be needed for the vaporizer and heat exchanger to function properly in cold ambient temperatures. However, even with a vaporizer, gas may not flow appropriately in cold ambient temperatures such as Midwest winter conditions. In these situations, longer fill times and/or holding times may be required.

Carcass disposal restrictions

None.

Configuration

Several setup configurations exist for CO₂ administration. The pig size, pig numbers, and carcass disposal will all impact which configuration is best suited for a given depopulation event.

- **Small containers:** gas is directly bled from a CO₂ pressurized cylinder into the chamber. This is appropriate for nursery pigs. A vaporizer is not required because of low flow rate. Hand carts and bins are examples of containers.

- **Intermediate containers:** High pressure CO₂ cylinder to a low-pressure tank. A vaporizer is not required because of low flow rate. Orifice plate is needed to control the flow from the low-pressure tank to the chamber. This set up is designed for small truck or dump trailers. A schematic of this type of configuration can be found here: aasv.org/shap/issues/v22n5/v22n5p248.html.
- **Large containers:** A vaporizer and external heaters are needed because of the high flow rate to decrease dry ice formation. Dumpsters, grain trucks, dump trucks, shipping containers, or earthen pits are suitable examples of holding containers. Carcass disposal method should be considered when choosing a container. Modifications to containers can be made to increase the efficacy of loading animals in and dumping carcasses. A schematic of this type of configuration using a dumpster can be found here: ncagr.gov/oep/documents/javma2448final.pdf. A schematic of this type of configuration using a modified dump trailer can be found here: aasv.org/shap/issues/v30n1/v30n1p31.html.

A schematic and supply list for ambient air vaporizer and CO₂ chambers can be found here: <https://www.ipic.iastate.edu/information/Final%20CO2%20depopulation%20operations%20manual.pdf>.

Primary resources

- **High-pressure CO₂ liquid.** Possible sources include welding companies, ethanol stations, gas-supply company, etc.
- **Vaporizer unit** is used to increase gas flow rate from the high-pressure liquid/gas storage to low-pressure gas while preventing the formation of dry ice. A variety of vaporizer units exist or can be constructed:
 - Commercial ambient temperature vaporizers can be purchased from welding shops or gas customization companies. Another example is creating an earth tube vaporizer by digging a 100-foot trench 4 to 5 inches deep and bury a 4-inch corrugated pipe. Release the liquid CO₂ into a 55-gallon drum. The gas will then travel through the 100-foot earth tube and the gas temperature will increase. A generator and external heaters are needed to prevent dry ice formation in the 55-gallon drum. A polyethylene bag is used as a CO₂ vapor collection reservoir. Details on how to construct an earth tube vaporizer can be found here: youtube.com/watch?v=WKMkj4Yg0KU.
 - Commercial electric or other heated vaporizers which can be purchased from sources including welding shops or gas customization companies.
 - Homemade heated vaporizer unit constructed from commonly available supplies. Details on how to construct a vaporizer can be found here: ncagr.gov/oep/documents/CO2VaporizerHowTov1.pdf and youtube.com/watch?v=WKMkj4Yg0KU. Vaporizer container should be a gas-tight vessel that has a pressure-relief valve and is capable of withstanding 500°F to 600°F.

Carbon Dioxide

- **CO₂ gas containment** can be used to store CO₂ gas until needed. Examples include 55-gallon metal drums, 250- to 1000-gallon used propane tanks, and polyethylene bags. This chamber can be used to sublimate dry ice accumulation back into gas. When using polyethylene bags to store or sublimate CO₂, be sure to secure the bags to the ground.
- **Pressure drop valve** rated for pressure and low temperature to prevent dry ice formation in the feed hose or truck valve. Check with your CO₂ supplier to ensure you have the correct connection available for the truck to connect with the vaporizer chamber.
- **Flow regulation** using a field constructed venturi and monometer. A blower can be used to move the gas from the storage bags to the chamber.
- **Airtight container** sized to accommodate the farm needs and the vaporizer capabilities. The ceiling height of the container can be reduced to reduce the available airspace to fill with CO₂ but must be high enough to accommodate the largest pigs (eg, adult pigs may require a 4-foot ceiling height and finisher pigs may only need 3-foot ceiling height). The container must be equipped with inlet and outlet valves. Because carbon dioxide is heavier than air, the container's outlet valve should be located at the top. This way, the container can be filled with carbon dioxide while the displaced air can escape. Examples of containers used for depopulation include earthen pits, modified dump trailer (aasv.org/shap/issues/v30n1/v30n1p31.html), shipping containers, roll-off solid waste dumpsters, and temporary corrals constructed of wire fence, plywood, and plastic sheeting. Carcass disposal options should be considered when choosing a container.
- **Penning panels** to create temporary corrals, alleyways, or chutes for pig movement out of the barn and into the container.

Ancillary resources

- **Animal handling tools** to move pigs from the barn to the container.
- **Adjustable loading chute** may be needed to load pigs into the container.
- **Front end loader** for carcass removal from the container.
- **Backhoe (optional)** to dig earthen pits for CO₂ container or trenches for earthen tubes.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Method classification

Preferred. Note this method is not specifically included for swine in the AVMA Guidelines for the Depopulation of Animals, 2019 but is listed as an acceptable method for swine in the AVMA Guidelines for the Euthanasia of Animals, 2020.

Suitable for

All phases of production.

Procedure

Carbon monoxide (CO) binds with hemoglobin to form carboxyhemoglobin in the blood stream, restricting the availability of oxygen to vital organs. Carbon monoxide concentration in the room or container should be maintained between 3,000 and 15,000 ppm throughout the duration of the exposure.

Biosecurity risk

Negligible risk due to minimal blood contamination.

Labor needs and throughput estimates

Minimal personnel are needed to implement depopulation with carbon monoxide. Most labor needs will be associated with carcass removal from the facility if applied in a building or room. Throughput will be dependent on the size of animals, the size of the room or chamber, and time needed for carcass removal.

Safety considerations

Carbon monoxide poses a serious risk to human safety. Personnel should be cautious of CO exposure (gaslab.com/blogs/articles/carbon-monoxide-levels-chart-and-defenderdetectors.com/standard/acgih_niosh_osh.pdf). Risk should be mitigated by using wearable gas monitors at all times and having self-contained breathing apparatus (SCBA) available on-site. Personnel should not enter the facility while CO generation is in progress. Allow complete ventilation of the container or room before entry for carcass inspection or removal. Personnel must not enter the room or container until CO concentrations are at or below 200 ppm. Personnel should be cautious of CO exposure and always work in pairs. Carbon monoxide is combustible at concentrations at or above 125,000 ppm.

Seasonality impacts

Facility design and wind speed may impact CO application and timeline.

Carcass disposal restrictions

None.

Configuration

Several setup configurations exist for CO administration. The ability to seal the pen, room or container is a key factor. Load animals into the sealed pen, room or container and start the CO source(s). Close the door or lid and turn off all exterior ventilation (stir fans may continue to run if available). Monitor the pigs via remote video livestream. After the process is complete, it is essential to ventilate the space prior to entering to confirm insensibility and death. If conducted in a room, this can be achieved by turning on the ventilation fans. Be sure to avoid standing near the fans as the room exhausts. Alternately, if conducted in a container or earthen pit, open the doors and/or remove the tarp(s) and allow fresh air to circulate until CO concentration drops to 200 ppm or less. If the CO source is exterior to the location with the pigs, turn it off. If the CO source is inside the building or container, wait until it has exhausted sufficiently to be safe to enter, then go in and turn off the CO source.

Primary resources

- **Source of CO.** Gas-powered generators exhaust more highly concentrated CO than most other gas engines, including vehicles. Know the concentration of CO emitted from the source and ensure there are no safety shutoffs. For reference, some CO sources and the resulting CO concentration from output of each can be found here: <https://pubmed.ncbi.nlm.nih.gov/28768080/>.
- Compressed CO is available but extreme caution should be used if utilizing this as a source due to the increased risk of explosion.
- Depending on the source used, cooling and/or filtering the output may be necessary to reduce the temperature of and/or number of particulates in the exhaust output to improve pig welfare during the procedure.
- **Wearable CO monitors** with an audible alarm must be worn by all personnel participating in the depopulation.
- **Well-sealed room or air-tight container** large enough to accommodate the number and size of animals to be depopulated. Spray foam can be used to seal seams, cracks, and inlets in rooms and containers to prevent CO leakage. In addition to rooms used for housing pigs, examples of containers that could be used for this depopulation method include earthen pits with tarps covering the top and any openings; sealed trailers or dump trucks; rendering trailers covered by a tarp; shipping containers; roll-off solid waste dumpsters; and temporary corrals constructed of wire fence, plywood, and plastic sheeting. Barns or rooms with shallow pits are preferable; deep pitted barns/rooms may also be used but will increase the length of time necessary unless pits are covered by a solid material or are filled with water.
- **Livestream remote video monitoring** to safely monitor pig activity and assess when the process is complete.
- **Remote CO monitor** placed at pig level in the room or container to monitor CO concentrations during and after application.

Ancillary resources

- **Animal handling tools** to move pigs from the barn to the container if not conducted in the pigs' living space.
- **Wheelbarrows, skid loaders, or other carts** for carcass removal from the room or container.
- **Remote temperature probe** to monitor the ambient temperature in the pig space.
- **Self-contained breathing apparatus** to have available as additional personal protective equipment.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Method classification

Preferred.

Suitable for

Nursery pigs or older.

Procedure

Gunshot to the head results in concussion and damage to vital areas of the brain caused by the impact of the penetrating bullet. The ideal target for gunshot is half an inch above eye level, on the midline of the forehead and aiming toward the tail of the pig. An alternative target for gunshot is behind the ear so that the bullet enters the skull from behind the ear aiming toward the opposite eye. When using a firearm, the muzzle should be held 2 to 10 inches from the pig's skull (Figure 1).

Biosecurity risk

Potential for contamination due to blood loss through the bullet points of entry and exit.

Labor needs and throughput estimates:

Personnel must be trained in firearm safety and have marksmanship skill. Throughput is estimated to be 1-2 minutes/pig.

Safety considerations

Gunshot poses a high safety risk to personnel. Additional personnel should always remain behind the shooter. Pigs should be moved outdoors on soil where the danger of a bullet ricocheting is reduced. Hearing and eye protection should be worn by all personnel. The use of full metal jacket ammunition, in both .38 special and 9mm caliber (>300 ft.-lb.) firearms, is not recommended, as these combinations can pass through the skull of market weight pigs with enough remaining energy to create a human safety hazard.

Seasonality impacts

Cold weather can impact chambering of ammunition.

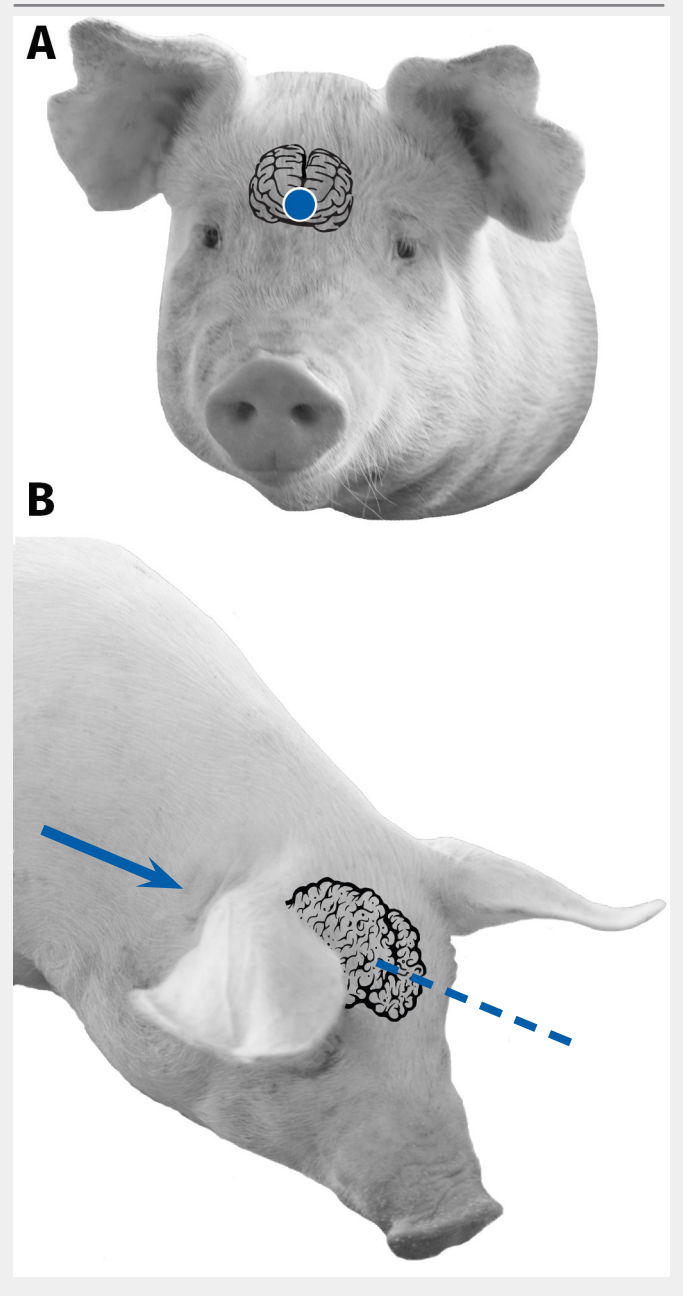
Carcass disposal restrictions

None.

Configuration

Chutes or corrals with removable side panels can be constructed outside of the barn. Chutes can be constructed in an I or Y formation with a width that allows pigs to stand single file and the sides tall enough to prevent pigs jumping over. After pigs are loaded into the chute, shooting can begin with the last pig and work towards the front of the line. Confirm death and lower one side of the chute to facilitate carcass removal. Snaring the pigs is another option for restraint; however, additional personnel must remain behind the person operating the firearm to minimize safety risks.

Figure 1: Gunshot. When using the gunshot method to euthanize pigs, the ideal target is half of an inch above eye level, on the mid-line of the forehead and aiming toward the tail of the pig as indicated by A. An alternative target is behind the ear as indicated by B. The bullet should enter the skull from behind the ear aiming toward the opposite eye.



Primary resources

- **Rifle or shotgun.** The rifle and ammunition selected must have a minimum muzzle energy of 139 foot pounds to enable the bullet to pass through the skull thickness of grow/finish and mature adult pigs. A factsheet to understand muzzle energy when selecting a firearm can be found here: <https://bit.ly/3IG6b73>. Table 1 provides energy values of common ammunition. A 12-, 16-, or 20-gauge shotgun can be used for grow/finish pigs and mature sows and boars. A 28- or 410-gauge shotgun is recommended only for nursery pigs.
- **Ammunition.** Slug ammunition is recommended for shotguns because of its ability for consistent and effective penetration of the skull. Bulleted ammunition should be round-nosed and solid to ensure penetration of the skull. The common type of ammunition known as a “wadcutter” is designed for target shooting and is not suitable. Fragmenting bullets are recommended only for use in nursery and grow/finish pigs as they tend to fragment before fully penetrating the skull thickness of adult animals.
- **Penning panels** to create temporary alleyways or chutes for pig movement out of the barn and into the single file configuration.

Ancillary resources

- **Animal handling tools** to move pigs from the barn to the chute.
- **Front end loader** for carcass removal.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Table 1: Table of Common Ammunition Energy values. Red text denotes those calibers and bullet type combinations providing the recommended 300 ft-lb energy. Reprinted with permission from National Pork Board.

Caliber	Manufacturer	Bullet type	Bullet mass (grains)	Manufacturer part number	Manufacturer published muzzle velocity (ft/s)	Manufacturer published muzzle energy (ft-lb)	Manufacturer data source
.22 Long rifle (.22 LR)	CCI	CPHP	36	31	1260	127	https://www.cci-ammunition.com/rimfire/cci/minimag/6-31.html
	CCI	CPRN	40	30	1235	135	https://www.cci-ammunition.com/rimfire/cci/target_mini-mag/6-30.html
	CCI	CPHP (Stinger)	32a	50	1640	191	https://www.cci-ammunition.com/rimfire/cci/stinger/6-50.html
.22 Winchester Magnum Rimfire (.22 WMR)	Federal	FMJ	40	737	1880	314	https://www.federalpremium.com/rimfire/champion/champion-training---rimfire/11-737.html
	CCI	TMJ	40	23	1875	312	https://www.cci-ammunition.com/rimfire/cci/maximag_tmj/6-23.html
	CCI	JSP	40	22	1875	312	https://www.cci-ammunition.com/rimfire/cci/gamepoint/6-22.html
.38 Special	Winchester	FMJ	130	Q4171	800	185	https://winchester.com/Products/Ammunition/Handgun/USA/Q4171
	Hornady	JHP	125	90324	900	225	https://www.hornady.com/ammunition/handgun/38-special-125-gr-xtp-american-gunner#!/
	Speer	JHP (+P)	135	23921GD	860	222	https://www.speer.com/ammunition/handgun/gold_dot_short_barrel_personal_protection/19-23921GD.html
	Hornady	JHP	158	90362	800	199	https://www.hornady.com/ammunition/handgun/38-special-158-gr-xtp#!/
.357 Magnum	Winchester	JHP	110	Q4204	1295	410	https://winchester.com/Products/Ammunition/Handgun/USA/Q4204
	Federal	JHP	125	C357B	1440	575	https://www.federalpremium.com/handgun/federal-personal-defense/personal-defenserevolver/11-C357B.html
	Hornady	FTX	140	92755	1440	644	https://www.hornady.com/ammunition/handgun/357-mag-140-gr-ftx-leverrevolution#!/
	Federal	JHP	180	C357G	1080	466	https://www.federalpremium.com/handgun/powershok/power-shok-handgun/11-C357G.html
9mm Luger (9 x 19mm parabellum) (9mm NATO)	Winchester	FMJ	115	Q4172	1190	362	https://winchester.com/Products/Ammunition/Handgun/USA/Q4172
	Federal	FMJ	124	AE9AP	1150	364	https://www.federalpremium.com/handgun/american-eagle/american-eagle-handgun/11-AE9AP.html
	Federal	FMJ	147	AE9FP	1000	326	https://www.federalpremium.com/handgun/american-eagle/american-eagle-handgun/11-AE9FP.html
	Hornady	JHP	115	90244	1155	341	https://www.hornady.com/ammunition/handgun/9mm-luger-115-gr-xtp-american-gunner#!/
	Federal	JHP	124	P9HST1S	1150	364	https://www.federalpremium.com/handgun/premium-personal-defense/personal-defensehst/11-P9HST1S.html
.223 Remington	Federal	FMJ	55	AE223	3240	1282	https://www.federalpremium.com/rifle/american-eagle/american-eagle-rifle/11-AE223.html
	Federal	BTHP	55	P223S	3200	1250	https://www.federalpremium.com/rifle/premiumcenterfire-rifle/barnes-tsx/11-P223S.html
	Federal	Soft point	64	223L	3050	1322	https://www.federalpremium.com/rifle/powershok/power-shok-rifle/11-223L.html
	Federal	BTHP	77	GM223M3	2720	1265	https://www.federalpremium.com/rifle/goldmedal/gold-medal-sierra-matchking/11-GM223M3.html
12 Gauge	Federal	Rifled slug	437.5	F127 RS	1610	2521	https://www.federalpremium.com/shotshell/powershok/power-shok-rifled-slug/11-F127+RS.html
	Remington	Rifled slug	437.5	SP12RS	1560	2361	https://www.remington.com/ammunition/shotshell/slugs/sluggger-rifled-slugs

Method classification

Preferred.

Suitable for

Pigs less than 70 lbs.

Procedure

The nonpenetrating captive bolt (NPCB) gun typically has a mushroom shaped or flathead bolt that, when applied to the forehead of the pig, causes concussion and severe trauma of the brain. The pig should be restrained so that the head is held firmly in place in a manner that allows the restrainer's hands to be out of harm from the device. The NPCB gun should be placed firmly against the forehead of the pig (Figure 2).

Biosecurity risk

Minimal risk for contamination if skin remains intact. Some blood discharge may occur.

Labor needs and throughput estimates

Labor needs are estimated to be a 3-person team per NPCB station: one person to handle animals and carcasses at the station, one person to restrain and use the NPCB gun, and one person to manage the equipment. Additional labor will be needed for moving animals from the barn to the station and moving carcasses from the station to the disposal location. Throughput is estimated to be between 30 seconds and 1 minute/pig depending on the type of device used. Additional time is required to confirm insensibility and death.

Safety considerations

NPCB poses a low risk to human safety. Operators should be aware of their hand placement when restraining the pig. A customized hand shield can be used to protect the restraining hand when operating the NPCB gun. Pig restraining devices such as a notch board or a cradle will provide additional safety for the restrainer (Figure 3). A board with a "V" notch for restraint can minimize risk of worker injury during device application. Hearing and eye protection should be worn by all personnel.

Seasonality impacts

None identified.

Carcass disposal restrictions

None.

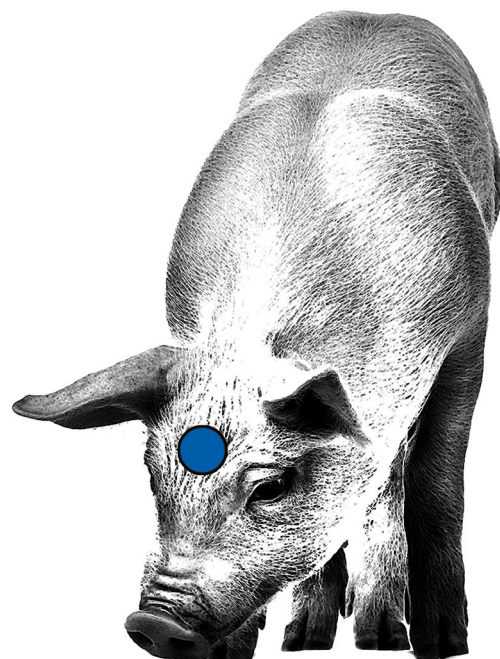
Configuration

Identify a location to set up NPCB stations so that pigs can easily be brought to the station by using carts or set up holding pens near the station. The station location should also allow for easy carcass removal.

Primary resources

- **Proper restraint device** that can be used for restraining pigs for NPCB application. Examples include a table, bench, a "V" notch board that the pig's head can be placed into, or PVC restraint trough set at waist height to accommodate operator ergonomics. Larger pigs can be restrained against the floor.
- **Nonpenetrating captive bolt guns** can be cartridge powered or pneumatic.
 - The cartridge-powered guns can be inline or pistol grip. Nonpenetrating captive bolt guns that achieve a force higher than 120 psi have been shown to be effective as a single-step method for pigs weighing up to 70 lbs. The cartridge-powered guns will become hot after 15-20 minutes of continual use, so it is recommended that the tools be rotated every 15 minutes to allow for cooling. Additional devices should be obtained so that they can be rotated to accommodate the cooling period. During the cooling period, the breech should be disassembled from the barrel to accelerate cooling and the parts can be inspected for damage. Have a wire brush and gun solvent for cleaning and maintenance. Replacement kit for the gun is required with multiple bumpers.
 - The pneumatic bolt guns are air-powered and resemble air-powered nail guns. Nonpenetrating captive bolt guns achieving a force of 120 psi have been shown to be effective as a single-step method for pigs weighing less than 20 lbs. Pneumatic bolt guns are air-cooled and can be used repeatedly without a cooling period. Have a wire brush for cleaning after repeated use.

Figure 2: Non-Penetrating Captive Bolt. The non-penetrating captive bolt gun should be placed firmly against the front of the head in the area shown.



Nonpenetrating Captive Bolt

- **Powder cartridges or compressed air** depending on the type of NPCB gun used. For cartridge-powered NPCB guns, follow manufacturer's recommendations on proper cartridge loads to use. Operators can use a 2-pouch carpenter's tool belt to hold live and spent power loads. For pneumatic NPCB guns, use an air compressor capable of 150 psi output. A 25- to 50-foot air hose is needed to connect the compressor to the gun. Prolonged use of some air compressors can result in water accumulation, so the drain petcock should be opened periodically for draining. Proper power supply or amperage to power multiple air compressors is needed.
- **Replacement parts** and cleaning equipment will be needed to maintain the guns throughout operation to ensure proper bolt velocity. Refer to manufacturer's recommendations for proper gun cleaning protocols. Cartridge-powered NPCB guns should be inspected during cooling periods and worn parts replaced. The pneumatic fitting of the NPCB gun should be oiled according to manufacturer recommendations.

Ancillary resources

- **Carts** for movement of small pigs from the barn or movement of carcasses.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Figure 3: Restraint cradle for use with nonpenetrating captive bolt. Photo courtesy of Pipestone Veterinary Services.



Method classification

Preferred.

Suitable for

Pigs over 12 lbs.

Procedure

The penetrating captive bolt (PCB) gun has a sharp-rimmed, concave bolt that extends and penetrates the skull to cause concussive and physical damage to the skull and brain upon impact. The placement should be directed at the mid-line of the forehead, a half inch above eye level (even with the eyebrows). The PCB gun should be placed very firmly against the skull, aimed at the brain, and directed toward the tail (Figure 4).

Biosecurity risk

Contamination will occur due to blood loss through the bolt point of entry.

Labor needs and throughput estimates:

The total number of people needed will depend on the setup configuration and factors including facility design and movement of pigs. At a minimum, a 3-person team is needed per PCB station: one person to move pigs into position and ensure maintained restraint, one person to use the PCB gun, and one person to remove carcasses. A fourth person may be needed to manage, maintain, and clean the PCB equipment. Additional labor will be needed for moving animals from the barn to the station and moving carcasses from the station to the disposal location. Throughput is estimated to be 1-2 minutes/pig. Additional time is required to confirm insensibility and death.

Safety considerations

When used appropriately, PCB poses a low risk to human safety. Operators must be aware of and use the safety features of the PCB gun and use caution to avoid accidental firing causing human injury. Animals must be properly restrained to minimize the risk of accidental movement of the device while firing. Hearing and eye protection should be worn by all personnel.

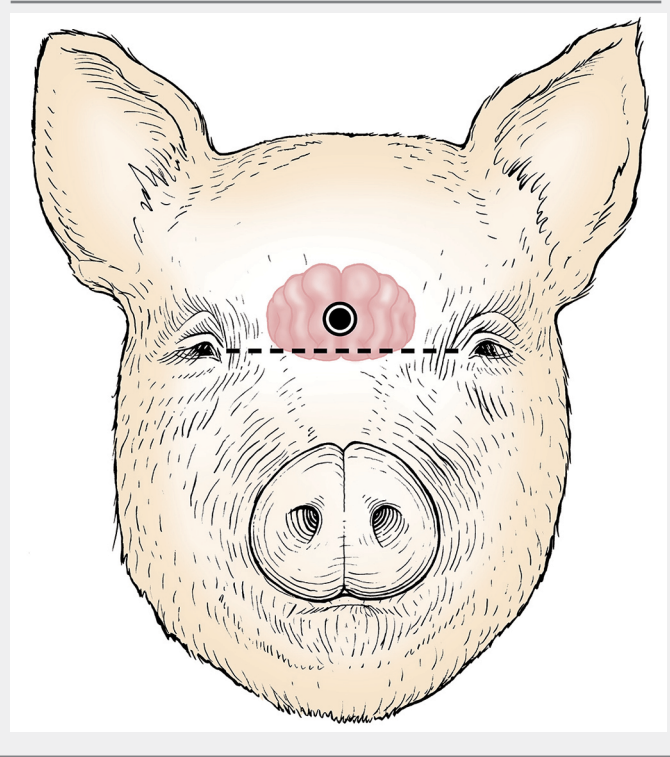
Seasonality impacts

None identified.

Carcass disposal restrictions

None.

Figure 4: Penetrating Captive Bolt. The anatomic location for penetrating captive bolt placement is in the center of the forehead slightly above a line drawn between the eyes. The bolt should be directed toward the spinal canal. The ideal target location and direction of aim may vary slightly according to the breed and age of the animal owing to face shape and growth of the frontal sinuses. Illustration provided by American Veterinary Medical Association, used under CC BY-NC-ND 3.0.



Configuration

Chutes with removable side panels can be constructed at the exit of the barn. Chutes can be constructed in an I or Y formation with a width that allows pigs to stand single file and the sides tall enough to prevent pigs jumping over. After pigs are loaded into the chute, the PCB gun can be applied beginning with the last pig and working towards the front of the line. Confirm death and lower one side of the chute to facilitate carcass removal. If materials for constructing a chute system are not available, walking the animals to the normal loadout or dead removal area of the barn is an option. Alternatively, a chute can be constructed at the exit of the barn that leads to a center track or V restrainer. Pigs enter the restrainer where the PCB can be applied and exit onto a conveyor where death can be confirmed before they are loaded into a conveyance for disposal.

A schematic and supply list for penetrating captive bolt with a v-restrainer can be found here: <https://www.ipic.iastate.edu/information/Final%20V-Restrainer%20depopulation%20operations%20manual.pdf>.

Penetrating Captive Bolt

Primary resources

- **Penetrating captive bolt guns** can be cartridge powered or pneumatic.
 - The cartridge-powered guns can be inline or pistol grip. It is important to select the bolt length and cartridge combination appropriate to the age and size of pig being depopulated to ensure that the bolt is long enough to penetrate the pig's skull. The cartridge-powered guns will become hot after 15-20 minutes of continual use, so it is recommended that the tools be rotated every 15 minutes to allow for cooling. During the cooling period, the breech should be disassembled from the barrel to accelerate cooling and the parts can be inspected for damage and cleaning. Have a wire brush and gun solvent for cleaning and maintenance. Replacement kit for the gun is required with multiple bumpers.
 - The pneumatic bolt guns are powered by an air compressor and can be used repeatedly without a cooling period. The pneumatic PCB guns are heavy and typically have a counter lever that needs to be mounted on or near the chute or restrainer to facilitate correct PCB gun placement to the animal's head. Maintain the gun according to the manufacturer recommendations.
- **Powder cartridges or compressed air** depending on the type of PCB gun used. For cartridge-powered PCB guns, follow manufacturer's recommendations on proper cartridge loads to use for the age and size of pig being depopulated. Operators can use a 2-pouch carpenter's tool belt to hold live and spent power loads. For pneumatic PCB guns, use a compressor capable of 150 psi output. An air hose long enough to span the distance between the compressor and the gun will be needed. Prolonged use of some air compressors can result in water accumulation, so the drain petcock should be opened periodically for draining.
- **Replacement parts and cleaning equipment** will be needed to maintain the PCB guns throughout operation to ensure proper bolt velocity. Refer to manufacturer's recommendations for proper gun cleaning protocols. Cartridge powered PCB guns should be inspected during cooling periods and worn parts replaced.
- **Penning panels** to create temporary alleyways or chutes for pig movement out of the barn and into the single file configuration or chutes for pig movement into the restrainer.
- **Center track or V restrainer** to facilitate successful application of PCB. Tips to improve animal movement into conveyor restrainers can be found here: grandin.com/restrain/improve_mvmt.html
- **Conveyor belt system** can be used to move carcasses away from the restrainer. Confirmation of death can be performed once the pig exits onto the conveyor. The speed of the conveyor must be adjusted to allow for confirmation of death. The conveyor system can be installed at an incline to move pigs into the conveyance used for disposal.

Ancillary resources

- **Animal handling tools** to move pigs from the barn to the chute.
- **Front end loader** for carcass removal.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Method classification

Preferred.

Suitable for

Pigs over 3 days of age.

Procedure

Electrocution induces death by insensibility of the brain followed by cardiac fibrillation and cerebral anoxia (no oxygen to the brain). The flow of electricity (the current) should be at least 0.5 amps for pigs up to 6 weeks of age, at least 1.3 amps for pigs 6 weeks of age to 220 lbs, and 2.0 amps for pigs greater than 220 lbs. The force behind the flow of the electric current is the voltage and is recommended to be at least 110 volts for piglets over 10 lbs and up to 6 weeks of age, and 250 volts for pigs 6 weeks of age and older. The current's amperage can be increased by increasing the voltage or decreasing the resistance. Resistance can be affected by the length and gauge of wire delivering the current to the pig, electrode contact with the skin, cleanliness of the electrodes, wetness of the skin, presence of hair, thickness of skin and fat layers, and the thickness of the skull. The frequency of the current delivered should be approximately 60 hertz (US standard) of alternating current (AC).

Electricity can be applied in one of two methods.

- Head only application is achieved by placing electrodes 1) between the eyes and base of the ears on both sides of the head, 2) below the base of the ears on both sides of the head, or 3) diagonally, below one ear to above the opposite eye and passing electric current through the brain for a minimum of 3 seconds. This method must be followed by a secondary step, such as across the chest electrocution, within 15 seconds of initial stunning (Figure 5).
- Head-to-heart application is achieved by placing the front electrode on the head, level with or in front of the brain and the rear electrode placed on the body behind the heart. When applying the front electrode to the ear, clipped to the inside of the base of the ear is the recommended location. The rear electrode is placed on the rear flank or base of the tail. The current should be applied for a minimum of 15 seconds (Figure 6).

For either method, electricity must pass through the brain first. The electrode should be in full contact with the pig prior to applying electricity. The electrodes must stay in contact with the pig for the full time of electricity application. A commercially available electric stunner device should be used for best results.

Biosecurity risk

Negligible risk due to minimal blood contamination.

Labor needs and throughput estimates

Labor needs for handheld units are estimated to be a 3-person team per electricity unit: one person to handle animals, one person to apply the electrodes, and one person to confirm death. Additional labor will be needed for moving animals from the barn to the location where electrocution will be performed and moving carcasses to the disposal location. Throughput is estimated to be 1-2 minutes/pig.

Safety considerations

Electrocution poses a moderate risk to human safety. Proper lockout/tagout procedures must be in place to protect human safety. An isolation transformer should be used to improve safety and provide sufficient amperage. The operator should work in a dry location, wear rubber boots, and stand on a nonconductive surface. The restrainer frame and worker walkway structure should be grounded to a perfect ground. The side of the restrainer near the operator should be covered with heavy insulating materials. In a small batch pen setup, only the operator should be in the pen when electrocuting pigs. The penning and flooring cannot be metal, and the ground should be dry to protect human safety. A rubber mat could also be considered.

Seasonality impacts

Not a viable option for use outdoors in rainy or snowy conditions if the equipment is not covered.

Carcass disposal restrictions

None.

Figure 5: Head-only Electrocution. Proper electrode placement for (A) between the eyes and the base of the ears on either side of the head, (B) below the base of the ears on either side of the head, and (C) diagonally below one ear to above the opposite eye. Regardless of position, this method must be followed by a secondary step.

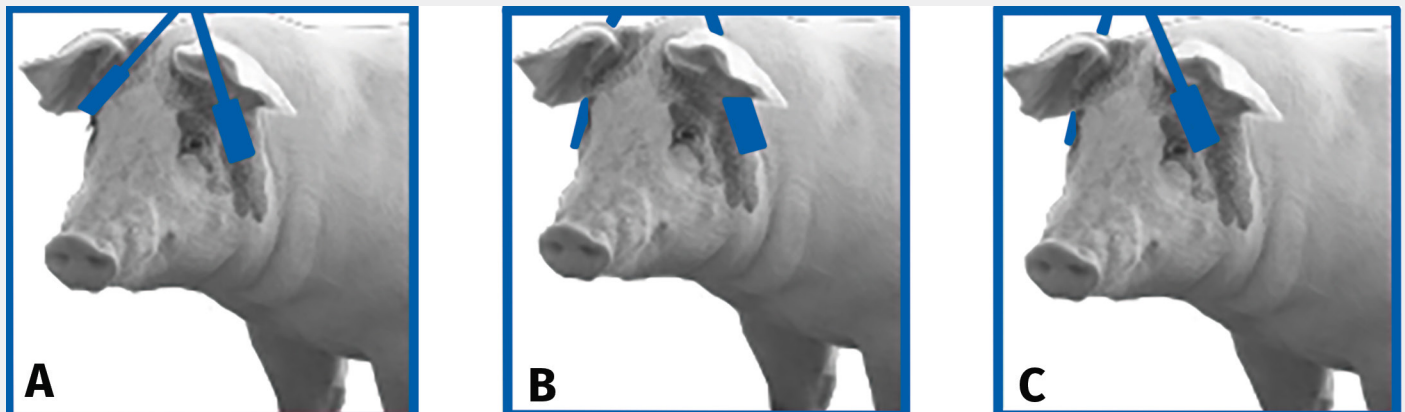
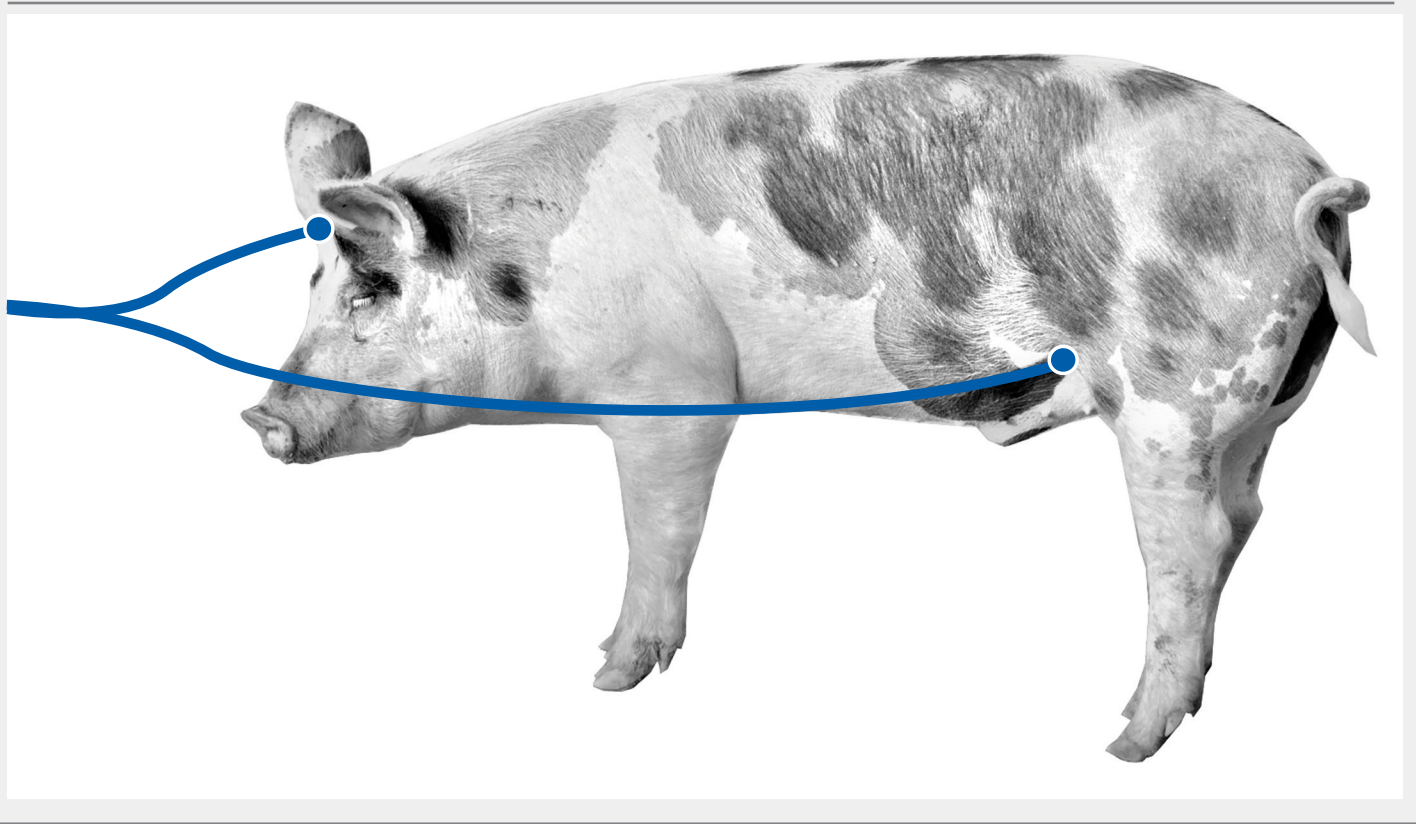


Figure 6: Head-to-Heart Electrocution. Proper electrode placement for head-to-heart electrocution as indicated by the dots allows for current to pass simultaneously through the brain and heart.



Configuration

Alleyways and pens can be constructed outside the barn. Pens should be large enough to hold small groups of pigs. Once pigs are placed in the pen, personnel can approach individual pigs with the electrodes and apply electricity to the animal. After pigs have been electrocuted, death can be confirmed, and carcasses removed from the pen. Alternatively, a chute can be constructed at the exit of the barn that leads to a center track or V restrainer. Pigs enter the restrainer where the electrodes can be applied and exit onto a conveyor where death can be confirmed before they are loaded into a conveyance for disposal.

A schematic and supply list for electrocution using a v-restrainer can be found here: <https://www.ipic.iastate.edu/information/Final%20V-Restrainer%20depopulation%20operations%20manual.pdf>.

Primary resources

- **Misters or drippers** to dampen pigs prior to electricity application. A garden hose with a mist setting could also be used. Water should be applied in a separate location from where electricity is to be applied to protect human safety.
- **Power source** to generate electricity with the proper amperage and voltage.
- **Electrodes** come in the form of tongs, wands, or saddles. Tong and wand electrodes can be used for head only followed by chest application and wand and saddle electrodes can be used for head-to-heart application. Electrode ends must be kept clean for proper flow of electricity.

- **Penning** to create temporary alleyways for pig movement out of the barn and into a pen or chutes for pig movement into the restrainer. Pen construction should use non-metal materials, such as plastic fencing or plywood.
- **Center track or V restrainer** to facilitate successful application of electrocution. Tips to improve animal movement into conveyor restrainers can be found here: grandin.com/restrain/improve.mvmt.html. The speed of the conveyor must be adjusted to allow for proper duration of electrocution application.
- **Conveyor belt system** can be used to move carcasses away from the restrainer. Confirmation of death can be performed once the pig exits onto the conveyor. The speed of the conveyor must be adjusted to allow for confirmation of death. The conveyor system can be installed at an incline to move pigs into the conveyance used for disposal.

Ancillary resources

- **Animal handling tools** to move pigs from the barn to the chute.
- **Front end loader** for carcass removal.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Method classification

Preferred.

Suitable for

Pigs weighing less than 12 pounds.

Procedure

Provide a quick, firm blow to the top of the head over the brain. It is essential that the blow be administered accurately and with resolve to ensure death and not just stunning. The preferred method for administering the quick, firm blow is to hold the pig by both rear legs above the hocks, one leg in each hand, and bring the pig swiftly down so the top of the head contacts the solid concrete flooring. Avoid plastic or slatted flooring. The alternate method is to restrain the pig properly and use a solid, hard object, such as a hammer or mini sledgehammer, to administer a quick, firm blow to the top of the head over the brain (Figure 7).

Biosecurity risk

Potential for contamination due to blood loss.

Labor needs and throughput estimates

Labor needs will depend on number and size of pigs to depopulate. One person can depopulate a litter of pigs in approximately 3 minutes, assuming the person is not already physically spent. Additional time is required to confirm insensibility and death.

Safety considerations

Risk of trauma to hands and arms and muscle strains, pulls, or fatigue. Physical, mental, or emotional exhaustion may be a considerable risk for some people. If using an object to administer the blow, there is risk of the object slipping from one's grip and hitting other personnel.

Seasonality impacts

Heat stress or heat exhaustion could be a risk during summer months.

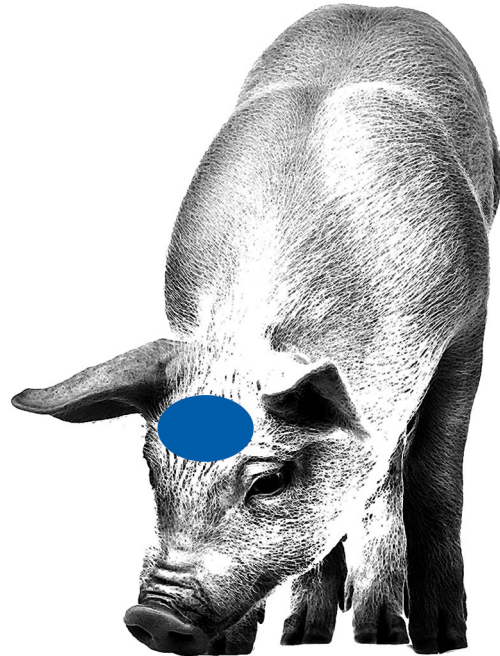
Carcass disposal restrictions

None.

Configuration

Pig handlers can be positioned at the front and rear of the farrowing stall to catch piglets and pass them to the personnel administering the method. Once manual blunt force trauma is applied, the piglet can be placed in a cart where insensibility and death are confirmed on each piglet prior to piling additional carcasses in the disposal container.

Figure 7: Blunt Force Trauma. Blunt force trauma is a quick, firm blow to the top of the head over the brain. It is essential that the blow be administered accurately and with resolve to ensure euthanasia and not just stunning.



Primary resources

- **People** who are trained, experienced, and physically capable to perform this method.
- **Solid concrete flooring or a solid metal hammer or mini sledgehammer.**
- **Proper restraint device** that can be used for restraining pigs if utilizing an object such as a hammer to deliver the blow. Examples include a table, bench, a “V” notch board that the pig’s head can be placed into, or PVC restraint trough.

Ancillary resources

- **Carts** for carcass removal.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Transport to processing plants with routine use of stunning and kill methods should be used for grower or adult pig depopulation, whenever possible. Processing plants are purpose built to handle humane killing of large numbers of pigs on a daily basis. This method may be recommended provided that certain circumstances are met, including the following:

- A competent authority grants permission to transport pigs to a processing plant.
- The processor is willing to conduct emergency slaughter.
- The pigs being killed do not pose a public safety risk (from exposure to live animals, carcasses, or animal products).
- The pigs are mobile with minimal outward signs of disease.
- Animal movement during transit poses minimal risk of disease transmission to other animals.
- Swine pass antemortem and postmortem inspection at the plant.

This method may not be an available option in instances where processing plants already have reduced operating capacity (eg, marketplace disruptions).

Method classification

Anesthetic overdose is preferred.

Compounded or nonpharmaceutical-grade injectable anesthetics and euthanasia agents are permitted under constrained circumstances.

Suitable for

All phases of production but not practical for large-scale depopulation.

Procedure

Euthanasia solutions (ie, barbiturates) are used to depress the central nervous system, causing deep anesthesia progressing to respiratory and cardiac arrest. This method of euthanasia requires an intravenous injection to be given to the pig. These agents are controlled substances and must be bought, stored, and used under supervision of an individual, such as a licensed veterinarian, who is registered with the US Drug Enforcement Administration.

Use of compounded or nonpharmaceutical-grade injectable anesthetics and euthanasia agents is justified for depopulation. In addition, the veterinarian may make a professional judgment about the use of agents that have exceeded their product expiration date.

Biosecurity risk

None.

Labor needs and throughput estimates

Labor needs will depend on configuration and the total number of animals to be depopulated on the site. At least one person will be needed to snare and physically restrain the animals and at least one person must be a licensed veterinarian who is registered with the US Drug Enforcement Administration.

Safety considerations

Minimal safety risks to humans.

Seasonality impacts

None.

Carcass disposal restrictions

Carcasses are not accepted for rendering. Burial or composting of carcasses may be prohibited to prevent incidental exposure of scavenging animals to chemical residues in the carcass. Check federal (EPA) and state environmental regulatory agency requirements related to carcass burial and composting when using this depopulation method.

Configuration

Pigs must be individually restrained by snaring and anesthetic agents administered through intravenous injection.

Primary resources

- **Anesthetic agent** in sufficient quantity for the number and size of pigs to be depopulated. These agents are controlled substances and must be bought, stored, and used under supervision of an individual, such as a licensed veterinarian, who is registered with the US Drug Enforcement Administration.
- **Syringe and needles** appropriate for the size of pigs being depopulated.
- **Sharps container** for proper disposal of needles.
- **Proper restraint device** such as a snare for larger pigs or a table, bench, or v-trough for piglets.

Ancillary resources

- **Wheelbarrows, skid loaders, or other carts** for carcass removal.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Method classification

Permitted in constrained circumstances.

Suitable for

Literature indicates that this method can be utilized for nursery and grow-finish pigs.

Procedure

Ventilation shutdown plus (VSD+) includes closing facility openings, shutting inlets, and turning off ventilation fans AND the addition of supplemental heat and humidity or CO₂. VSD+ should only be used in facilities with the capability to adequately increase air temperature and relative humidity to a level that results in at least a 95% death rate in less than 1 hour. A temperature of 130°F should be reached within 30 minutes. Once at 130°F, this is time zero for the process, and the process should be continued until all pigs become silent (no audible sounds or movement). The humidity target is > 95% ambient humidity. After VSD+ is complete and ventilation resumes in the facility, death must be confirmed, and a backup method applied to any remaining live animals.

Biosecurity risk

Negligible risk due to minimal blood contamination.

Labor needs and throughput estimates

Minimal personnel are needed to implement VSD+. Most labor needs will be associated with carcass removal from the facility. Specialized labor is required; veterinary oversight of the on-going process, animal well-being personnel to monitor (visual and auditory) to assure process progression and conclusion. Throughput will be dependent on the size of the animals, assuring animal death, and time needed for carcass removal. An agricultural engineer and electrician will be required to install the supplemental heat and humidity source and assure human safety.

Safety considerations

Personnel should not enter the facility while VSD+ is in progress. Allow the facility ventilation to resume before entering the barn to confirm death and remove carcasses. The person in charge of the process oversight will give permission to enter the facility. The heat and humidity required for VSD+ has the potential to impact the structural integrity of the building. Always consult an agricultural engineer for the proper equipment and setup.

Seasonality impacts

Depending on facility design, low ambient temperatures, low relative humidity, and high wind speeds may impact VSD+ application.

Carcass disposal restrictions

None.

Configuration

Configuration for VSD+ will be impacted by the age and size of the facility; the insulation of the facility; the ventilation system; the ability to adequately seal fans, louvres, doors, curtain openings, building seam leaks, and windows; and the number and size of animals in the facility. Facilities with solid dirt flooring are preferred. If using this method in a barn with a pit, it is important to remove air space within the pit to help moderate the air temperature. With solid or slatted concrete flooring, adding insulation (eg, additional bedding) may be necessary to help minimize heat loss due to conduction. A minimum temperature of 130°F should be reached within 30 minutes, and the humidity target is > 95% ambient humidity.

This method could be performed in an alternate container but must meet the specific temperature and humidity targets and an agricultural engineer should be consulted. Steam must be introduced in a way to avoid direct contact with the pigs. Metal containers must be insulated to prevent burns due to the addition of high heat.

An example of a VSD+ configuration using supplemental heat and humidity can be found here: <https://doi.org/10.2460/javma.259.4.415>.

Primary resources

- **Heat sources** used in addition to VSD+ to increase and maintain elevated temperatures. Heat sources must be external to the building and vented into the building.
- **Humidity sources** used in addition to VSD+ to increase and maintain the humidity within the barn to > 95% throughout the process. Steam generators used for cleaning tanker railcars can be sourced from the railroad industry. The steam should enter the barn at ceiling level to prevent direct contact with the pigs until it filters down into the pig zone. The rate of steam induction must be 2 lbs/cuft/hr, or 18,000 lbs of steam per hour. A 600-700 hp boiler (27,000 pph) is required to achieve this rate.
- **Monitoring devices (ie, Logtag)** must be installed to allow for remote monitoring of temperature and humidity throughout the process and allow for adjustment of the heat and humidity as needed to assure efficacy.
- **Carbon dioxide** can be used in addition to VSD+ to induce death. Refer to the carbon dioxide factsheet in this series for additional details on CO₂ administration.
- **Plastic sheeting or tarps** can be used with smaller pigs to decrease the head space in the room and assist with elevating temperature and humidity to lethal levels at pig level.

Ancillary resources

- **Winches or mortality carts** for carcass removal.
- **Skid loaders** can be used for carcass removal if the barn is structured to allow access and flooring is modified to allow the weight of the skid loader. If the building has a dirt floor, skid loaders can be readily used.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Method classification

Permitted under constrained circumstances.

Suitable for

Growing and adult swine.

Procedure

Ingestion of toxic levels of sodium nitrite causes a lethal rise in methemoglobin and prevents the release of oxygen into the tissues leading to death.

Sodium nitrite can be administered orally to individual animals by oral gavage using a liquid dosing device used to administer cattle dewormer products. Dosages > 441 mg/kg appear to work best for efficacy and success rate by oral gavage.

Groups of pigs may consume sodium nitrite freely when mixed with feed or water. Attempts have been made to restrict feed and water to improve sodium nitrite consumption, but to date those attempts have not resulted in 100% mortality efficacy using restriction durations that would be considered welfare acceptable. When exposing pigs to the sodium nitrite, designing a pen with extra feed or water access points may encourage consumption. Controlling how much each animal consumes with this method may be difficult. In disease situations, animals with reduced feed intake may struggle to voluntarily to consume a toxic dose.

Variation in individual animal responses after sodium nitrite administration can be expected. Death may take as long as 3 hours from consumption. Any pigs still alive at 3 hours post consumption will require a secondary euthanasia option.

Biosecurity risk

Negligible risk due to minimal blood contamination. Sodium nitrite is metabolized into safer components inside the body after consumption.

Labor needs and throughput estimates

Individual animal dosing requires more labor than group administration. For individual animal dosing, 1-2 people are needed to restrain the pig with a sort board(s) and 1 person to administer the sodium nitrite solution using a hooked drench device. Additional people are needed to move dosed pigs to desired location after administration. For group administration, people are needed to move pigs to desired area after consumption.

Safety considerations

Wear gloves while handling product. Avoid consumption and contact with mucous membranes.

Seasonality impacts

Depending on water temperature, pH, and composition, sodium nitrite has a solubility of ~0.7 g sodium nitrite/mL of water.

Carcass disposal restrictions

Carcasses may not be accepted for rendering. Please consult with your rendering operation first. Check federal (EPA) and state environmental regulatory agency requirements related to carcass burial when using this depopulation method.

Configuration

After sodium nitrite administration, walk pigs to an area where removal of carcasses can be safely and easily accomplished (eg, an outdoor pen).

Primary resources

- **Oral gavage equipment**, such as a cattle drenching gun, is needed for individual animal administration. A pneumatic drenching gun with a hook shape provides fastest application.
- **Sodium nitrite**. Different sodium nitrite sources may dissolve differently in solution.

Ancillary resources

- **Animal handling tools** to move pigs from locations.
- **Extra penning** if necessary.
- **Additional water cups, water gruel pans, water nipples, or other equipment** for increasing pig access during group exposure.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.

Method classification

High-expansion foam plus gas is preferred.

Water-based foam is permitted under constrained circumstances.

Suitable for

All phases of production.

Procedure

Foam is generated by passing foam concentrate and water through a foam screen. High-expansion foam bubbles are filled with inhaled gases such as Nitrogen (N₂) or Carbon Dioxide (CO₂) and is classified as a preferred method of depopulation. Water-based foam contains air and is classified as permitted under constrained circumstances. Animals will be placed in a pen or container to which foam will be applied. Foam will be applied in a rapid manner to cover the animals as quickly as possible; the animals must remain under the foam until all audible sounds and pig movements have ceased.

Biosecurity risk

Negligible risk due to minimal blood contamination.

Labor needs and throughput estimates

Labor needs will vary by configuration and number and size of pigs. For large depopulation events, four technicians plus an animal handler are recommended. Throughput may be limited due to water availability.

Safety considerations

Human safety concerns will vary depending on the type of foam and gas used. Enter foam-filled areas with caution. Keep foam and foam concentrate from covering nose and mouth. Foam may be slippery. Some foams may cause dermal and eye irritation. Anyone working with foam should be observed at all times. Have suitable respiration equipment (self-contained breathing apparatus [SCBA], oxygen) and human rescue equipment available.

Seasonality impacts

Cold weather may cause issues applying foam. Water pumps must remain on and pumping water even when foam is not being applied to avoid freezing.

Carcass disposal restrictions

Foams with high water content may affect some disposal methods. Foam concentrates with toxic ingredients may not be used in composting, burial, or rendering.

Configuration

Foam is created by mixing foam concentrate and water according to manufacturer directions. The mixture is pumped through heavy hose and foam nucleation screen to create foam. Gas, such as N₂ or CO₂ can be added into the mixture.

Use a sealed pen by covering slats and creating solid sides or a container with high sides. Load animals into the pen or container and close the gate or door. Apply foam well over the pigs' heads so that they remain in the foam until all audible sounds and pig movements have ceased. Once the foam dissipates, death is confirmed and a secondary or backup method applied if needed. Carcasses may be removed by hand, with heavy equipment, or by dumping if a dump truck is used as the container.

Primary resources

- **Foam concentrate**
- **Water pumps**
- **Large water containers or water sources**
- **Foam nucleation screens appropriate for foam type**
- **Gases for gas-filled foaming**
- **Container** sized to accommodate the farm needs and the foaming equipment capabilities. The floor of the container should be a non-slip surface. Examples of containers used for depopulation include earthen pits, sealed trailers or dump trucks, shipping containers, roll-off solid waste dumpsters, and temporary corrals constructed of wire fence, plywood, and plastic sheeting.
- **Penning panels** to create temporary corrals, alleyways, or chutes for pig movement out of the barn and into the container.

Ancillary resources

- **Animal handling tools** to move pigs from the barn to the container.
- **Adjustable loading chute** may be needed to load pigs into the container.
- **Front end loader** for carcass removal from the container.
- **Self-contained breathing apparatus** to have available as additional personal protective equipment.

Secondary or backup method must be in place and applied if the primary method is unsuccessful.