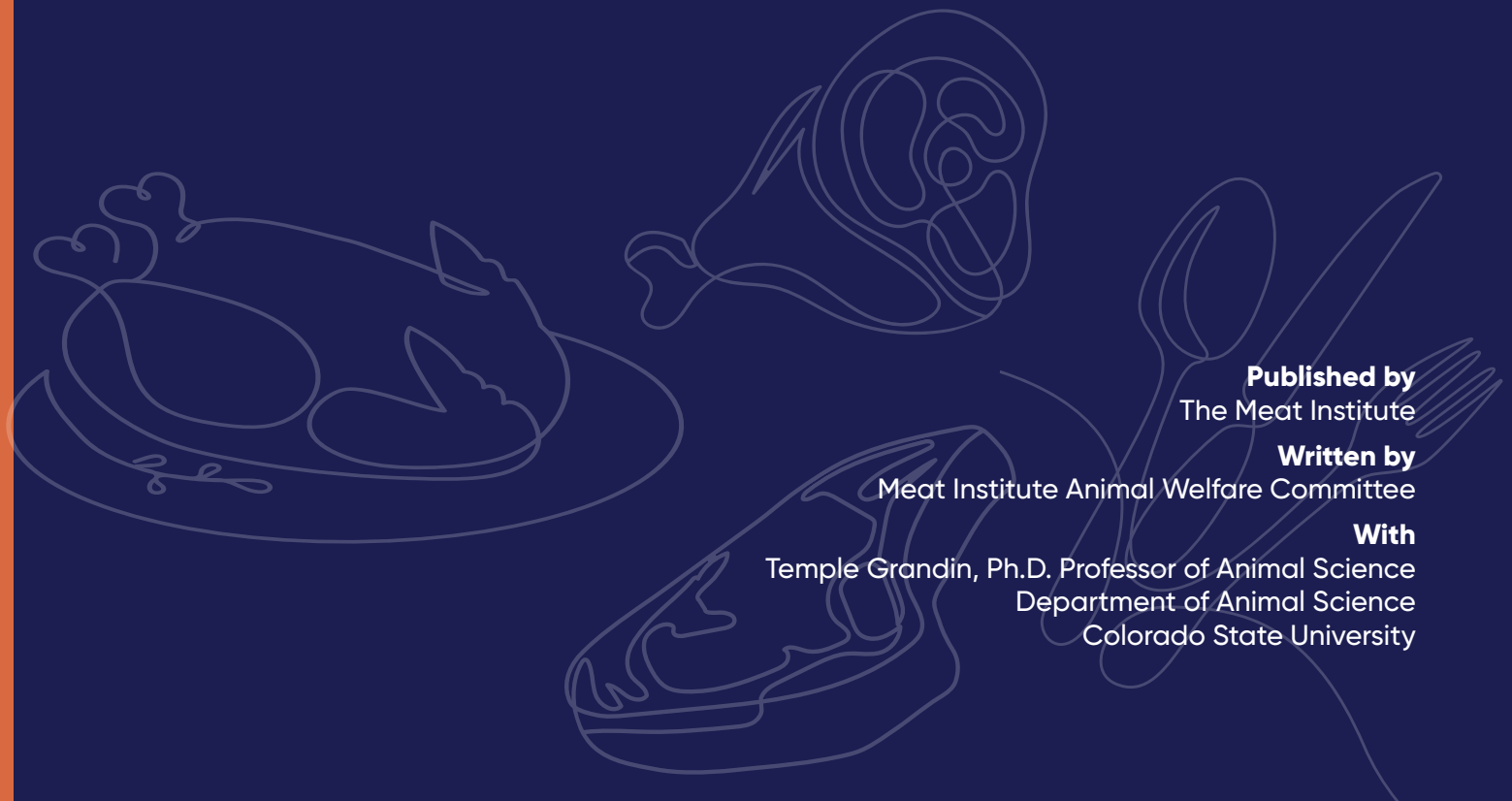
Meat Institute

Nourishing Today
Sustaining Tomorrow

Meat Industry Recommended Animal Handling Guidelines

A Systematic Approach to Animal Welfare at Transport and Slaughter



Published by
The Meat Institute

Written by
Meat Institute Animal Welfare Committee

With
Temple Grandin, Ph.D. Professor of Animal Science
Department of Animal Science
Colorado State University

TABLE OF CONTENTS

EXECUTIVE SUMMARY AND HISTORICAL PERSPECTIVE

The Humane Methods of Slaughter Act of 1958 was the first federal law governing the handling of livestock in meat plants. The 1958 law applied only to livestock slaughtered for sale to the government. In 1978, the Humane Methods of Slaughter Act was reauthorized to cover all livestock slaughtered in federally inspected meat plants. As a result of the Act, federal inspectors are in meat packing plants continuously, monitoring compliance with humane slaughter regulations. Additional information is found in the Code of Federal Regulations and in specific USDA directives and notices.

The Meat Institute has a demonstrated commitment to voluntary animal handling programs that go above and beyond regulatory requirements. In 1991, the Meat Institute published *Recommended Animal Handling Guidelines for Meat Packers*, the first voluntary animal welfare guidelines for meat packing operations. Authored by Temple Grandin, Ph.D., of Colorado State University, the illustrated guidelines offered detailed information about optimal handling of animals, how to troubleshoot animal handling problems in packing plants, how to stun animals effectively, how to maintain equipment thoroughly, and how to move non-ambulatory animals while minimizing stress. The guidelines were implemented widely by members of the meat packing industry.

In 1997, at the request of the American Meat Institute[1], Dr. Grandin developed a new document called *Good Management Practices (GMPs) for Animal Handling and Stunning*. The document detailed measurable, objective criteria that could be used to evaluate the well-being of livestock in meat packing plants. Self-audits using the criteria were recommended in an effort to identify and address any problems and sustain continuous improvement. When the GMPs were developed and implemented, they were envisioned as a voluntary tool for use by meat companies. In the years that followed, major restaurant chains began developing animal welfare committees and conducting audits of their meat suppliers using the Meat Institute's audit tool. Beginning in 1999, compliance with the GMPs became part of many customer purchasing specifications.

In 2004, the Meat Institute's Animal Welfare Committee determined that the two animal welfare documents should be merged into a single, updated document that included official audits for swine, cattle and sheep slaughter. The merged document was released in 2005 and has been updated every other year since that time. In 2024, an official audit for bison was added. In 2026, the Animal Welfare Committee voted to separate the audit portion of the document from the guidelines.

The objective criteria in this document were developed based on survey data collected over time in plants throughout the United States (Grandin, 1997, 1998a, 2000, 2001b). The Meat Institute Animal Welfare Committee, together with Dr. Temple Grandin, have determined what "targets" are reasonably achievable when plants employ good animal handling and stunning practices.

[1]The North American Meat Institute was formed in 2015 from the merger of the American Meat Institute and the North American Meat Association. In 2023, the board voted to change the name of the North American Meat Institute to the Meat Institute.

INTRODUCTION

Ethical, Regulatory and Economic Considerations

Note about Bison: These guidelines are designed for livestock, specifically cattle, swine, sheep, and bison, though the concepts may be applicable to other species and additional species may be mentioned where applicable. The term domestic livestock only refers to cattle, swine, and sheep, not bison. Recommendations that are bison specific are marked with their respective symbol: 

Optimal domestic livestock and bison handling is extremely important to meat packers for ethical reasons. Once domestic livestock – arrive at packing plants, proper handling procedures are not only important for animal well-being, but they can also be the difference between safe and unsafe workplaces. Research clearly demonstrates that many meat quality benefits can be gained through careful, quiet animal handling. (Hambrecht *et al.*, 2005ab, Warner *et al.*, 2009)

In addition, government bodies around the world dictate strict humane handling and slaughtering standards for packing plants. This document provides practical information that can be used to develop animal handling programs and to train employees in the principles of good animal handling practices.

Management Commitment

A key factor in establishing and maintaining optimal animal welfare in plants is a clearly communicated management commitment to animal handling. All levels of management must play an active role. This commitment can include:

- An animal welfare mission statement that is widely circulated and/or posted visibly in various places in a plant.
- A program of ongoing monitoring and measurement of animal handling and stunning practices and outcomes.
- Regular internal training and opportunities to attend outside training programs.
- Recognition and/or rewards for jobs well done.

This guide provides employees and managers with information that will help them improve both handling and stunning. Proper animal handling is not only an important ethical goal, it helps ensure the industry operates safely, efficiently, and profitably.

Managers must be committed to animal welfare. Plants that have managers who insist on good handling and stunning practices tend to have better results. Positive and negative feedback is also very important.

Maintaining good transportation, handling, and stunning practices requires continuous measurement, monitoring, and management.

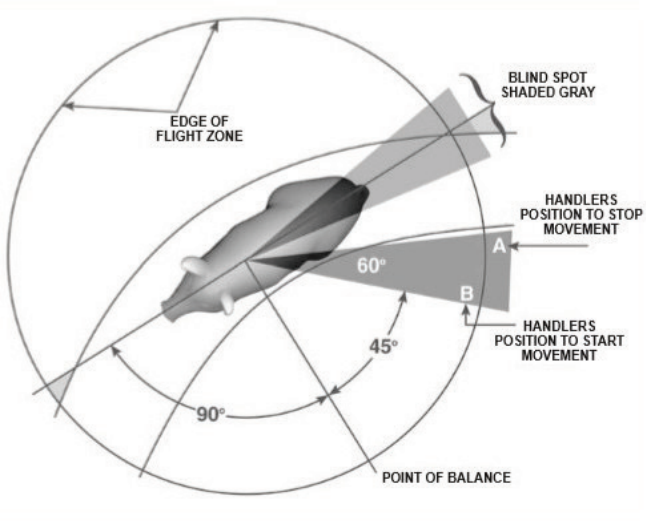
Note about Country-Specific Regulations: This document may be used globally. However, it is essential to be aware of country-specific regulatory requirements. Some country-specific regulations are noted throughout this document, and are marked with their respective country symbols ( for United States regulations, and  for Canadian regulations).

Section 1: Recommended Domestic Livestock Handling Principles

The principles of good livestock handling are similar for different species. All livestock are herd animals and are most easily handled in groups by calm handlers who work with livestock's natural instincts and behaviors.

Understanding Flight Zone and Point of Balance

Handlers who understand the concepts of flight zone and point of balance can move animals easily. The "flight zone" is the animal's personal space and the size of the flight zone is determined by the disposition of the animal, or how accustomed the animal is to people and handling. Quiet, tame animals have no flight zone and people can touch them. Less tame animals will begin to move away when the handler penetrates the edge of the flight zone.



(Photo courtesy of the National Pork Board's TQA Handbook, 2004)

Flight Zone Diagram—This diagram shows the correct positions for the handler to move livestock. To make an animal go forward, the handler should work on the edge of the flight zone in positions A and B. The handler should stand behind the point of balance to make an animal go forward and in front of the point of balance at the shoulder to make an animal stop or back up. The handler should avoid the blind spot behind the animal's rear.

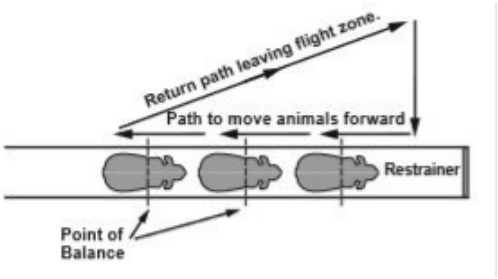
A handler will know if they are outside the flight zone if animals face them without backing up or moving. To keep livestock calm and move them easily, the handler should work on the edge of the flight zone. Penetrate the flight zone to prompt movement and back out of the flight zone to stop movement. The best positions are shown on the Flight Zone Diagram (right). The handler should avoid the blind spot behind the animal.

Animals become agitated when a person is inside their flight zone and they are unable to move away, as might happen in a small pen, so for safety, deep penetration of the flight zone should be avoided. If livestock turn back and run past the handler while they are being driven, the handler should back out of the flight zone and increase the distance between them.

If a group of livestock balks at an object, a smell, or a shadow ahead, be patient and wait for the lead animal to cross the affected area. The other animals will follow. If cattle rear up

in a single file alleyway, back away from them and don't touch them. They are rearing in an attempt to increase the distance between themselves and the handler and will usually settle down if left alone.

The "point of balance" is at the animal's shoulder. The handler's position in relationship to the point of balance can cause livestock to move forward or backward. All livestock species will move forward when the handler stands behind the point of balance and will back up if the handler stands in front of the point of balance (See Point of Balance Diagram, right).



Point of Balance Diagram—Cattle will move forward when the handler passes the point of balance at the shoulder of each animal. The handler walks in the opposite direction along side the single file race.

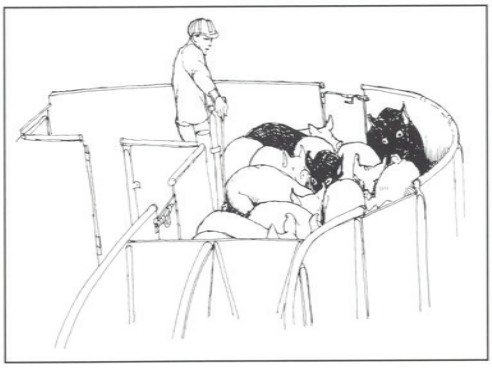
Many handlers mistakenly stand in front of the point of balance or place handling tools such as paddles or flags in front of the animal's point of balance while attempting to make an animal move forward in a chute or alley. This will result in the opposite of the desired effect (i.e., the animal will move backward).

Groups of cattle, sheep, or swine will often move forward without using an electric prod when the handler walks past the point of balance in the opposite direction. If animals are moving by themselves, leave them alone.

Moving Livestock

Livestock naturally follow the leader and handlers should leverage this behavior. Prompt one animal to move in the right direction and others likely will follow due to their instinct to move as a group.

Partially empty alleyways are valuable because they provide room to take advantage of the following behavior of livestock. Handlers are often reluctant to allow alleyways to become partially empty because they fear gaps will form in the line and slow the process, but once a handler learns to use this method, they will find it is more effective in handling animals calmly and efficiently.



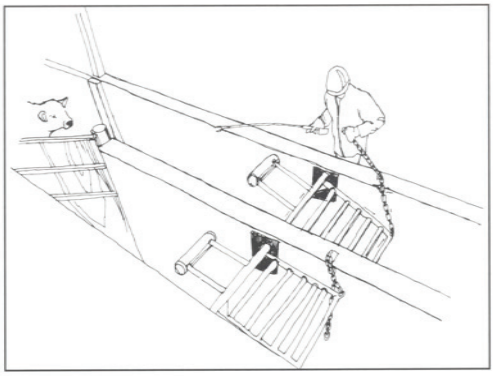
Swine crowd pen with an abrupt entrance to prevent jamming.

A common mistake is overloading the crowd pen that leads to the single file chute. The crowd pen and the staging alley between the crowd pen and the yards should never be more than approximately 50 - 75% full so that animals have room to turn around. Often when animals have space to turn around, they will voluntarily flow into the alleyway. Livestock will move more easily from the crowd pen into the single file alleyway when the alleyway is partially empty. This space allows animals to enter the alleyway immediately and reduces the frequency of animals turning around in the crowd pen.

Handlers must avoid pushing the crowd gate too tightly on the animals. An effective method is to leave the crowd gate open and allow the animals to flow voluntarily into the single file alleyway. The crowd pen should become the "passing through" pen. The crowd gate may be used to follow the animals but should never be used to push them forcibly. If the handler focuses on moving the leaders into the alleyway instead of pushing animals at the rear of the group, others will follow.

Cattle moving into a single file, following a leader.

One-way or sliding gates at the entrance to the single file alleyway should be open when livestock are brought into the crowd pen because they will balk at a closed gate. One-way flapper gates can be equipped with a rope to open them from the crowd pen. When the crowd pen is operated correctly, driving aids such as flags, paddles, and flexible shafts with streamers can be used and often can lead to reduced electric prod use. Animals can easily be turned by blocking the vision on one side of the head with these aids.



Holding a one-way gate open to facilitate cattle entry into the chute.

Many automated CO_2 units use powered (automatic) driving gates. Powered gates may be used to move animals by making contact with them but should never cause an animal to fall and they must never be used to skid or slide animals across the floor.

Calm animals are easier to move than excited animals and efforts to keep livestock calm enhance both welfare and efficiency. For example, some highly excitable animals are difficult to drive and once excited can require up to 30 minutes to calm down. These animals often vocalize, bunch, and pile up. As another example, swine hauled shorter distances (e.g. 45 minutes) may be more difficult to unload, because they have not had sufficient time to rest after being loaded on the farm.

Careful, quiet handling during the last few minutes before slaughter can help improve meat quality. Research shows that excessive use of electric prods in the stunning chute increases toughness in beef and lowers meat quality in pork (Van de Perre, 2010, Warner et al., 2009). For example, frequent electric prodding of swine before stunning was shown to have a negative effect on pH which influences meat quality.

Finally, it is important to note U.S. and Canadian federal rules prohibit driving ambulatory livestock over non-ambulatory livestock.

Preventing Injuries, Bruises, and Falls

Flooring

All areas where livestock walk should have a non-slip surface to prevent falls and crippling injuries. Animals can become agitated and excited when they lose their footing. It is particularly important in stunning boxes and restrainer entrances and can also be used on weigh scales.

An example of grooved concrete, non-slip flooring.

New concrete floors should have a diamond or square pattern with deep grooves. A rough broom finish is not sufficient because it will become worn smooth. It is also essential to use the right concrete or epoxy mix for maximum resistance to wear. For specific design considerations, see Appendix I at the end of this document.

Injury and Bruise Prevention

Livestock can be bruised moments before slaughter, and it is important to monitor edges and surfaces throughout the livestock holding and driving areas. The entrance to the restrainer/knock box should be inspected often for broken parts with sharp edges. Gates, fences, and chutes should have smooth surfaces. Sharp edges with a small diameter, such as angle iron, exposed pipe ends, and channels will cause bruises if livestock are pushed up against it.

This bruise point could cause damage to both hide and meat.

Round pipe posts or edges with a larger diameter are less likely to cause bruises than edges with a small diameter (picture of bruise point). Vertical slide gates (automatically or manually controlled) in chutes should be counter-weighted to prevent back bruises. The bottom of these gates should be padded, such as with cut tires or conveyor belting. The gate track should be recessed into the chute wall to eliminate a sharp edge.

Pressing up against a smooth flat surface such as a concrete alley wall will not cause bruises. However, a protruding bolt or piece of metal may cause injury, damage hides, and bruise the animal. Bruise points can be detected by tufts of hair or a shiny surface on a fence or gate. Fresh bruising should also be monitored on carcasses and if there is a commonly bruised area, the source of bruising should be investigated.

In pork plants, the bottom of a vertical slide gate can be cut off at an appropriate height for the type of swine being slaughtered and replaced with a curtain made from flexible material, such as conveyor belting. The swine will not attempt to go through the curtain. This change will prevent back injuries if the gate is closed on a swine.

Improving Animal Movement

Calm animals will move naturally through well-designed systems with a minimum of driving and prodding. To keep animals calm, take the following steps:

- **Handlers should be quiet and calm:** Each group of animals is different and should be handled according to their level of reaction. In most cases, yelling, banging on walls with paddles, and arm-waving may excite and agitate animals. The use of low stress handling techniques is always recommended.
- **Take advantage of lighting:** Animals tend to move from darker areas to more brightly lit areas and may refuse to enter a dark or shadowy place. Lights can be used to illuminate the chute up ahead and attract animals. Lights should never shine directly into the eyes of approaching animals.

  Illuminating the entire chute area with uniform lighting can eliminate patches of light and dark which may confuse or distract animals. Animals may be difficult to drive out of the crowd pen into the chute if the pen is brightly illuminated by sunlight and the chute is inside a darker building.

  It is important to maintain lights and their bulbs. In many instances, a handling system may work well when lights are new, but the animals will balk more and more as the lights dim with age. Experiment with portable lights to find the most efficient and consistent lighting.

An animal looks at a sun spot and stops.

Hose may cause balking.

Even yellow tape can frighten cattle because it is unfamiliar to them.

- **Eliminate visual distractions:** Handlers should get down to livestock eye level to observe from the animals' perspective. Livestock balk at flapping objects such as a coat hung over a fence, a hanging chain, shadows, puddles of water, light reflections, or any object that stands in their way. A drain or a metal plate running across an alley can cause animals to stop and when possible should be located outside the areas where animals walk. Install shields or use flexible material, such as strips of conveyor belting, to create curtains to prevent animals from seeing movement up ahead as they approach the restrainer or stunning box.
- **Redirect air flow:** Air hissing and ventilation drafts blowing in animals' faces can seriously impede movement. Ventilation systems may need to be adjusted to avoid such impediments.

- **Use solid sides in chutes and crowd pens leading up to chutes:** Solid sides in these areas help prevent animals from becoming agitated when they see activity or distractions outside the fence, such as people. Livestock tend to be calmer in a chute with solid sides. The crowd gate on the crowd pen should also be solid to prevent animals from attempting to turn back towards the area they just left.
- **Reduce noise:** Animals are very sensitive to noise. Reducing high-pitched motor and hydraulic system noise along with any other banging or reverberation can improve animal movement. Clanging and banging metal should be reduced and hissing air should be muffled.
- **Move animals in small groups:** When a group of animals is particularly difficult to move, reduce the group size (Lewis, 2007). Cattle, swine, and goats should be moved in small groups. However, sheep are different and may be handled in large groups in a continuous flow and the crowd pen can be filled all the way up. If a lone animal becomes nervous or agitated, place it with other animals where it is likely to become calmer.
- **Spray water from above or behind:** When wetting animals, water should be applied as a low-pressure mist.

Section 2: Recommended Bison Handling Principles

Minimal Handler Influence

Bison handling differs from domestic livestock species. Bison are still wild animals, undomesticated, and handlers should take this into account. Bison prefer to move through handling facilities at their own pace rather than being driven.

Understanding Fight, Flight, or Freeze

The flight zone for bison is much larger than cattle. A handler in sight of the bison is within its flight zone, which means that extra precautions should be taken by handlers. Bison commonly form a predator circle when they feel threated. If bison are becoming agitated by a handler, moving out of their flight zone may make them feel less threatened, depending on space allowance.

Bison usually are either standing still or running and abruptly transition between the two. Bison often freeze in response to handling and may refuse to move. Bison may also be aggressive and choose to fight over flight which increases the safety risk for handlers as well as other bison. Bison generally do not vocalize in response to handling but mature males may vocalize if a female is in estrus.

Moving Bison

Bison do not like to be confined or alone and prefer to move as a group. Moving two bison at a time rather than one prevents them from being alone and becoming agitated. If two bison are moved at the same time into the single file alleyway, they should be stunned in rapid succession to help prevent the second bison from becoming agitated. Bison can be systematically allowed to move through the handling facility at their own pace. By opening a gate and allowing them to move as a group into the next part of the facility, they will choose to move at their own pace which oftentimes is at a run. The natural instinct for bison is to run, which is not dependent on handling. Bison can pile up as a result of running in a group which also is not a result of handler behavior.

Dominant animals can be very dangerous, never enter the pen with an aggressive animal. Bison may give a warning pounce toward a handler or handling tool before charging. Experienced handlers who understand behavior can move bison from outside or inside the pen.

Preventing Injuries, Bruises, and Falls

Cull cows and mature bulls are the most likely to cause injuries to other bison in the form of aggression. Bison who have not been housed together previously should not be put into the same pen.

Since bison are prone to run, non-slip flooring is needed to prevent falls and injuries.

Closed gates may not serve as a deterrent to bison that causes them to balk, but rather they may run full speed into the gate and injure themselves. Keeping gates to the facility open for bison to exit the truck as a group and flow into a pen away from handlers will help prevent injury.

Improving Movement

- Minimal handler involvement
- Allow bison to move in groups
- Allow bison to decide where to go at their own pace
- If bison repeatedly freeze at the same location, investigate the cause

Section 3: Livestock Driving Tools

Electric Prods

Electric prods should not be used as a primary driving tool and should be used sparingly to move livestock during transport or in plants. A well-designed plant that has eliminated distractions and other handling impediments (detailed above) can greatly reduce electric prod use, though it is difficult to eliminate it entirely. Certainly, the need for electric prod use can vary depending on breeds of animals, production practices on the farm, class of animal (i.e., cull dairy cows versus fed steers), the group of animals, the day, and the handling system used.

 Electric prods can be effectively used on bison, if used sparingly. If necessary, prod use may be a better alternative than continuing to agitate the animal which may cause it to freeze.

Electric prods should only be picked up and used on a resistant animal and then put back down. Many well- managed plants have eliminated electric prods in the holding pens and the crowd pen that leads to the single file alleyway. Survey data collected during audits of 30 plants indicated that in 81% of the beef plants and 77% of the pork plants, 5% or less of the animals were moved with an electric prod (Grandin, 2012).

The voltage should be low enough that it does not consistently produce a "bark" or "squeal" in swine or a "moo" or a "bellow" in cattle, but still sufficient to persuade animals to move. Prods with sufficient power to knock an animal down or paralyze it must not be used. Electric prods also must never be applied to sensitive parts of the animal such as the eyes, ears, mouth, nose, vulva, testicles, udder, or anus. The prod must not be used on the animal's head. In addition, prods also must not be used on an animal that has been identified as stressed, non-ambulatory, or disabled.

When non-battery-operated prods are used, they must never be wired directly to house current; a transformer must be used. Refer to country-specific regulations regarding acceptable voltage parameters for electric prod use.

Electric prods are ineffective on sheep because the wool insulates the shock of a properly applied prod. This lack of response could lead handlers to prod animals in sensitive areas such as the anus or vulva, which is considered an egregious act of abuse. As a result, electric prods should be a tool of last resort when handling sheep, and used only when absolutely necessary (typically limited to large rams at the entrance to the restrainer), after all other driving tool options have been exhausted.

 Note: The Meat Institute recommends that electric prods be the driving tool of last resort while unloading animals after other options have been attempted. Some plants have opted to not allow the use of electric prods during the unloading process. In these instances, electric prods will only be used when difficult animals are encountered.

 Canadian federal regulations prohibit the use of electric prods on sheep.

Other Driving Tools

Alternatives to electric prods are possible in most instances. Effective driving tools can include plastic paddles, witches' capes, flexible shafts with nylon flags on the end, or large flags. Plastic streamers or garbage bags attached to a flexible shaft also can be used. Cattle can be easily turned and moved in the crowd pen by shaking streamers near their heads.

For moving swine, a large flag on a short handle or a rattle paddle will work well. Flags can be made from lightweight plastic tarp material and can vary in size from 20 inches x 20 inches to 30 inches x 30 inches (50 cm x 50 cm to 76 cm x 76 cm). Lightweight sorting boards can be used to move smaller livestock such as swine.

Shakers (which may be attached to a variety of handles), cans, or paddles that make a shaking sound can move sheep and swine effectively. The tools should be used to gently guide animals through sound and visual cues and should never be used to hit or strike an animal. To view a video by Dr. Temple Grandin about proper use of driving tools, go to https://www.grandin.com/videos/videos.html.

Moving cattle with flag.

Some plants may use "lead" animals like other sheep as an animal handling tool. These animals are trained to go on trailers and lead the other sheep off or to enter pens and lead sheep up alleyways.

Moving swine with paddle.

**Note:* Lead animals must be provided appropriate housing, daily feed, and access to water when not working.

Moving swine with sort board.

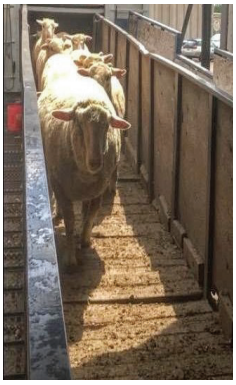
Vibrating or air prods are driving tools that can move cattle or swine without applying electrical current. Because they are often made by modifying tools like engravers, it is critical that any pointed end be worn down and smoothed before the tool is used to handle animals. Vibrating prods can be applied to the back, rump or shoulders of animals. If used improperly, vibrating air prods can be stressful or even abusive to animals and cause bruising. Like electric prods, vibrating or air prods should never be used to strike or forcefully jab an animal or be applied to sensitive parts of the animal such as the eyes, ears, mouth, nose, vulva, testicles, udder, or anus. The vibrating prod must not be used on the animal's head.

Vibrating prods should not be used for sheep. Wool cover makes them less effective. In addition, a sheep's skin is softer than cattle or swine, which may make them more prone to injury from careless use of the vibrating prod.

Equipment may be used to aid in moving bison such as a skid steer with a bale or gate on the front, particularly when it is unsafe for a human to enter the pen.

Less is more is often true in regards to driving tools and bison. Foregoing a tool can be highly effective, only utilizing a tool when necessary. Shaker paddles with the rattle removed can be effective to move bison. Extending tools by using PVC pipe can help the handler stay farther away from the animal and respect its large flight zone.

A skid steer with a gate welded on the front



Lead Sheep

Section 4: Willful Acts of Abuse/Egregious Acts

Some behaviors toward livestock are so severe that they are considered egregious acts of abuse no matter where or why they occur.

Egregious acts of abuse include, but are not limited to:

- **Dragging or hoisting** a conscious animal, non-ambulatory or otherwise
- **Making cuts or skinning** conscious animals
- **Intentionally prodding sensitive parts** of the animal such as the animal's mouth, eyes, ears, nose, anus, vulva, testicles, or belly
- **Deliberate slamming** of gates on animals

Note: Bison may run into a pen and immediately turn around, causing a human safety hazard where the handler needs to quickly close a gate. Quickly closing a gate to prevent a human safety hazard, so long as it is not deliberately slammed on the animal(s) is acceptable.

- **Intentional driving of ambulatory animals** on top of one another either manually or with direct contact with motorized equipment
- **Driving animals off high ledges**, platforms, or off a truck without a ramp
  - driving market weight or adult animals off a low stock trailer is acceptable
- **Beating or excessive prodding of animals**
- **Animals frozen** to the floor or sides of the trailer
- **Leaving disabled animals** exposed to adverse climate conditions while awaiting disposition
- **Lifting sheep by the wool or throwing a sheep**
- **Otherwise causing unnecessary pain and suffering** to animals, including situations on trucks

Note: These acts violate the zero-tolerance policy for willful acts of abuse/egregious acts that the plant should have in place.

Section 5: Developing an Emergency Livestock Management Plan

It is essential that plants have emergency livestock management plans in place. Potential vulnerabilities should be assessed based on geographic location, climate, and other issues that would require swift action to ensure good animal welfare.

Plants should plan for short term emergencies, both natural and man-made, which may include contingency plans for trucks to keep moving under certain conditions until animals can be unloaded in adequate facilities. If a plant possesses the facilities to provide access to fans/water/protection on the plant site, the contingency plan may state that transporters are to use those provisions to provide an optimal internal trailer temperature.

In the event of an extended plant breakdown, snow storm, motor vehicle accident, natural disaster, building damage, fire, tornado, or other long-term line stoppage, procedures should be in place to stop additional truckloads of animals from arriving at the plant.

Plans should be kept in an accessible location and should be reviewed at least annually. At a minimum, the emergency plan should include guidance for the following:

- How feed and water will be provided during an emergency, such as a plant shutdown where livestock may need to be held overnight.
- How electricity can be provided [back-up generators] should power be lost.
- How alternate housing will be provided to animals should the regular housing become uninhabitable.
- How animals will be evacuated in an emergency, if needed.
- For animals that cannot be returned to the farm of origin, there should be a designated place such as a livestock auction yard, stockyard, buying station, feedyard, or other location where animals can be unloaded and provided adequate facilities.

In the event of a disruption to normal operations inside the plant that stops the flow of livestock for a period of time, livestock may need to be kept in drive alleys or unloading docks, rather than returning animals to holding pens or back to the farm of origin. Establishments should include in their humane handling procedures a timeline for when animals waiting in drive alleys should be assessed and provided water.

Environmental factors such as ambient temperature, humidity, access to shade, and stocking density should be considered when determining when water will be provided to animals being held in a drive alley or conveyance area. If livestock show any signs of stress or discomfort at any time, water should be provided. Reasonable attempts to remove or properly stun all animals in the restrainer system should be taken in the event of a breakdown.

CHAPTER 2: TRANSPORTATION PRACTICES

Section 1: General Transportation Considerations

Managing the transportation of animals involves many variables. Management of these variables may include temperature control, careful driving practices, proper trailer design and maintenance, as well as the actual loading and unloading process. Proper management of these factors should result in enhanced animal welfare and improved meat quality.

Please refer to the applicable industry transportation program (i.e., BQAT, TQA, CLT) for species-specific standards and recommendations. The following items should be considered when transporting animals:

- **Training:** Thanks to meat animal industry leaders, strong science-based programs dedicated to educating producers, transporters, and packers about proper animal handling practices exist today. Many of these species-specific programs provide training and certification. Training provides the building blocks of good animal handling skills. Certification proves that a producer/transporter/packer is aware of and practices industry-approved animal handling techniques. It is the position of the Meat Institute that producers, transporters, and packers should consider participating in industry-approved, formal transportation training.
- **Truck driving practices:** Careful truck driving helps prevent bruises and injuries. Sudden stops and rapid acceleration increase injuries and stress, which can lead to decreased welfare and carcass value. Selecting routes that are the most direct and minimizing time on unpaved roads will also provide benefits.
- **Stoppages:** The number of ill, injured, and fatigued animals as well as dead on arrival (DOA) and euthanized on arrival (EOA) numbers increase dramatically when a vehicle is stopped. Drivers are encouraged to have a plan for animal care if stops will be made.
- **Design:** Livestock trailers should be designed in a manner that is conducive to the humane transport of the species being transported. All flooring should be non-slip. Trailers must have sufficient height between decks to allow animals to stand in their natural position without their head or back coming in contact with the roof. Internal ramps should sit flush, with panels/rails in place to prevent animals from falling off the side. Ramps should not be so steep they cause animals to slip and should be constructed of non-slip material. Gates and doors should open and close freely and must securely shut.
- **Maintenance and cleanliness:** Trailers should be kept clean and in good repair. Trailers should be regularly inspected and maintenance performed as needed. Excessive manure, urine, and wet bedding should be addressed between loads. The addition of materials such as sand or shavings can provide supplemental traction to floors. Drain plugs/traps should be securely in place after clean out and prior to loading.

- **Load density and compatibility:** Research shows that overloading livestock trucks can increase bruising and the number of fatigued, injured, non-ambulatory, or dead animals (Ritter et al., 2007). Trailers must be loaded at the proper industry recommended level. Trailers should not be overcrowded and gating utilized. For guidance on loading density, please reference industry transport guidelines for specific species. Drivers and loading crews must be aware of trailer square footage and average weight of animals to determine number of animals per compartment. Drivers must also be aware of conditions that require density adjustments such as extreme weather, animal class, and condition (i.e., cull animals), or physical attributes such as horns. Animals that are not compatible by nature (i.e., aggressive intact males or animals of very different sizes) must be segregated and all gates closed on loads that require segregation during transport.
- **Fitness for transport:** All animals presented for transport must be fit for transport. It is necessary to have a mechanism in place to notify suppliers when unfit animals arrive at the plant.
- **Receiving:** The plant is responsible for ensuring that the facility is prepared to receive animals. Ramps and docks should have non-slip flooring and lighting in the area sufficient for unloading. Acceptable handling equipment must be available for staff and drivers with training on proper use provided. Rushing livestock during unloading can be a major cause of bruises, particularly loin bruises. Management should closely supervise truck unloading. Extreme weather management tools must be provided and loads must be scheduled to prevent truck line ups and allow for timely unloading of trailers. Policies and resources for properly handling non-ambulatory animals must be provided, including well-maintained euthanasia equipment and trained personnel.

Section 2: Temperature Management During Transport

Temperature extremes can be harmful to animals, but careful planning and temperature mitigation strategies can protect them.

Bison are more cold-tolerant than other livestock, special considerations for other species should not necessarily be applied to bison.

Cold Weather Management

Special Considerations for Swine: Freezing temperatures and wind chills can be dangerous, particularly for swine. The combination of cold ambient temperatures and wind speed can create significant wind chill. Wind protection and bedding should be provided according to the species-specific industry standard used by the facility. Older cull swine are particularly vulnerable. Trailers should be loaded lighter in extreme cold because extra room is required to ensure no animal is forced up against the sides of the trailer.

Special Considerations for Cattle, Veal, and Sheep: While cattle and sheep are less sensitive to cold weather than swine, it is still important to manage temperatures to protect animals. Keeping animals dry is essential for protecting them from cold stress. In cold weather transport, consider proper boarding and bedding for sheep, veal calves, cull dairy cows and sometimes cull beef cows, as these animals are all likely to lie down during transport. Veal calves are particularly temperature-sensitive and require special care during transport. They must be handled with extreme consideration and checked often during cold weather transport.

Note: Trucks should follow plant and industry bedding requirements or industry best practices.

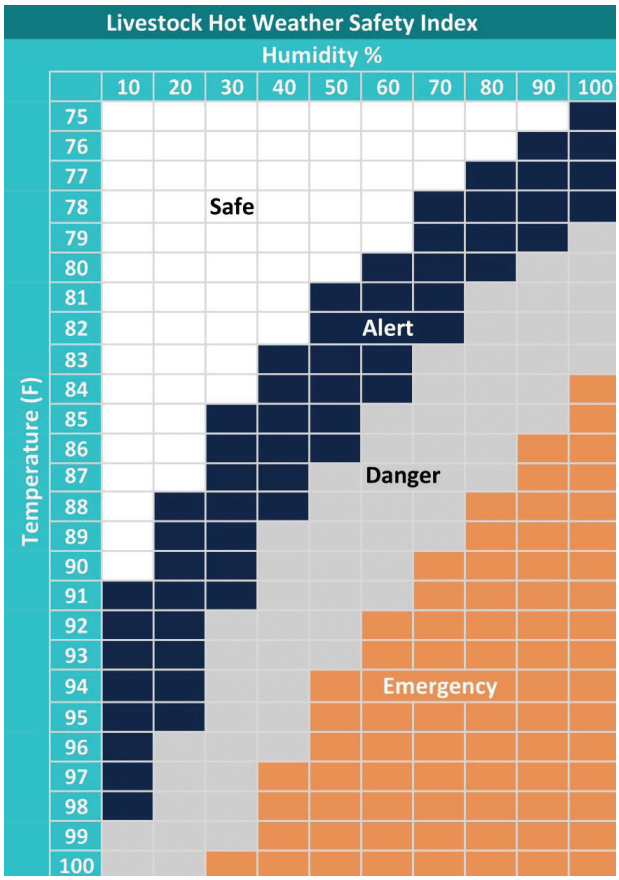
Hot Weather Management

Special Considerations for Swine: Ensuring that swine are hydrated prior to transport is extremely important. Hydration can also help prevent heat stress. Hot weather and humidity are deadly to swine because they do not have functioning sweat glands, so special precautionary measures must be taken in hot weather conditions. Problems with heat stress may start to occur at 60˚F (16˚C; National Pork Board TQA Handbook, 2020). At 90˚F (32˚C) death losses almost double compared to 60˚F (16˚C; Sutherland et al., 2009).

Additionally, rapid temperature fluctuations and periods of extremely hot weather can greatly increase the incidence of meat quality and animal welfare issues. In these circumstances, plants should take extra care in handling animals.

Special Considerations for Sheep and Cattle: While sheep and cattle are less vulnerable to heat stress than swine, it is important to develop heat mitigation plans for sheep and cattle when extreme heat occurs.

Considerations for All Species: Drivers are encouraged to minimize stoppages in hot weather. Truck moving promotes air flow and reduces heat stress. Use the following procedures to keep animals cool and eliminate unnecessary transport losses during extreme weather conditions. Refer to country industry-specific recommendations for other heat mitigation strategies.



Heat Stress Chart—The chart provides a guide for plant managers and truckers to help reduce heat stress of livestock. Hazard to the animal increases when both temperature and humidity increase. When conditions are in the "alert zone", truckers need to be careful to keep livestock cool. When conditions get into the danger and emergency zone, try to shift loading schedules to avoid the hottest part of the day. Problems with heat stress in swine may start as low as 60°F (16°C.) Source: *National Pork Board Transport Quality Assurance Handbook Version 8.*

Pre-Transport and Loading:

- The combination of high heat and humidity is especially dangerous if animals must be transported in the 'danger zone' of the emergency index (see figure to the right). When possible, schedule transportation and receiving early in the morning or at night.
- Open nose vents.
- Unplug ventilation holes/slots.
- Do not bed swine with unprocessed, long-stem straw in hot weather because it can increase temperature on the trailer. Processed, chopped straw is acceptable to use in hot weather.
- When necessary, reduce loading densities using good judgement and guidance from industry transportation programs.
- Load promptly to avoid heat buildup.
- Wetting and misting of hogs and sheep is a recognized heat mitigation strategy.

During Transport:

- Be prepared to adjust to rapid temperature fluctuations which are especially prevalent in spring and fall.
- Do not stop for extended periods of time. When stopping to check animals, be sure it is for a short period of time to prevent overheating and to keep air moving.

Arrival at Plant:

- Barns/lairage at packing plants should have sufficient capacity and an arrival schedule to promptly unload animals from trucks and provided cover, when appropriate.
- Trailers will have better air flow if trucks do not park side by side.
- Heat mitigation strategies may need to be initiated at the plant, including wetting, misting, and fans. Continuous movement of trailers is also an effective heat mitigation strategy.

Section 3: Timeliness of Arrival and Wait Time to Unload

The time that animals spend on trucks directly correlates to animal welfare and ultimately, to final meat quality (Sutherland *et al.*, 2009; Ritter *et al.*, 2006). Longer periods of time on a truck without water and extended exposure to extreme weather can cause increased fatigue, EOA, DOA, lameness, injury, and weather-related stress. Moreover, pale, soft, and exudative meat (PSE in swine), dark cutters (in beef), and carcass bruising will increase the longer animals are on a stationary trailer. During hot weather the time that animals spend on the trailer is detrimental to animal welfare.

In order to reduce unnecessary time spent on a trailer, producers, buyers, transporters, and plant staff need to work together to create a streamlined process for trucks to arrive and unload in a timely manner. If the stakeholders involved in the transportation of animals do not uphold their responsibilities or communicate efficiently, the results are long truck lines at plants, decreased animal welfare, poor meat quality, tired transporters, and trucks that may be late for their next load.

Delivering and receiving animals at a plant is a multifactorial process to protect animal welfare, to ensure product quality, and maintain efficiency. It is recommended that large plants (more animals = more trucks delivering) give each truck a scheduled time to unload. Scheduling trucks ensures plant staff is available to receive animals, provides a steady flow of trucks to the plant, prevents truck lines, and reduces the time animals spend on the trailer. Plants may give an exact time (i.e., 2 p.m.) or a window of time (i.e., 2-3 p.m. or 2-6 p.m.) for an appointment, depending on slaughter scheduled and lairage space. Appointment times should be clearly communicated and transporters should adhere to the schedule. Arriving early or late can cause a truck line and delay unloading. Trailers should not be parked at off-site locations not intended to hold livestock.

Producers, buyers, and transporters need to work together to plan a reasonable loading time at the site of origin. The amount of time it takes to load animals depends upon site design, animal temperament, drive time to the plant, weather, traffic, road conditions, *etc.* These factors need to be considered when determining a loading time. Transporters should always leave immediately after loading in order to provide air movement during hot weather, allow animals to spend less time on the trailer, and stagger loads arriving at the plant.

Even with a precise scheduling program, timeliness of truck arrivals and unloading can still be affected by outside factors that can include weather, miscommunication of scheduled appointment time at the site of origin and/or plant, plant disruption resulting in lairage being filled to capacity, trucks arriving before/after receiving hours with no staff available, etc. If a transporter is delayed and will be arriving outside of their scheduled appointment time, they should communicate an estimated time of arrival to the plant. If the plant is experiencing a situation that does not allow for timely unloading of animals, the plant must initiate its Emergency Livestock Management Plan (see Chapter 1, Section 5).

Delayed unloading can cause death losses and non-ambulatory animals due to extreme temperatures, exposure, and stress. For this reason, animals should be unloaded as soon as possible during periods of extreme temperatures to prevent exposure, stress, and possibly increased mortality.

 Bison unloading should commence in a timely manner from when the truck arrives. However, the length of time to unload the truck is much more variable with bison than other species. It may take hours for bison to unload and decide to come off the truck. Often, the longer bison travel, the longer it will take them to leave the trailer.

Section 4: Non-Ambulatory Animals on Trucks

A non-ambulatory animal is an animal that cannot or will not rise from a recumbent position or that cannot walk. This includes, but is not limited to, acutely split animals and animals that require hobbles to assist in the healing of injuries or to prevent further injury.

When a non-ambulatory animal is found on a trailer, the ambulatory animals within the compartment should be removed first, taking care not to compromise the non-ambulatory animal or drive the ambulatory animals over it. Once all ambulatory animals are removed from the compartment, the non-ambulatory animal should be humanely moved (where allowed) or euthanized. If a non-ambulatory animal impedes unloading, it should be euthanized or humanely moved (where allowed) before continuing with the unloading process. Ambulatory animals must not be driven over non-ambulatory animals because it causes unnecessary pain and suffering to animals which is as an egregious act.

To off-load a non-ambulatory animal from a truck, employees must utilize a process that causes as little stress as possible. Examples of devices used for removing non-ambulatory animals from trailers include sleds, slide boards/belting, or carts. Consideration needs to be given to where in the trailer the animal is located; because it can be very difficult to humanely and safely remove an animal from certain areas, such as the nose or doghouse. Live animals must never be dropped down from any part of the trailer.

Canadian federal rules prohibit the movement of non-ambulatory animals. The animal must be euthanized where it is.

Section 5: Euthanizing Animals on Trucks or In the Yards

When an animal has to be euthanized, extra care must be taken to ensure that it does not recover sensibility. Species specific diagrams in Section 3, Chapter 3, can be referenced for proper stun placement. In addition to the primary application of the euthanasia device (most commonly a captive bolt gun for domestic species) a second step should be used to ensure death. Examples of a secondary step include:

- Administering a second knock with either captive bolt or firearm.
- Pithing by inserting a thin metal or plastic rod into the hole made by the captive bolt to further damage the brain. Pithing must never be used on ruminant animals (cattle or sheep) that will be used for food.
- Exsanguination (bleeding the animal after it has been euthanized with a captive bolt gun).

Canadian federal rules prohibit the use of pithed swine from use for human consumption.

All signs of return to sensibility that are specified in Chapter 3, Section 3 must be absent. Handlers should stay with the animal until death is confirmed and the animal should be rechecked before movement or disposal to ensure euthanasia was effective. If the animal is showing any signs of sensibility, or returning to sensibility at any point, they should be immediately shot again.

Bison may be euthanized on the trailer or in lairage that are considered overly aggressive and "on the fight" and refuse to move. This can be a more humane option than trying to move an aggressive and fearful animal through the handling system and is unique to bison. Bison still on the trailer may be euthanized with a firearm from outside of the trailer.

Additional information on cattle and bison euthanasia can be found in the American Association of Bovine Practitioners Guidelines for the Humane Euthanasia of Cattle: https://www.aabp.org/Resources/ AABP_Guidelines/EUTHANASIA-2023.pdf.

CHAPTER 3: HUMANE HANDLING AND STUNNING AT THE PLANT

Section 1: Lairage

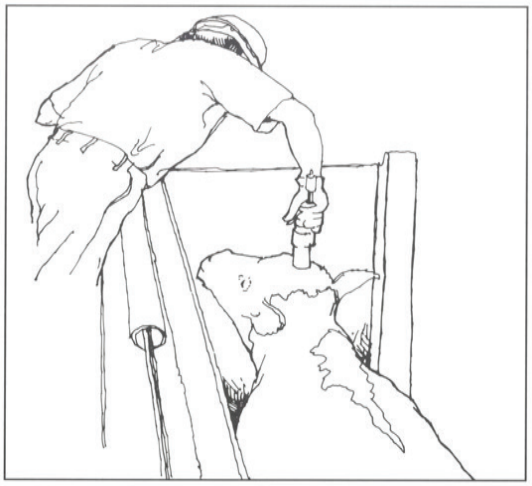
After arrival at the plant livestock should be rested prior to stunning to improve meat quality, following species-specific company or industry standard practices (Warriss, 1998, Ferguson, 2001). When possible, animals should be kept in their original transport groups to prevent aggressive behavior due to new social environments.

For a detailed description of recommended pen space allocations and optimal facility layout, see Appendix I.

Pen space allocations may vary depending upon weather conditions, animal sizes and holding times, such as overnight or a few hours during the day. All species should be able to lie down if held overnight.

Section 2: Proper Design and Use of Restraints

A variety of equipment is used to prepare animals for stunning and slaughter, and the design and maintenance of them may impact both handling and stunning efficacy. Common examples are center track and V restrainers, but some plants stun animals in pens or boxes. Livestock should enter a restraint device easily with minimal balking. If the sides of the v restrainer do not run at the same speed, it can stretch the skin and damage blood vessels. Correcting problems with animal restraint devices can also help reduce bruises and meat quality defects such as blood splash.



Well-designed stunning box.

Restraint Design

Animals should enter the restrainer without balking. Cattle, swine, and sheep may balk at the restrainer entrance if they can see people or moving conveyors through the end of the restrainer. Eliminate air hissing and other distractions such as clanging and banging (see Chapter 1, Section 1).

As in other areas, mufflers can be used on air valve exhausts or they can be located outside. Rubber stops on gates can be used to stop clanging, and braking devices on the shackle return can improve safety and reduce noise. In addition, consider replacing small diameter with large diameter plumbing, which makes less noise, and replace pumps with quieter ones. Rubber hose connections between the power unit and metal plumbing will help prevent power unit noise from being transmitted throughout the facility. Any new equipment installed in animal holding or stunning areas should be engineered for quietness.

The restraint device must be properly lit. Animals will not enter a dark place or a place where light blinds them. To reduce balking at the entrance of a conveyor restrainer, install a light above the entrance over the single-file alleyway. It should illuminate the entrance of the restrainer, but must not shine into the eyes of approaching animals. Lighting over the top of the conveyor in the restrainer room will help induce cattle to raise their heads for the stunner. Light coming up from under a conveyor restrainer should be blocked with a false floor to prevent animals from balking at the "visual cliff effect."

Restrainer systems should be equipped with a long, solid hold-down rack to prevent rearing. For cattle, the hold-down should be long enough so that the animal is fully settled down onto the conveyor before it emerges from under it. This hold-down is only intended as a visual barrier, and should not press on the animal's back. Extending the solid hold-down cover on a conveyor restrainer will usually have a calming effect and most animals will ride quietly. Solid hold-downs can also be beneficial for swine on conveyor restrainers. Sheep have an intense, natural behavior to follow the sheep in front of them, so a solid hold down may not be needed.

Both sides of V conveyor restrainers should move at the same speed. To test this, mark each side with tape or a crayon. After three revolutions, the marks should be no more than four inches apart, or the width of one slat.

Provide non-slip flooring in box-type restrainers and a non-slip, cleated entrance ramp on conveyor restrainers. A restraint device must either fully support an animal or have non-slip footing so the animal can stand without slipping. Animals tend to panic when they lose their footing and feel like they may fall.

Restraint devices that use a floor that suddenly drops, as opposed to a pneumatically controlled false floor, are not acceptable.

The restraint device must apply sufficient pressure to provide the feeling of being held but avoid excessive pressure that causes pain. Very little pressure is required to hold an animal if it is fully supported by the device. If an animal bellows or squeals in direct response to the application of pressure, the pressure should be assessed, and if needed, reduced. Different size animals may require different levels of pressure.

Pneumatic or hydraulic systems should have pressure regulators to reduce the maximum pressure applied and controls to stop the cylinder mid-stroke when needed.

Restraint devices should hold animals in a comfortable, upright position. Any parts of a restrainer that contact the animal should have smooth, rounded surfaces and be designed so that uncomfortable pressure points are avoided. Parts of restrainers operated by pneumatic or hydraulic cylinders that press against the animal's body should move with a slow steady motion. Sudden, jerky motion excites animals. Utilize flow control valves for smooth steady movement of parts that press against the animal.

Head holding devices may also be utilized for restraint and are designed to avoid excessive bending of the neck.

Head Holding Device

It is possible to modify existing restraint devices to lower vocalization scores and agitation. Isolated animals will often vocalize. Vocalizations during restraint may indicate:

i. contact with a sharp edge(s)

ii. pressure from the hold-down rack

iii. sides of a v-restrainer moving at different speeds

iv. hitting or poking livestock

v. excessive pressure applied by moving mechanized parts of an animal restraint device such as a head-holder, rump-pusher gate, or body restraint equipment Many effective modifications require minimal expense, such as non-slip floor grating, lighting, and shields to block vision which may reduce balking and vocalization. For information on restraint used in religious slaughter see Chapter 3, Section 5.

Restraint Operation

Head restraint is much more agitating for livestock than body restraint. Never hold an animal in a head restraint device for more than a few seconds; the animal should be stunned or ritually slaughtered as soon as possible to achieve an effective stun after the head holder is applied. The animal's reaction to head restraint should be observed. If the animal struggles or vocalizes, it is an indication that the device is causing discomfort. The operator should reduce sudden and jerky motion of moving parts on the restrainer to keep animals calm. Many cattle will stand still if the device is slowly closed up around them and less pressure will be required to hold them.

Vertical slide gates constructed from flexible curtain made from conveyor belting will not injure the swine if it is accidentally closed on them. Note how the framework that slides in the track is bolted above the curtain.

Animals can be held in a comfortable body restraint for longer periods. Small animals such as sheep may be held manually by a person.

Note: Electrical immobilization must not be confused with electric stunning. Electrical immobilization devices that restrain an animal by paralyzing muscles, but do not cause insensibility, are unacceptable.

Handling principles at restraint include:

- If an animal is walking into the restrainer by itself, do not touch it.
- Gentle handling prevents damage to small blood vessels caused by excited animals jamming against each other or equipment.
- Electric prod usage should be kept at a minimum.
- Animals should never be left in the restrainer system during breaks or lunch.

Section 3: Recommended Stunning Practices

Good stunning practices promote animal welfare and meat quality. When stunning is done correctly, animals feel no pain and become instantly unconscious. Stunning animals correctly also prevents stress, which enhances meat quality. See the table below for species-specific stunning methods that are commonly used. Additional information and other stunning recommendations can be viewed in the Meat Institute Stunning Guide.

Stunning Method:	Species Commonly Used In:
Captive Bolt	Cattle, sheep, and others
Electrical	Swine, sheep, and others
Controlled Atmosphere CO_2	Swine and others
Firearm*	Cattle, bison, swine, sheep, and others

*Note: Firearm safety recommendations can be viewed in Appendix III.

Refer to the American Veterinary Medical Association's (AVMA) Guidelines for the Euthanasia of Animals and Guidelines for the Humane Slaughter of Animals for information on the use of firearms to stun livestock.

To accurately assess effective stunning in small plants, data can be collected over a period of time and averaged.

Captive Bolt Stunning

The penetrating captive bolt stunner consists of a steel bolt housed in a barrel with a flange and piston at one end. When fired, the expansion of gases propels the piston forward and forces the bolt out of the muzzle of the barrel. The bolt is retained within the barrel by a series of cushions that absorb the excess energy of the bolt. The bolt is then retracted back into the gun either automatically or manually, depending upon the design of the gun. These guns are powered by either gunpowder in a cartridge or compressed air. Both penetrating and non-penetrating captive bolts (also called "mushroom head stunners") may be effective depending on the species and age of animal, if used and maintained correctly. Non-penetrating stunners cause less damage to the brain (Finnie *et al.*, 2000) and are considered reversible. Non-penetrating captive bolts may be less effective on large, fed cattle and bulls (Oliviera, *et al.*, 2018; Gibson *et al.*, 2019).

The two main factors contributing to the effectiveness of the captive bolt gun are 1) bolt velocity and 2) accurate placement and angle. To be effective, the bolt must have sufficient velocity for the weight class and animal type. Bolt velocity is dependent on grain strength of the cartridge (or air pressure), maintenance, repair, and storage. The cartridge strength must be appropriate to animal class and species. In addition, the gun must be accurately placed on the animal's head perpendicular to and flush with the skull.

To produce instantaneous unconsciousness, the bolt of a penetrating bolt gun must penetrate the brain with a high concussive impact. If a non-penetrating stunner is used, as they sometimes are with cattle and veal in religious slaughter, accurate aim is critical to

achieve instantaneous insensibility. A head-holding device may be needed to position the head for non-penetrating captive bolt.

Pneumatic stunners must have an adequate air supply. Low air pressure is one cause of poor stunning. The compressor pressure gauge should be checked to make sure that the stunner is receiving the manufacturer's recommended air pressure so that bolt velocity is appropriate for the species, sex, skull mass, and weight class of the animal being stunned. All equipment manufacturers recommendations and instructions must be followed.

The correct positions for stunner placement are shown in the diagrams on the next page. A good stunner operator learns to be patient and avoid chasing the animal's head, taking the time to aim and get one good, effective shot squarely on the animal's head. A good stunner also recognizes when they haven't achieved a good stun and immediately takes a second shot. A second application of the stunner is acceptable as a safety or security measure after the initial stun achieved insensibility.

 For bison, only a penetrating stunner has been shown to be effective. The frontal placement position should be approximately 1 inch (2.5 cm) above an imaginary line connecting the center of the horns. An additional firearm placement position for bison is the poll shot. The firearm can be placed behind the poll, aiming toward the angle of the jaw. This is a common entry point for animals with thick skull mass, horns, or when the frontal shot is difficult to make.

If one-shot efficacy falls below 96%, immediate action must be taken.

Captive Bolt Stunner Maintenance and Design

Poor stunner maintenance and/or improper cartridge caliber and loading can result in failed effectiveness of the captive bolt gun. Stunners must be cleaned and serviced per the manufacturer's recommendations to maximize velocity and to prevent misfiring or partial firing. If a "test stand" to measure bolt velocity is available, daily use is strongly recommended. If a test stand is not available, then the plant should work with their equipment supplier to determine an acceptable alternative.

 Canadian federal rules require a test stand as part of a Preventative Control Plan.

A verified maintenance program where a trained employee signs off each day that they have cleaned and tested the stunners is recommended. Captive bolt stunners must be taken apart and cleaned every day they are fired. If parts show signs of wear, they should be replaced. A stunner should be cleaned according to manufacturer recommendations every week, even if it is not fired.

Stunner cartridges must be kept dry and the correct cartridge strength must be used. A day's supply of cartridges may be stored in the stunning area in a water tight container. It is recommended that all leftover cartridges that have been exposed to moist environments be properly discarded daily. For long-term storage beyond a day's supply, store cartridges in an airtight container in a room with low humidity, such as an office. Damp cartridges will cause poor stunning and should be properly discarded.

A major impediment to good stunning is poor ergonomic design of bulky pneumatic stunners. Ergonomics for stunning in a conveyor or restrainer can be improved with a handle extension on the stunner and by hanging the pneumatic stunner on an angle.

Fatigued operators can also contribute to ineffective stunning. Scoring at the end of the shift will pinpoint this problem. In some large plants, two stunner operators may be necessary. Rotating the stunner operator to other jobs throughout the day may help prevent errors caused by fatigue. To reduce fatigue, the balancer device that reduces the heavy pneumatic stunner weight must be well-maintained so that it works freely and easily.

Diagram 1

Diagram 2

Beef Cattle Stunner Placement—For cattle, the stunner is placed on the middle of the forehead on an "X" formed between the eyes and the base of the horns. Stunning an inch above (2.5 cm) the intersection of the X is also very effective. The animal can also be shot with a firearm behind the poll (Diagram 2). This is a common point of entry for animals with thick skull mass, horns, or when the frontal shot is difficult to make. The poll shot is for firearms only.

Diagram 3

Diagram 4

Dairy Cattle Stunner Placement—For long-faced dairy cattle, such as Holsteins, the point of entry for firearms and penetrating captive bolt guns is approximately 2 inches (5cm) above the intersection of the "X" formed between the eyes and the base of the horns (Diagram 3). Holstein can also be shot with a firearm behind the poll (Diagram 4).

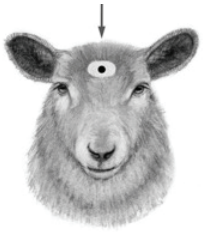


Diagram 5

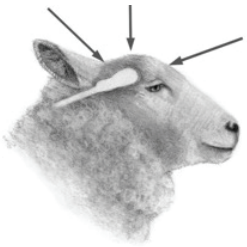


Diagram 6

Sheep Stunner Placement—For the application of the captive bolt gun, the ideal points of entry are the frontal position or the highest point/top of the head (Diagram 6). There is great variation in the skull shape of the different sheep breeds. There are three acceptable points of entry for firearms on sheep: the front of the head just above the eyes, the top of the head, and the back of the poll. The ideal position is the top of the head with the bullet traveling down towards the throat. When shooting on the frontal part of the head, the bullet must enter right above the eyes (Diagram 5). When an animal has horn mass, the most effective shot is behind the poll, pointing towards the mouth of the sheep.

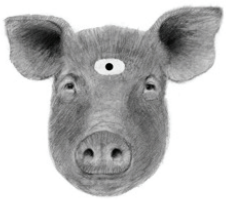


Diagram 7

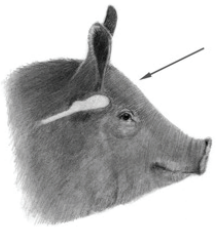


Diagram 8

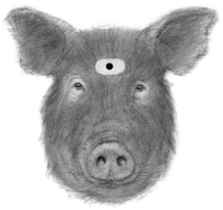


Diagram 9

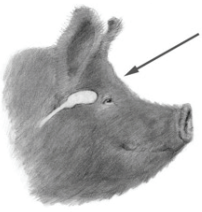


Diagram 10

Market Swine, Sow, and Boar Stunner Placement—For gunshot the bullet should enter the pig's skull approximately 1 inch (2.5cm) above the eyebrow, in the middle of the forehead. Ideally, the bullet will travel at an angle directing it to the brainstem (Diagrams 7 & 8). For older boars and sows, the shot should be located 1.5-2 inches (3-4 cm) above the eyebrow (Diagrams 9-10). When using a penetrating captive bolt, the target for shooting a market weight swine is approximately 1inch (2.5cm) above its eyebrow, in the middle of its forehead. For mature boars and sows, the captive bolt shot should be located 1.5-2 inches (3-4cm) above the eyebrow. Mature swine with exaggerated skull structures may require a slightly lower (1cm) target location. The captive bolt gun must provide adequate force and penetration depth, which many of the captive bolt guns for stunning do not. New technology has provided captive bolts with extended bolts and proper force for more effective stunning and killing of larger animals.

For detailed stunning recommendations, see the Meat Institute Stunning Guide.

Electric Stunning

Effective electric stunning will render the animal insensible. Sufficient amperage (current) must pass through the animal's brain to induce a grand mal epileptic seizure.

There are three distinct types of electric stunning:

1. **Head-only stunning:** Electric current is passed through the brain only and causes a temporary period of unconsciousness that is reversible. When scissor-type tongs are used, the electrodes may be either placed on the forehead, top of the head and bottom of the head, or clamped around the sides of the head like ear muffs. Electrodes also may be placed in a "top to bottom" position on top of the head and below the jaw. The animals will return to consciousness unless bled within 15 seconds for swine and within 10 seconds for cattle and sheep. When head-only stunning is used, the signs of a grand mal epileptic seizure can be easily observed. The first phase is a still, rigid (tonic) phase, followed by a vigorous kicking (clonic) phase. If the animal is not bled, it will return to sensibility when the kicking phase stops. This type of stunning is often used in Halal slaughter plants.

2. **Head-to-body cardiac arrest stunning:** Electric current is simultaneously passed through the brain and the heart with one application. Some systems use a single wand that extends from head to body. When using a single wand, the distance between the head electrode and the back electrode should be appropriate to the animal class. When a wand with two stationary electrodes is used, they may be placed in the hollow behind the ears or on the forehead, and the other electrode is placed on either the back or the side of the body, for at least 2 seconds for swine and 3 seconds for sheep. Other systems use two separate wands that are applied to the brain and the heart at the same time. Stunners should be equipped with a timer. Stunning tongs and wands must never be placed on the neck because this would cause the current to bypass the brain, nor should it be placed on sensitive areas such as inside the ear or in the eye. When correctly done, unconsciousness is permanent. However, bleeding within 60 seconds is recommended.

3. **Two-step cardiac arrest stunning:** Some plants may achieve cardiac arrest stunning through a two- step method by first applying the tongs to the head for 2 seconds for swine and 3 seconds for sheep to induce insensibility, then immediately reapplying to the chest to stop the heart for an additional 2 seconds for swine and 3 seconds for sheep. When correctly done, unconsciousness is permanent. However, bleeding within 60 seconds is recommended.

In all three types, the electrodes must be placed properly to ensure that the electric current passes through the brain. Electrodes must be placed firmly against the animal because breaking electrical contact during the stun may reduce the effectiveness of the stun.

*Special Audit Point for Plants That Use Head-Only Reversible Electric Stunning

Plants that use head-only reversible electric stunning systems must use extra care in ensuring that animals remain insensible when they are bled. Plants using this method should consider adding an audit point to their regular audits: when evaluating the effectiveness of reversible electrical stunning, the auditor monitors whether or not an animal is rendered insensible immediately following administration of a stun as evidenced by the absence of signs that an animal is starting the process of a return to consciousness.

Electric head-to-back cardiac arrest stunner placed in the correct position on a pig in a V restrainer.

Canadian federal rules prohibit placing electrodes on the forehead or top of the head and bottom of the head. In Canada, electrodes should only be placed around the sides of the head. Head-to-back stunning is permissible.

Electrical Specifications for Electric Stunning

Meat packers should verify amperage, voltage, and frequency settings to reliably induce unconsciousness. Insufficient amperage may fail to create a current to pass through the brain and result in a large electric shock or heart attack signs, even though the animal may be paralyzed and unable to move. Both properly and improperly stunned cardiac arrested animals can look similar. Electric stunning equipment must operate within the electrical parameters that have been verified by scientific research to induce instantaneous insensibility.

Modern stunning circuits use a constant amperage design. The amperage is set and the voltage varies with the animal's resistance. Older style circuits are voltage-regulated. These circuits are inferior because they allow large amperage surges, which can fracture bones and cause blood splash.

Amperage: The flow of electricity is called the current and is measured in amps. Scientific research has shown that an electric stunner must have sufficient amperage to induce a grand mal seizure to ensure that the animal will be made instantly insensible. Insufficient amperage can cause an animal to be paralyzed without losing sensibility. Amperage is the most important variable to measure. If lower amperages are used, the stunner may induce cardiac arrest, but the animal will feel the shock because the seizure was not induced.

Plants should be permitted to use circuits that lower the amperage setting after an initial, one second stun at the recommended amperage. Plants should also be encouraged to use constant amperage electronic circuits that prevent amperage spiking. High amperages can increase bloodsplash (Blackmore and Peterson, 1981).

Voltage: The force or pressure of the current is called voltage and is measured in volts (V). There must be sufficient voltage to deliver the recommended minimum amperage. The required voltage depends on the type of stunner, the wetness of the animal's skin, and whether or not the animal is dehydrated.

Frequency: The frequency of the current is how many times the waveform is repeated in a second and is measured in Hertz (Hz). This is important for head and back stunning. Electricity that is supplied at a frequency of 50 Hz means it repeats itself 50 times each second. Most AC power sources (household power) are delivered at 50 Hz or 60 Hz (U.S. and Canada are 120 V/60 Hz).

Electrical Settings for Different Species

Small Swine 180-200lb/85kg
Amperage (amps): Minimum 1.25
Voltage (volts): Minimum 250
Frequency (Hz): 50-60
Time (seconds):* Minimum 2.0

Market Swine and Large Sows >200lb/100kg
Amperage (amps): 2.0 or more
Voltage (volts): Minimum 250
Frequency (Hz): 50-60
Time (seconds):* Minimum 2.0

Large Boars
Amperage (amps): 3.0 to 5.0
Voltage (volts): ~ 400
Frequency (Hz): 50-60
Time (seconds):* Minimum 2.0

*Note: It will typically take 3-5 seconds to stun swine and sheep.

Cattle**
Amperage (amps): 1.5
Voltage (volts): 400
Frequency (Hz): 50-60
Time (seconds): 1.0 for insensibility, up to 15.0 to reduce kicking

**Note: In the U.S., electrical stunning of cattle is mainly used for veal calves. In other countries it is used for all classes of cattle.

Sheep
Amperage (amps): Minimum 1.0
Voltage (volts): Minimum 250
Frequency (Hz): 50-60
Time (seconds):* 3.0

Supplemental information about electrical stunning can be found in Appendix II.

Ensuring Effective Electric Stunning

Adequate electrical parameters for cardiac arrest stunning at a frequency of 50 to 60 Hz cannot be determined by clinical signs, because cardiac arrest masks the clinical signs of a seizure. Measurement of brain function is required to verify any new electrical parameters that may be used in the future. Common causes of a return to sensibility after electric stunning are based on the animal, equipment, or method:

Animal

- Animal dehydration
- Dirty animals
- Long hair or wool

Equipment

- Dirty electrodes or poorly maintained equipment
- Electrode contact area that is too small

Method

- Wrong position of the electrode
- Poor electrode contact with the animal or interrupted contact during the stun
- Amperage too low
- Poor bleed out
- Insufficient wetting of animals

Note: Electrically-stunned cattle and mature swine may require a two-phase stun: a current should first be applied across the head to render the animal insensible before a second current is applied from the head to the body to induce cardiac arrest. Modern systems may have a third current to reduce convulsions.

KEY POINTS FOR ELECTRICAL STUNNING:

Equipment:

- Do not slide the stunning wand on an animal when the wand is energized. This is considered hot wanding.
- The slats on the V restrainer, hold-down rack, and chutes should be insulated to prevent electrical current leakage.
- The electrode cleaning schedule be frequent enough to ensure a good electrical connection. The minimum cleaning schedule should be once a day. For personal safety, the electrode wand must be disconnected from the power supply before cleaning.
- Stunning wands and wiring should be checked often for electrical continuity and electrodes should be kept clean to provide good electrical contact.
- A worn switch may break the circuit enough to cause bloodsplash.
- To ensure that the electrodes remain in firm contact with a bovine's head for the duration of the stun, the animal's head must be restrained in a mechanical apparatus.

Method:

- Application of a second stun should be done only when there is a question about the efficacy of the initial stun or if routine second stuns (security stuns) are part of a plant's systematic approach to animal welfare. Additional electrical stuns can increase bloodsplash in swine.
- Animals should be wetted prior to stunning. It is important that sheep are wetted sufficiently to get water all the way down through the wool or hair. The most modern sheep stunners use water jets to conduct electricity down through the wool.
- Operators should never use the stunning wand as a prod.

Preventing 'Hot Wanding'

To prevent pain to the animal and bloodsplash in the meat, the wand must be firmly pressed against and in full contact with the animal before electrodes are energized. The operator must not break and remake the circuit during the stun because this causes the animal's muscles to tense up more than once and bloodsplash may increase. If the stunning wand is energized before it is in full contact with the animal, the animal will be shocked, which is called "hot wanding." Hot wanding is detrimental to the welfare of the animal because the animal feels the shock. Some animals, such as swine, will vocalize from hot wanding, but others, such as sheep, may not.

Note: Not all vocalization is due to hot wanding. Vocalizations can be caused by handling pressure, restraint, ineffective stunning, pain, fear, or animals simply communicating.

Plants that observe significant vocalizations immediately prior to electrical stunning should consider whether this is the sign of a hot wanding problem. Plants with excessive vocalization scores due to hot wanding during electric stunning also often have return to sensibility problems.

Controlled Atmosphere Stunning

Controlled atmosphere carbon dioxide (CO_2) stunning may be used in swine to induce death or to result in a state of surgical anesthesia (unconsciousness). These states are dependent upon the relationship between exposure time and CO_2 concentration, and systems will produce swine in both states.

KEY POINTS FOR CO_2 STUNNING:

- Research and manufacturer recommendations show that concentrations of CO_2 for swine should be about 90% and never less than 82% (Atkinson et al., 2012).
- Concentration and dwell time in CO_2 should be monitored and documented.
- If concentrations are lower, then dwell times must be longer.

In the scientific literature, there are inconsistent results on how swine react to the induction of CO_2 anesthesia. Some genetic breeds or lines of swine tend to attempt escape from the container when they first smell the gas while others respond with a calm anesthetic induction. A Dutch researcher found that the excitation phase occurred prior to the onset of unconsciousness (Forslid, 1987). Another study has shown that swine of a Pietrain genetic

background may have more physiological reactiveness to CO_2 induction (Troeger and Wolterdorf, 1989).

Background genetics may be a contributing factor and may require a different gas mixture or other adjustment. The stunning parameters for each plant should be evaluated by comparing gas concentration to insensibility after stunning. In most systems, the induction phase is not visible, but where it is, the gas mixture is not acceptable if the swine have excessive excitation or escape movements prior to loss of consciousness. However, it is normal to observe kicking and convulsions (clonic and tonic systemic and muscle reactivity phases) after swine lose consciousness (fall over).

Handlers must be careful not to overload the gondolas (elevator boxes) that hold groups of swine. In a properly loaded gondola, the swine must have sufficient room to stand without being on top of each other. There are many different sizes and configurations of gas stunning systems, and each facility has its own specifications for loading animals.

Space Recommendations for Gondola Loading*

Average Weight (lbs.)	Square Feet Per Head
12	0.65
50	1.53
100	2.32
150	2.95
250	4.26
275	4.57
300	4.79
350	5.48
400	6.39
450	7.00
500	7.69
550	8.39

*The recommendations provided are taken from the National Pork Board's Transportation Space Recommendations, which are an accepted guideline for gondola space.

Refer to the facility procedure for gondola loading parameters. This should be supported by either manufacturer recommendations or company/facility data. The National Pork Board TQA transportation space recommendations are an accepted guideline for gondola space. Handlers must never overload the gondolas by forcing swine to jump on top of each other.

In evaluating any stunning method, one must look at the entire system including the handling and means of stunning. Group stunning using CO_2 gas provides significantly less stressful handling as swine are moved more slowly and in groups which eliminates the need for swine to line up in single file chutes and a restrainer, which is contrary to their natural behavior.

Optional suggestion for internal audits: Another simple method for monitoring continuous improvement within a plant is estimating the percentage of time that the entire stunning room is quiet, known as room vocalization. As each animal is stunned, the person scoring notes whether the room was quiet. The score is the percentage of stunning cycles where the room was quiet.

When CO2 stunning is evaluated, a stunning cycle consists of the time to fill a gondola. Because vocalization scores can vary by auditor, number of swine, and room acoustics, room vocalization scores are difficult to compare across plants and should not be measured by third party auditors. This is for internal use only.

However, one can conclude that a plant that has continuous, constant squealing may have swine welfare problems. This method is excellent for internal plant monitoring over time.

Additionally, plants can easily install a decibel monitor, which can help to determine room vocalization even when no active audit is being performed."

> Note: Plants with CO_2 systems that have shorter gas exposure times need to check insensibility on the shackle table as well. Plants that fall into this category should consider adding an audit point to their internal audits.

Stunning to Bleed Interval Recommendations

Captive bolt: Animals stunned with a non-penetrating captive bolt gun should be bled within 30 seconds. There is no maximum stun to bleed interval for penetrating captive bolt (OIE 2016).

CO_2: No maximum stun to bleed interval for large machines with long duration (greater than 90 seconds) immersion. The maximum stun to bleed interval for short duration (where immersion may be less than 90 seconds) is 30 seconds.

Head-to-body or Two-step electric cardiac arrest: 60 seconds maximum is recommended if no secondary stun is applied because these methods are considered irreversible.

Head-only reversible electric: The stun-to-bleed interval should be within 15 seconds for swine and 10 seconds for cattle and sheep when head-only reversible electric stunning is used.

> Note: This parameter does not have to be measured for welfare reasons unless non-penetrating captive bolt or head-only reversible electric stunning is used.

Section 4: Determining Insensibility and the Signs of Return to Sensibility

Physiological processes occur in response to stunning and some of these processes can be confusing. It is important for anyone working in meat plants or other facilities where livestock are slaughtered or euthanized to understand what various physiological processes indicate in different species and how they may be impacted by stunning methods. With this information, proper assessments of insensibility can be made and appropriate additional actions can be taken, when necessary, to ensure insensibility.

Immediately upon the successful application of a stunning method, two phases will be observed. The Tonic phase where the animal displays stiffness and rigidity due to extreme muscle contraction. Within seconds, the clonic phase will begin. This phase displays uncontrolled kicking and twitching. It is important to remember that the movements observed during the clonic phase are involuntary and the animal is insensible.

Research confirms that consciousness and unconsciousness occur on a continuum with three phases: 1) definitely unconscious, 2) the transition phase, and 3) definitely conscious (Terlouw, *et. al.* 2016). The presence of one or more of three signs: corneal reflex (eyeball movement in response to touch), eyelash reflex in response to touch, and rhythmic breathing (where the ribs move in and out at least twice), indicates that an animal is unconscious but is in the transition phase and may soon become conscious (see Table 1 at the end of this section). In such a case, prompt second stun is essential from an immediately available backup stunner (see Table 2 at the end of this section). Complete return to sensibility can occur as quickly as 15 to 20 seconds, or as long as 60 seconds or more.

Characteristics are not signs of sensibility. Being familiar with what characteristics are often observed for different stunning methods will help prevent confusion when observing a properly stunned animal with normal limb, head, back, neck, eye, and tail characteristics following stunning.

Limb Characteristics

Captive Bolt, Firearm, and Electrical Stunning

Uncoordinated kicking of the unrestrained back leg and uncoordinated paddling of the front legs are often misunderstood and misinterpreted.

With firearms, captive bolt, and electrically stunned animals, kicking will occur. Ignore the kicking; focus on the head. When using a captive bolt gun or firearm, swine in particular can display violent and uncoordinated kicking and thrashing. This is not an indication of sensibility and should not be confused with a righting reflex.

Paddling movements may also continue even when the spinal cord is severed, because the walking circuit is located in the middle of the spine.

CO_2 Stunning

When swine are stunned using CO_2 to induce insensibility some animals may have slow limb movement. This is acceptable. Sudden, involuntary reflexes including muscle jerks or twitches are acceptable.

Head, Neck, and Back Characteristics: All Stunning Methods

To put it simply: THE HEAD MUST BE DEAD. When cattle are shot with a captive bolt, it is normal to have a spasm for 5 to 15 seconds, but the spasm should stop after 15 seconds. For all methods of stunning, when cattle and swine are hung on the rail, their head should hang straight down and be limpy and floppy and their backs must be straight.

Due to differences in anatomy, sheep that are properly stunned and are insensible may not hang with their heads straight down. However, their heads should be limp and floppy.

No effectively stunned animal should exhibit an arched-back righting reflex. When a partially sensible animal is hung on the rail it will attempt to lift up its head as if the animal is trying to stand up and remove itself from the rail. Sometimes the head will flop up momentarily if a back-leg kicks or spasms, but this should not be confused with a righting reflex.

Tongue Characteristics: All Stunning Methods

If the tongue is out, it should be straight and limp. A stiff, curled tongue is a sign of possible return to sensibility. In addition, if the tongue goes in and out, this may be a sign that the animal is starting the process of returning to consciousness and the animal should be re-stunned. The tongue retained within the mouth is not to be used as an indicator of sensibility as the tongue may just get stuck inside.

Eye Characteristics

Captive Bolt or Gunshot

When captive bolt is used, the eyes should be wide open with a blank stare. Insensibility may be questionable if the eyes are rolled back or they are vibrating (nystagmus); this is a sign of a potential return to consciousness and the animal should immediately be re-stunned.

Electrical Stunning

If an electrically-stunned animal blinks within five seconds after stunning, this is a sign that the amperage is too low. Blinking should be checked within five seconds and after 60 seconds. In most plants, blinking will not be found immediately after stunning because the plant is using the correct amperage.

Nystagmus (vibrating eye) is acceptable in electrically stunned animals, especially those stunned with frequencies higher than 50 to 60 Hz. After it has been verified that the amperage is set correctly, the most important time to observe for signs of return to sensibility is 60 seconds after electrical stunning. This provides time for the eyes and neck to relax after the rigid (tonic) and kicking (clonic) phases of the epileptic seizure. Checking for signs of return to sensibility after bleeding ensures that the animal will not recover.

CO_2

In some unusual instances, nystagmus has been observed in a CO_2 stunned swine, and when this occurs, it often is associated with short CO_2 exposure time.

Eyes: All Stunning Methods

In some cases, the animal will clamp its eyes shut, but they should relax into a blank stare. If the animal blinks with a natural blink, where the eyes open and then re-close, it is not properly stunned. The animal must NEVER show a natural blink where the eyes open and then re-close or have an eye reflex in response to touch. Look at live animals before assessing insensibility to understand what a natural blink looks like.

Palpebral and/or menace reflexes (when the eye blinks when a hand is waved in front of it) must be absent. Eye movements can be misinterpreted when untrained people indiscriminately poke at the eyes (for example, when looking for a corneal reflex). Instead, a hand can be waved in front of the eye to test for the menace or threat reflex.

Tail Characteristics: All Stunning Methods

Shortly after being hung on the rail, the tail should relax and hang down.

Bison may show a tail twitch after stunning which is not indicative of consciousness.

Respiration: All Stunning Methods

There should be no rhythmic breathing where the ribs move in and out at least twice.

> Note: Agonal breathing or gasping like a fish out of water may be present in electric and CO_2 stunned animals. It is the sign of a dying brain and is acceptable.

Vocalizations: All Stunning Methods

There should be no vocalizations such as a moo, bellow, or squeal. A groan, moan, or last breath is not considered vocalization.

Bleed Rail Insensibility

Hoisting or any dressing procedure such as skinning, scalding, limb removal, etc. must never be performed on a sensible animal.

No sensible animal should be observed on the bleed rail or bleed table. However, on rare occasions, it is possible that an animal with potential return to sensibility will be observed. Research by Terlouw, *et. al.,* (2016) confirms that consciousness and unconsciousness occur on a continuum that essentially has three phases:

1. definitely unconscious,
2. the transition phase, and
3. definitely conscious

The presence of one or more of three signs:

- Eyelash reflex,
- Corneal reflex, or
- rhythmic breathing

indicates that an animal is unconscious but is in the transition phase and may soon become conscious *(see table 1 on pg. 48.)*

It is critical that animals showing signs of return to sensibility be re-stunned promptly.

An animal showing transition signs is NOT counted as sensible as long as the backup stunner is readily accessible and a successful second stun is administered promptly prior to the animal returning to sensibility.

TABLE 1: ASSESSING UNCONSCIOUSNESS IN DOMESTIC LIVESTOCK DURING SLAUGHTER

Definitely Unconscious: ***ALL of the following signs are ABSENT***	**Unconscious But Beginning Transition Back to Consciousness:** ***ONE OR MORE of the following signs are PRESENT***	**Definitely Conscious:** ***ANY of the following signs are PRESENT***
• Menace reflex • Eyelash reflex • Corneal reflex • Rhythmic breathing	• Menace reflex • Eyelash reflex • Corneal reflex • Rhythmic breathing	• No loss of posture • Righting reflex • Vocalization • Natural blinking • Eye pursuit of a moving object
Unconscious: No Action Needed	**Unconscious: Re-stun Immediately**	**Conscious: Re-stun Immediately**
See below for differences between the menace, eyelash, and corneal reflex tests		

Understanding and Evaluating Signs for Determining Sensibility

Eye Reflexes

No reflex is a sole indicator of consciousness, as reflexes are autonomic actions, which do not require full sensibility to stimulate (Fischer and Truong, 2015).

- **Menace reflex test:** The menace reflex is a reaction that causes the animal to blink in response to a sudden movement toward the eye. The menace reflex test can be helpful in assessing sensibility because the neurologic path goes through the cerebrum (the area of the brain that generates complex thoughts and controls body movements), rather than the brainstem only (area of the brain that controls automatic functions). Blinking in response to a menace reflex test is a sign of potential consciousness.

  The menace reflex can be tested by waving a hand in front of the eye.

- **Eyelash reflex test:** The palpebral reflex, commonly referred to as the eyelash reflex, is a reaction that causes the eye to blink in response to stimulation of the skin around the eye or eyelid. The eyelash reflex can be used to help assess consciousness, but should not be the sole indicator of consciousness, because the neurologic path goes through the brainstem only. Blinking in response to an eyelash reflex test is a sign of a potential return to consciousness.

  The eyelash reflex can be tested by lightly touching the eyelash or skin surrounding the eye.

  Note: Auditors are to have employee(s) from the establishment conduct the eyelash reflex test. The auditor is not to conduct this test on their own.

- **Corneal reflex test:** The corneal reflex is a reaction that causes the eye to blink in response to stimulation of the cornea, the area of the eye that covers the iris and the pupil. This is one of the most sensitive areas of the eye, making it a reasonable tool for assessing sensibility in animals, but should not be the sole indicator of consciousness, because the neurologic path goes through the brainstem only. Blinking in response to a corneal reflex test is a sign of a potential return to consciousness.

  The corneal reflex can be tested by lightly touching the surface of the eye, ideally avoiding the pupil. Any touch should be gentle, because if the animal is conscious, it will be painful

  Note: Auditors are to have employee(s) from the establishment conduct the corneal reflex test. The auditor is not to conduct this test on their own.

Other Signs

- **Rhythmic breathing:** is when an animal breathes in and out at least twice. This sign is indicated by the rib cage moving in and out in a normal breathing pattern at least twice. Agonal breathing (gasping like a fish out of water) may be present in electric and CO_2 stunned animals and should not be considered a sign of consciousness or return to consciousness.

- **Loss of posture:** is when an animal can no longer maintain a standing position. The animal will collapse and no longer holds its weight on its limbs. Depending on the restraining system, the animal may remain in an upright position while restrained, but the head and body will go limp and loss of posture will be evident once restraint is released.

- **Righting reflex:** is when a conscious animal attempts to stand up. This sign is indicated by a hanging animal attempting to "right" itself, lifting its head and arching its neck and back as if to put its feet down towards the ground.

- **Vocalization:** is when an animal makes a normal sound for that animal, such as a moo, bellow, bleat, or squeal. Properly stunned animals may groan, moan, or gasp as a unconscious result of stunning and slaughter, which is not considered a vocalization.

- **Natural blinking:** is natural blinking where the eyes open and then re-close.

- **Eye pursuit of a moving object:** is where the eyes move to track a moving object. This sign can be identified by moving a finger in front of the eyes to see if the eyes follow the movement of the finger.

TABLE 2: SIGNS OF A PROPERLY STUNNED ANIMAL BY STUNNING METHOD

	Head	Tongue	Back	Eyes	Limbs	Vocalization	Respiration	Tail	Response to pain
Cattle -- captive bolt	Must appear dead, hang straight and floppy	Straight and limp	Hanging straight, no righting reflex	No natural blinking. Wide open, blank stare, no response to touch; nystagmus absent	Uncoordinated kicking of hind legs is acceptable, no righting reflex present	None	Rhythmic breathing (ribs moving in and out at least twice) is absent. Agonal gasping not acceptable	Relaxes shortly after being on the rail	A pinch or pinprick may be applied to the nose only and no response should be observed.
Cattle -- electric	Must appear dead, hang straight and floppy	Straight and limp	Hanging straight, no righting reflex	Eyes may vibrate (nystagmus), but no natural blinking	Uncoordinated kicking of hind legs is acceptable, no righting reflex present	None	Agonal gasping like a fish out of water is normal. Rhythmic breathing (ribs moving in and out at least twice) is absent.	Relaxes shortly after being on the rail	A pinch or pinprick may be applied to the nose only and no response should be observed.
Swine -- CO_2	Must appear dead, hang straight and floppy	Straight and limp	Hanging straight, no righting reflex	No natural blinking	Uncoordinated kicking of hind legs is acceptable, no righting reflex present	None	Agonal gasping like a fish out of water is normal. Rhythmic breathing (ribs moving in and out at least twice) is absent.	Relaxes shortly after being on the rail	A pinch or pinprick may be applied to the nose only and no response should be observed.
Swine -- electric	Must appear dead, hang straight and floppy	Straight and limp	Hanging straight, no righting reflex	Eyes may vibrate (nystagmus), but no natural blinking	Uncoordinated kicking of hind legs acceptable, no righting reflex present	None	Agonal gasping like a fish out of water is normal. Rhythmic breathing (ribs moving in and out at least twice) is absent.	Relaxes shortly after being on the rail	A pinch or pinprick may be applied to the nose only and no response should be observed.
Swine -- captive bolt	Must appear dead, hang straight and floppy	Straight and limp	Hanging straight, no righting reflex	No natural blinking. Wide open, blank stare, no response to touch; nystagmus absent	Uncoordinated kicking of hind legs is acceptable, no righting reflex present	None	Rhythmic breathing (ribs moving in and out at least twice) is absent.	Relaxes shortly after being on the rail	A pinch or pinprick may be applied to nose only and no response should be observed.
Sheep -- electric	Must appear dead, neck hangs on angle with limp and floppy head	Straight and limp	Due to anatomical differences in sheep, back may not hang completely straight; no righting reflex	Eyes may vibrate (nystagmus), but no natural blinking	Uncoordinated kicking of hind legs is acceptable, no righting reflex present	None	Agonal gasping like a fish out of water is normal. Rhythmic breathing (ribs moving in and out at least twice) is absent.	Relaxes shortly after being on the rail	A pinch or pinprick may be applied to the nose only and no response should be observed.

Section 5: Religious Slaughter (Kosher and Halal) of Domestic Livestock

Religious (ritual) slaughter is conducted according to the requirements of either the Jewish (kosher) or Muslim (halal) faith. These religions have specific conditions that must be met for the slaughter of acceptable animals. During the religious slaughter process, a ritual slaughter man cuts the neck of the animal with a razor-sharp knife. The major difference between religious and conventional slaughter is that in religious slaughter, animals are typically not stunned prior to neck-cutting. Most notably, kosher traditions prohibit pre-slaughter stunning. Some methods of halal slaughter allow stunning of animals before the cut is made, as long as the unconsciousness produced can be reversed. Stunning address the regulatory aspects of religious slaughter.

The Humane Slaughter Act acknowledges that religious slaughter can be performed humanely (7 USC 1906), and USDA FSIS Directive 6900.2 and CFIA Guidelines for Ritual Slaughter of Food Animals without Pre-Slaughter

Note: Swine are not covered under religious slaughter because their consumption is forbidden under Jewish and Muslim law.

Restraint in Religious Slaughter

Cattle, calves, sheep, or other animals that are religiously slaughtered without stunning should be restrained in a comfortable position. For both humane and safety reasons, plants should install modern upright restraining equipment whenever possible.

The WOAH guidelines (2016) clearly state that "methods of restraint causing avoidable suffering should not be used in conscious animals because they cause severe pain and distress. Suspending or hoisting animals (other than poultry by the feet or legs) should not be used." Some examples of restraint systems include:

Stationary knock box: This device consists of a narrow stall with an opening in the front for the animal's head. After the animal enters the box, the rear gate comes into place and in some systems, a belly lift comes up under the brisket. The head is restrained by a chin lift that holds it still for the throat cut. Vertical travel of the belly lift should be restricted to 28 inches (71.1 cm) so that it does not lift the animal off the floor. The rear drop gate should be equipped with either a separate pressure regulator or special pilot-operated check valves to allow the operator to control the amount of pressure exerted on the animal. Pilot-operated check valves enable the operator to stop the air cylinders that control the apparatus mid-stroke.

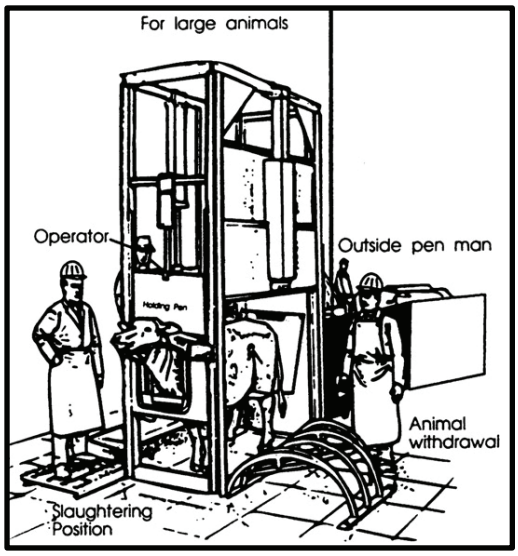
Conveyor Restrainer Systems: Either V restrainer or center track restrainer systems can be used for holding cattle, sheep, or calves in an upright position during religious slaughter. The restrainer is stopped for each animal and a head holder positions the head for the ritual slaughter official.

Small Restrainer Systems: For small locker plants that religiously slaughter a few calves or sheep per week, an inexpensive rack constructed from pipe can be used to hold the animal in a manner similar to the center track restrainer.

Head restraint is the last step. Head holding devices should be designed to avoid excessive bending of the neck. The restrainer should be adjusted so that the animal is held in a balanced upright position. The operator should reduce sudden and jerky motion of moving parts on the restrainer to keep animals calm prior to cutting. Many cattle will stand still if the box is slowly closed up around them and less pressure will be required to hold them. Small animals such as sheep may be held manually by a person during religious slaughter. Ritual slaughter should be performed immediately after the head is restrained (within 10 seconds of restraint). Immediately after the cut and the captive bolt stun (in the case of religious slaughter with stunning), the operator should completely release the rear pusher gate and loosen the head holder.

Trip floor boxes and leg clamping boxes should never be used. In a very limited number of glatt kosher plants in the United States and more commonly in South America and Europe, restrainers that position animals on their backs are used. For information about these systems and evaluating animal welfare, refer to https://www.grandin.com/ritual rec.ritual.slaughter.html.

The Cut in Religious Slaughter

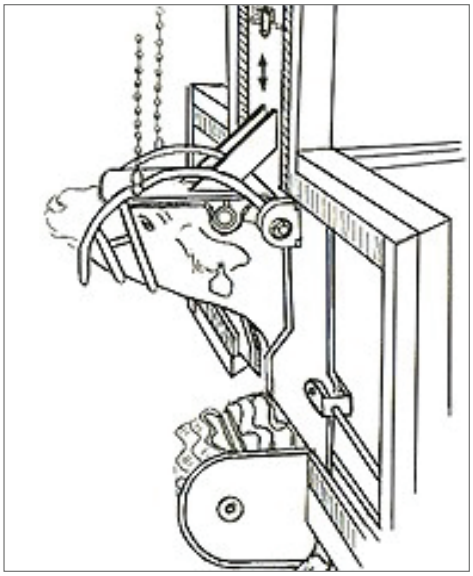


Upright pen for religious slaughter.

Halal slaughter has fewer specifications for the type of knife that is used compared to kosher slaughter. In all religious slaughter operations, the knife must be sufficiently sharp to pass a paper sharpness test conducted by dangling a single sheet of standard printer paper by the corner with the thumb and forefinger. When the knife is held in the other hand, it should be able to easily slice through the edge of the dangling sheet of paper. The knife must be dry when this test is performed. WOAH guidelines specify that the knife should be long enough to span the width of the animal's neck. It is considered a best practice to utilize a straight blade knife twice the width of the neck. A longer knife may be needed to accommodate large bulls. The knife should be maintained between each animal and a second sharp knife should be readily available.

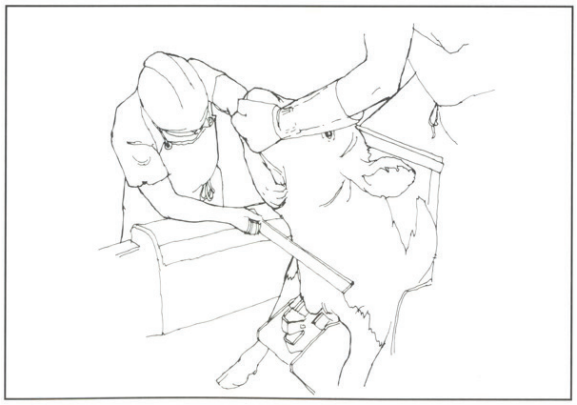
The throat cut should be a smooth motion without sawing, made immediately after the head is restrained (within 10 seconds), and cut the skin, trachea, esophagus, and two major blood vessels (carotid arteries and jugular veins) to ensure quick and thorough bleeding of the animal. Animals must be allowed to bleed out and become completely insensible before any other slaughter procedure is performed (shackling, hoisting, cutting, *etc.*)

CFIA guidelines describe the ritual cut as a continuous cut that may include several fluid sliding movements of the knife without any interruption, hesitation, stabbing with the knife or lifting of the knife off the animal's neck during the entire cut. The anatomy, size of the animal, thickness of coat or heavy neck skin folds, width of neck and type of restraint can affect the number of continuous back and forth movements required to complete the ritual cut. These factors must be considered when assessing a ritual cut.



Center track restrainer being used for religious slaughter.

According to CFIA guidelines, above all, the knife blade sharpness and length, as well as restraint technique, are the key components for correctly conducting ritual slaughter. The knife should be at least twice as long as the animal's neck width and exquisitely sharp for each animal. The knife should be tested on a regular basis to ensure its sharpness by, for example, dangling a piece of paper by a corner with a thumb and forefinger and with the other hand cutting it with the knife through the edge of the paper smoothly and effortlessly. The knife should not have any nicks or any other imperfections that might cause tissue tearing and pain.



Restrainer system for religious slaughter of calves and sheep.

Note: If the technique or knife fails, and the animal is still conscious, to prevent prolonged suffering the animal should be immediately stunned with a backup device.

Signs of Insensibility in Religious Slaughter

Signs of insensibility are distinct for un-stunned, religiously slaughtered livestock. If held in an upright box, loss of posture will be closely followed by eye roll and loss of alertness in the ears. Often the head will flex back as well.

Auditors may confirm insensibility by observing for:

- The eye roll and absence of spontaneous, natural blinking.
- A weak corneal reflex may still be present immediately after the eye roll.
- The animal may continue to gasp or breathe after the eye roll for a period of several seconds.

A set amount of time should be established for each species for loss of posture and sensibility based on industry best practices or a legislative limit. Without a stun, if the animal has not shown a loss of posture and sensibility following this set amount of time, then the backup device must be used.

Shackling, hoisting, and dragging can only occur once the animal is allowed to bleed out and is completely insensible, unless there is an effective post-cut stun. Before dressing procedures are performed, such as skinning, dehorning, leg removal, or severing the spinal cord, ALL signs of brain death must be observed. The breathing sound that can be heard from the cut trachea is considered rhythmic breathing if it is rhythmic rather than a single agonal gasp. This sound must be absent before invasive dressing procedures are conducted.

When slaughter without stunning is done, there is a transition zone between clearly conscious/sensible and unconscious/brain dead (Terlouw, et al., 2016). Animals that have not collapsed are definitely conscious. Animals are unconscious when the following three signs are absent: 1) corneal reflex in response to touch, 2) eyelash reflex and 3) rhythmic breathing. The transition zone from fully conscious to unconscious is not distinct.

When slaughtering without pre-cut or post-cut stunning, the animal should remain in the restraining box until after collapse (LOP – loss of posture) and eye roll in an upright box or eye roll alone in a rotating box. If either of these signs remain 40 seconds after the cut, the animal should be shot with a backup device. When slaughter without stunning is done with careful technique, the time for the animal to collapse can be shortened and over 95% of the animals should either collapse (LOP – loss of posture) and/or have eye roll within 30 seconds (Grandin, 2015; see Tables 3 and 4).

When slaughter with stunning is performed, the stun should be performed as soon as possible after the religious cut. Plants should make sure that they can meet all the stunning requirements outlined in Chapter 3, Section 2. All components of effective stunning must apply, and the procedure should be monitored like non- religious slaughter (see Chapter 3 Section 3).

Total Animals: n = 1810	Time between animal entering the box and complete of set up, in seconds	Time between setup completion and throat cut, in seconds	Time between throat cut and eye roll (loss of consciousness) in seconds
Average	25.5	3.8	22.8
Std. Dev.	5.99	1.69	3.78
Maximum	57	18	38
Minimum	3	1	3

	Cattle taking longer than 30 seconds to collapse and have eye roll	Cattle requiring a captive bolt shot
Number	35	0
Percent	1.97%	0%

Table 3. Bleed Efficacy Data: This data indicates that in one glatt kosher plant (no post-cut stun), 98% of the cattle col lapsed (eye roll) in 30 seconds or less; no cattle required a captive bolt shot due to ineffective bleeding. All cattle were insensible within 40 seconds and remained insensible on the bleed rail. The plant restrained the animals with light pres sure in an upright restraint box. Immediately after the throat cut, the restraint was loosened on the head and body to facili tate a rapid blood flow and hasten loss of consciousness. The chin lift was kept up to keep the cut open. Data collected between December 2010 to December 2014.

Total Animals: n = 7718	Number of Animals Sensible on Rail	Number of Animals Prod was used on	Number of Animals Slipping	Number of Animals Falling	Number of Animals Vocalizing
Number of Animals	0	208	48	0	346
% Required to Pass NAMI Audit	0	25	3	1	5
Plant Avg. %	0	2.7	0.6	0	4.5
Std. Dev	0	1.21	0.49	0	1.33
Worst Day %	0	14.3	6.7	0	15
Best Day %	0	0	0	0	0

Table 4. From weekly unannounced reviews (188 total audits). This data shows that limits were met for all measures when averaged, indicating program management and control. Typical week-to-week variation occurred. Electric prod use was minimal, with the average being 2.7%, which is considered excellent. The availablility of a vibrating prod and rattle paddle as primary driving tools contributed to this very low percent. Vocalization was the most challenging criteria to control, with 33% of the audit scores exceeding the 5% limit, but the average score was 4.5%. In most cases, the cause of vocalization was difficulty restraining the head, especially on smaller cattle; vocalization during neck washing; or due to agitation after prod use. Vocalization scores of 5% can be easily achieved in a well-managed plant that slaughters without stunning (Grandin, 2012). When excessive pressure is applied by a restraint device, vocalization scores may range from 23% to 47% (Grandin, 1998; Bourquet et al., 2011; Hayes et al., 2015). Collapse times can be improved by cutting the throat high on the neck in the C1 position close to the jaw (Gregory et al., 2012; Gibson et al., 2015). Data collected December 2010 to December 2014.

Section 6: Recommended Handling of Compromised Livestock

Although compromised animals represent a small fraction of all livestock arriving at packing plants, they are significant because they require special attention. It is important that water is accessible and shelter is provided to compromised livestock. Below is a list of terms used to describe compromised animals:

- **Non-ambulatory disabled animal:** according to USDA FSIS, livestock that cannot rise from a recumbent position or that cannot walk, including, but not limited to, those with broken appendages, severed tendons or ligaments, nerve paralysis, fractured vertebral column, or metabolic conditions.
- **Fatigued:** fatigued animals have temporarily lost the ability or the desire to walk but have a reasonable expectation to recover full locomotion with rest.
- **Otherwise compromised animal:** an animal with reduced capacity to withstand handling or transportation, but where handling or transportation with special provisions will not lead to undue suffering. Compromised animals may be locally transported with special provisions to receive care, be euthanized, or humanely slaughtered.

Per Canadian regulations, animals that are defined as unfit are likely to suffer during transport. They cannot be loaded or transported unless going for veterinary care. Some examples of animals considered unfit are the following conditions: non-ambulatory, severe open wounds, signs of dehydration or fever, stressed hogs, severe prolapse, or extremely thin. This is not the complete list of conditions.

Factors that May Cause Compromised Animals

- Aggressive handling
- Poor health/injury
- Fatigue that arises during handling or transport
- Some animals experiencing heat stress will appear fatigued, and may exhibit open-mouthed panting and/or reluctance to move.
- Mounting activity and animal fights can lead to injuries that can cause animals to become compromised.

Regulatory Considerations for Non-ambulatory Animals

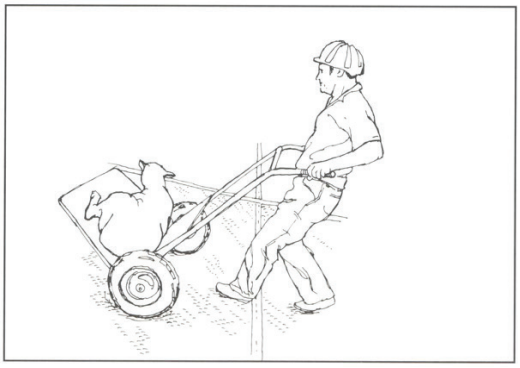
In the United States, all cattle that arrive at packing plants as non-ambulatory must be euthanized. Non-ambulatory cattle arriving on trucks should be humanely euthanized on the truck and removed for disposal. Non-ambulatory cattle should be euthanized and disposed of. If bleeding is the secondary step used in the euthanasia process, the area should be cleaned (i.e., bedding removed, area rinsed) afterward to prevent balking. Pithing is another secondary step that can be used which requires less cleanup. Some cattle may be deemed suspect and yet still be ambulatory. These cattle should be moved to separate pens for examination by USDA inspectors.

Non-ambulatory swine and sheep may be slaughtered if inspected and passed by a USDA veterinarian. These animals should be held in a designated location for additional ante-mortem inspection. At that time, they may be passed for inspection, condemned, or segregated and slaughtered as U.S. Suspect.

Per Canadian regulations, non-ambulatory animals must **NOT** be moved while they are conscious and must be stunned for slaughter or euthanized where they are located. Until the plant is able to euthanize the non-ambulatory animal, they must protect it from injury caused by other animals and stun the down animal before it is loaded onto any moving device.

Moving Compromised Animals

If compromised animals must be moved, they cannot be moved by dragging, pushing, pulling, or scooting. Animals can be transported humanely and efficiently to a pen or other area where they can be examined by an inspector (if necessary), stunned, and moved to slaughter by using slide boards, sleds, carts and other devices. In pork and sheep plants, the single file lead up to the stunning chute or restrainer should be equipped with side doors so that non-ambulatory livestock can be easily removed. In order to prevent further injury to non-ambulatory animals by



Cart used to move non-ambulatory animals.

equipment or other animals, minimal movement should be used to roll the animal or slide it onto carts and other devices. If this cannot be done without causing further injury, additional stress, or pain, reference Chapter 2 Section 5 for euthanizing the animal.

Swine being moved with proper equipment

Note: If the animal has been euthanized, the carcass may be dragged.

GLOSSARY OF TERMS

Amperage: the flow of electricity, or current (measured in amps).

Bloodsplash: petechial (pinpoint size) hemorrhages that result when small capillaries in muscle rupture because of increased blood pressure and muscular contraction.

Bison: Undomesticated animals that have a large flight zone and retain their wild instincts.

Clonic: a phase within a seizure in which the animal displays uncontrolled kicking and twitching.

Compromised animal: an animal with reduced capacity to withstand handling or transportation, but where handling or transportation with special provisions will not lead to undue suffering; compromised animals may be locally transported with special provisions to receive care, be euthanized, or humanely slaughtered.

Corneal reflex: the blinking effect elicited by lightly touching the cornea (surface) of the eyeball.

Crowd gate: a gate used in an animal handling system that can facilitate the movement of livestock from a large pen into a single-file alley or used for moving a group of animals along a drive alley.

Crowd pen: a pen which aids in the movement of animals into a single-file alleyway; contrary to the name, the crowd pen should never be crowded to the point that animals do not flow through the pen.

Domestic livestock: Only cattle, swine, and sheep — not bison.

Driving: Handler actively moving an animal.

Emaciated: Animals with a body condition score of one. Swine will be extremely narrow in the loin, have a hollow flank area, and their ribs and backbones will be easily visible. Cattle and sheep will be extremely thin, with their ribs and backbones easily visible. Such animals would be described as extremely thin if there is no fat on the rib or in the brisket and the backbone is easily visible, with some muscle depletion evident through the hind quarter. The extremely thin attributes of these animals may sometimes compromise their mobility, cause severe weakness, and lead to debilitation.

Euthanasia: Ending the life of an individual animal in a way that minimizes pain and distress.

Exsanguination: the act of draining the blood from an animal.

Fall: occurs when an animal loses an upright position suddenly in which a part of the body other than the limbs touches the ground.

Fatigued animal: fatigued animals have temporarily lost the ability or the desire to walk but have a reasonable expectation to recover full locomotion with rest.

Flight zone: an animal's personal space; determined by the wildness or tameness of the animal, or how accustomed animals are to people and handling.

Frequency (regarding electric currents): how many times the waveform is repeated in a second (measured in Hertz (Hz)).

Gondola: a large basket in which swine can be loaded before being exposed to carbon dioxide stunning.

Hot wanding: an instance in which the stunning wand is energized before it is in full contact with an animal, which usually elicits an adverse response, such as a squeal.

Involuntary movement: These may be associated with but not limited to the mouth, cheek, tail, forelimbs or back limbs, and may be characterized by kicking, reflexive movements, or spasms.

Knock box: area of containment where the animal is stunned, also known as a stun box.

Lairage: a place where livestock may be held during transit to a slaughter facility or in a slaughter facility.

Livestock: Cattle, swine, sheep, and bison raised in an agricultural setting to provide products for consumption such as meat.

Menace reflex: the blinking effect elicited by waving a hand in front of the eye; this reflex is a sign of sensibility.

Non-ambulatory animal: an animal that cannot or will not rise from a recumbent position or that cannot walk. This includes, but is not limited to, acutely split animals and animals that require hobbles to assist in the healing of injuries or to prevent further injury.

Non-penetrating captive bolt: a captive bolt device which provides a concussive effect without the bolt penetrating the skull.

Nystagmus: a condition in which the eye makes repetitive, uncontrolled movements; appears that the eye is vibrating.

Penetrating captive bolt: deliver bolts of varying diameters and lengths through the skull and into the brain. Unconsciousness is produced immediately by physical brain destruction and a combination of changes in intracranial pressure and acceleration concussion.

Pithing: causing further damage to the brain after an animal has been rendered in sensible by captive bolt or firearm by inserting a thin metal or plastic rod into the hole made by the concussive device.

Point of balance: the point at which an animal will move forward or backward in relation to a handler's movement, located at the shoulder of the animal.

Poor udder condition: the condition of an animal that displays a severely engorged udder that is interfering with the animal's ability to walk, including udders that descend below the hock, significantly push out against the rear legs causing difficulty of movement, or highly distended udders which cause obvious pain/distress to the cow.

Prodding: Handler using an electric or vibrating prod on an animal, regardless of if the prod is electrified.

Restrainer: a chute, box, or conveyor system that holds an animal still for handlers to more effectively place a captive bolt, firearm, or electric stun device to render an animal unconscious.

Rhythmic breathing: breathing displayed by animals, in which the ribs move in and out at least twice; this is a sign of sensibility.

Righting reflex: an attempt of an animal to lift up its head and/or arch its back (or right itself), in response to being hung upside down; animals which are sensible after being hung on the rail will exhibit such a reflex; the presence of this reflex is a sign of sensibility and is not acceptable.

Security stun: an additional stunning action taken after the first stun has rendered an animal unconscious.

Sensibility: When an animal is conscious as evidenced by spontaneous, natural blinking; presence of the menace or threat reflex; and may exhibit the righting reflex and raising the head.

Single file alleyway: an alleyway in which animals are moved single-file, usually leading up to the restrainer or stun box, also known as a single file chute or race.

Slip: occurs when a portion of the leg other than the foot touches the ground or floor, or a foot loses contact with the ground or floor in a non-walking manner.

Split animal: an animal (usually bovine) who cannot keep its back legs together to support its weight

Tonic: a phase within a seizure in which the animal displays stiffness and rigidity due to extreme muscle contraction.

Unfit animal: an animal with reduced capacity to withstand transportation and where there is a high risk that transportation will lead to undue suffering; if transported, unfit animals would endure unjustified and unreasonable suffering (unfit animals may only be transported for veterinary treatment or diagnosis).

REFERENCES

American Association of Bovine Practitioners. 2023. Guidelines for the Humane Euthanasia of Cattle. Available: https://www.aabp.org/Resources/AABP_Guidelines/EUTHANASIA-2023.pdf Accessed October 3, 2023.

Anil, AM and JL McKinstry. 1992. The effectiveness of high frequency electrical stunning in swine. Meat Sci. 31:481-491.

American Association of Bovine Practitioners. 2023. Guidelines for the Humane Euthanasia of Cattle. Available: https://www.aabp.org/Resources/AABP_Guidelines/EUTHANASIA-2023.pdf Accessed October 3, 2023.

Anil, MH and JL McKinstry. 1998. Variations in electrical stunning tong placements and relative consequences in slaughter swine. Vet. J. 155:85-90.

Atkinson, S, A Velarde, P Llonch, and B Alger. 2012. Assessing pig welfare at stunning in Swedish commercial abattoirs using CO_2 group stun methods. Anim. Welfare. 21: 487-495.

Becerril-Herrera, M, M Alonso-Spilsbury, C Lemus-Flores, I Guerrero-Legarreta, A Hernandez, R Ramirez- Necoechea, and D Mota-Rojas. 2009. CO_2 Stunning may compromise swine welfare compared to electrical stunning. Meat Sci. 81:233-237.

Beef Quality Assurance Transportation Manual. 2020. Pg 23. Available: https://www.bqa.org/Media/BQA/ Docs/bqat-manual_02-10-2021-91.pdf Accessed January 3, 2023.

Bellodi, L, P Giampaolo, D Caldriola, C Arancro, A Bertani, and D DiBelle. 1998. CO_2 induced panic attacks: A twin study. Amer. J. Psychiatry. 155:1184-1188.

Benjamin, ME, HW Gonyou, DL Ivers, LF Richardson, DJ Jones, JR Wagner, R Seneriz, and DB Anderson. 2001. Effect of animal handling method on the incidence of stress response in market swine in a model system. J Anim Sci. 79:279 (Supl. 1) (Abstract).

Berghaus, A and K Troeger. 1998. Electrical stunning of pig's minimum current flow time required to induce epilepsy at various frequencies. Intl Congress of Meat Sci and Tech. 44:1070-1073.

Blackmore, DK. 1988. Quality control of stunning. Proc Intl Congress of Meat Sci and Tech, CSIRO. Brisbane, Australia.

Blackmore, DK and GV Peterson. 1981a. Stunning and slaughter of sheep and calves in New Zealand. New Zealand Vet J. 29;99-102.

Blackmore, DK and JC Newhook. 1981b. Insensibility during slaughter of swine in comparison to other domestic stock. New Zealand Vet. J. 29:219-222.

Blackmore, DK and JC Newhook. 1983. The assessment of insensibility in sheep, calves and swine during slaughter. In: G. Eikelenboom (Editor). Stunning Animals for Slaughter. Marinus Nijhoff, Boston, MA. p. 13- 25.

Bourquet, C, V Deiss, EC Tannugi, EMC Terlouw. 2011. Behavioral and physiological reactions of cattle in a commercial abattoir and relationships with organizational aspects of the abattoir and animal characteristics. Meat Sci. 88(1):158-168.

Canadian Livestock Transport Program. 2023. Available: https://clt.online-compliance.com/ Accessed January 3, 2023.

Cook, CJ. 1992. Stunning Science, a guide to better electrical stunning. Meat Ind. Res Conf. MIRINZ. Hamilton, New Zealand.

Cook, CJ, CE Devine, and KV Gilbert. 1991. Electroencephalograms and electrocardiograms in young bulls following upper cervical vertebrae to brisket stunning. New Zealand Vet. J. 39:121-125.

Croft, PS. 1952. Problems with electrical stunning. Vet. Record. 64:255-258.

Devine, CE, KV Gilbert, and S Ellery. 1983. Electrical stunning of lambs: The effect of stunning parameters and drugs affecting blood flow and behavior on petechial hemorrhage incidence. Meat Sci. 9: 247-256.

Dodman, NH. 1977. Observations on the use of the Wernberg dip-lift carbon dioxide apparatus for pre- slaughter anesthesia swine. Br. Vet. J. 133:71-80.

Dunn, CS. 1990. Stress reaction of cattle undergoing ritual slaughter using two methods of restraint. Vet. Record. 126:522-525.

Edwards, LN. 2009. Understanding the relationships between swine behavior, physiology, meat quality, and management to improve animal welfare and reduce transit losses within the swine industry. Dissertation. Colorado State University, Fort Collins, CO.

Edwards, LN, T Grandin, TE Engle, SP Porter, MJ Ritter, AA Sosnicki, and DB Anderson. 2010. Use of exsanguination blood lactate to assess the quality of pre-slaughter pig handling. Meat Sci. 86(2): 384-390.

Ferguson, DM, HL Bruce, JM Thompson, AF Egan, D Perry, and WR Shorthose. 2001. Factors affecting beef palatability—farmgate to chilled carcass. Aust. J. Exper. Ag. 41: 879-891.

Finnie, JW, PC Blumbergs, J Manavis, GE Summersides, and RA Davies. 2000. Evaluation of brain damage from penetrating and non-penetrating captive bolt using lambs. Aust. Vet. J. 78:775-778.

Forslid, A. 1987. Transient neocortical, hippocampal and amygdaloid EEG silence induced by one-minute inhalation of high concentration CO_2 in the swine. Acta. Phys. Scandinavica. 130:1-10.

Frasier, Tim. Handling Help. Available: https://frasierbison.com/bison-consultation/handling-help/ Accessed May 5, 2023.

Gibson, TJ. 2015 Effect of neck position on time to collapse in halal slaughtered cattle without stunning. Meat Sci. 110:310-314.

Gibson, T.J. et al. 2019. Electroencephalographic assessment of pneumatically powered penetrating and non-penetrating captive bolt stunning of bulls. Meat Sci. 151:54-59.

Gilbert, KV, CJ Cook, and CE Devine. 1991. Electrical stunning in cattle and sheep: Electrode placement and effectiveness. Proc. 37th Int. Congress Meat Sci. Technol. p. 245-248. Kulmbach, Germany.

Grandin, T. 1985/1986. Cardiac arrest stunning of livestock and poultry. In: Fox MW, and LD Mickley (Eds.). Advances in Anim. Welfare Sci. Martinus Nijhoff, Boston, MA. pp. 1-30.

Grandin, T, SE Curtis, TM Widowski, and JC Thurman. 1986. Electro-immobilization versus mechanical restraint in an avoid-avoid choice test. J. Anim. Sci. 62:146-1480.

Grandin, T. 1988. Behavior of slaughter plant and auction employees towards animals. Anthro-zoo. 1:205- 213.

Grandin, T. 1988. Possible genetic effect on pig's reaction to CO_2 stunning. Proc. Intl. Congress of Meat Sci. and Tech. Brisbane, Australia. 34:96-97.

Grandin, T. 1991a. Recommended animal handling guidelines for meat packers. American Meat Institute. Washington, DC.

Grandin, T. 1991b. Principles of abattoir design to improve animal welfare. In: J. Matthews (Editor) Progress in Agric. Physics and Engineering. Oxon CAB International, Wallingford, UK. p. 279-304.

Grandin, T. 1993a. Report on handling and stunning practice in Canadian meat packing plants. Conducted for Agriculture Canada, the Canadian Federation of Humane Societies, and the Canadian Meat Council.

Grandin, T. 1994. Euthanasia and slaughter of livestock. J. of Am. Vet. Med. Assoc. 204:1354-1360.

Grandin, T and JM Regenstein. 1994. Religious slaughter and animal welfare: A discussion for meat scientists. Meat Focus International, Oxon CAB International, Wallingford, UK. p. 115-123.

Grandin, T. 1995. Restraint of livestock. Proc. of the Animal Behavior and the Design of Live-stock and Poultry Systems International Conference, Northeast Regional Agricultural Engineering Service. Cornell University, Cooperative Extension, Ithaca, NY. p. 208-223.

Grandin, T. 1996. Factors that impede animal movement at slaughter plants. J. Am. Vet. Med. Assoc. 209:757-759.

Grandin, T. 1997. Survey of handling and stunning in federally inspected beef, pork, veal and sheep slaughter Plants. ARS Research Project No. 3602-32000-002-08G, USDA.

Grandin, T. 1998a. Objective scoring on animal handling and stunning practices in slaughter plants. J. of Am. Vet. Med. Assoc. 212:36-39.

Grandin, T. 1998b. The feasibility of using vocalization scoring as an indicator of poor welfare during slaughter. Appl. Anim. Behav. Sci. 56:121-128.

Grandin, T. 2000. Effect of animal welfare audits of slaughter plants by a major fast food company on cattle handling and stunning practices. J. of Am. Vet. Med. Assoc. 216:848-851.

Grandin, T. 2001a. Solving return to sensibility problems after electrical stunning in commercial pork slaughter plants. J. Am. Vet. Met. Assoc. 219: 608-611.

Grandin, T. 2001b. Cattle vocalizations are associated with handling and equipment problems at beef slaughter plants. Appl. Anim. Behav. Sci. 71:191-201.

Grandin, T. 2001c. Ante mortem handling and welfare. In: Hui, YH, WK Nip, RW Rogers, and OA Young (Ed.). Meat Sci. and App. Marcel Dekker, New York, NY. p. 221-253.

Grandin, T. 2005/2007. Progress and challenges in animal handling and slaughter in the U.S. Applied Animal Behavior Science. 100:129-139.

Grandin, T. 2007. Handling and welfare of livestock in slaughter plants. In: Grandin, T. (Ed.) Livestock Handling and Transport. Oxon CAB International, Wallingford, UK. p.329-353.

Grandin, T. 2012. Developing measures to audit welfare of cattle and swine at slaughter. Anim. Welfare. 21: 351-356.

Grandin, T. 2013. Making slaughterhouses more humane for cattle, swine, and sheep. Annual Reviews. 1(1): 491-512.

Gregory, NG. 1988. Humane slaughter. Proc. 34th. Int. Cong. Meat Sci. Tech. Workshop on Stunning Livestock. Brisbane, Australia.

Gregory, NG and SB Wotton. 1984. Sheep slaughtering procedures. III. Head to back electrical stunning. British Vet. J. 140:570-575.

Gregory, NG. 1993. Slaughter technology. Electrical stunning of large cattle. Meat Focus Intl. Oxon CAB International. Wallingford, UK. 2:32-36.

Gregory, NG. 1994 Pre-slaughter handling, stunning and slaughter. Meat Sci. 36:45-46.

Gregory, NG. 369. 2001. Current profiles during electrical stunning. Intl. Cong. of Meat Sci. and Tech. 46:368-

Gregory, NG. 2008. Animal welfare at markets and during transport and slaughter. Meat Sci. 80:2-11.

Gregory, NG. 2012. Complications during Shechita and Halal slaughter without stunning in cattle. Anim. Welfare. 21:81-86.

Griez, E, J Zandbergen, and J Pols. 1990. Response to 35 percent CO_2 as a marker of panic and severe anxiety. Am. J. Psychiatry. 147:796-797.

Grillner, T. 2011. Neuroscience, human locomotors circuits conform. 334:912-913.

Hartung, J, B Nowak, KH Waldmann, and S Ellerbrock. 2002. CO_2 stunning of slaughter swine, effects of EEG, catecholamines and clinical reflexes. Deutsche Tierarztliche Wochenschrift. 109:135-139.

Hayes, NS. 2015. The relationship to pre-harvest stress and carcass characteristics of beef heifers that qualified for kosher designation. Meat Sci. 100:134-136.

Hemsworth, PH, M Ric, MG Karlen, L Calleja, and JL Barnett. 2011. Human animal interactions in abattoirs, relationships between handling and animal stress. Appl. Anim. Behav. Sci. 135:24-33.

Hoenderken, R. 1983. Electrical and carbon dioxide stunning of swine for slaughter. In: Ikelenboom, G. (Ed.) Stunning of Animals for Slaughter. Martinus Nijhoff, Boston, MA. p. 59-63.

Jongman, EC, JL Barnett, and PH Hemsworth. 2000. The aversiveness of carbon dioxide stunning in swine and a comparison of CO_2 crate vs. the V restrainer. Appl. Anim. Behav. Sci. 67:67-76.

Kline, HC, LN Edwards-Callaway, and T Grandin. 2018. Field observation: Pen stocking capacities for overnight lairage of finished steers and heifers at a commercial slaughter facility. Appl. Anim. Sci. 35: 130- 133.

Lambooy, E. 1985. Electro-anesthesia or electro immobilization of calves, sheep and swine. Fenix Stockstill. Vet. Quarterly. 7:120-126.

Lambooij, B, S Gerard, M Merkus, NV Voorse, and C Pieterse. 1996. Effect of low voltage with a high frequency electrical stunning on unconsciousness in slaughter swine. Fleischwirtschaft. 76:1327-1328.

Lanier, JL, T Grandin, RD Green, D Avery, and K McGee. 2000. The relationship between reaction to sudden intermittent movements and sounds and temperament. J. Anim. Sci. 78:1467-1474.

Lewis, C.R.G. and McGlone, J.J., 2007. Moving finishing swine in different group sizes: Cardiovascular responses, time, and ease of handling. Livest. Sci. 107:86-90.

National Bison Association. Bison Behavioural Management and Handling Facilities Design. Available: https:// bisoncentral.com/bison-behavioural-management-and-facilities-design/ Accessed May 5, 2023.

National Pork Board. 2018. Swine Care Handbook. Pg 15. Available: https://library.pork.org/?mediaId=B75B3A6A-75B3-441B-9A316C342353D356 Accessed December 9, 2022.

National Pork Board. 2020. Transport Quality Assurance Handbook. Version 7. Pg 29, 35. Available: https:// www.porkcdn.com/sites/all/files/documents/TQA/V7.0/TQA_v7_HandbookEnglish.pdf Accessed September 26, 2022.OIE. 2017. Terrestrial Animal Health Code, Chapter 7.5. Slaughter of Animals. World Organization for Animal Health. Paris, France.

Oliviera, S.E.O. et al. 2018. Effectiveness of pneumatically powered penetrating and non-penetrating captive bolts in stunning cattle. Meat Sci. 140:9-13.

Pascoe, PJ. 1986. Humaneness of electro-immobilization unit for cattle. Am. J. Vet. Res. 10:2252-2256.

Raj, AB, SP Johnson, SB Wotton, and JL McInstry. 1997. Welfare implications of gas stunning of swine. The time to loss of somatosensory evoked potentials and spontaneous electrocorticograms of swine during exposure to gases. Vet. Rec. 153:329-339.

Ritter, MJ, M Ellis, J Brinkman, JM DeDecker, KK Keffaber, ME Kocher, BA Peterson, JM Schlipf, and BF Wolter. 2006. Effect of floor space during transport of market-weight swine on the incidence of transport losses at the packing plant and the relationships between transport conditions and losses. J. Anim. Sci. 84 (10): 2856-2864.

Ritter, MJ, M Ellis, CR Bertelson, R Bowman, J Brinkmann, JM DeDecker, KK Keffaber, CM Murphy, BA Peterson, JM Schlipf, and BF Wolter. 2007. Effects of distance moved during loading and floor space on the trailer during transport on losses of market weight swine on arrival at the packing plant. J. Anim. Sci. 85(12): 3454-3461.

Rushen, J. 1986. Aversion of sheep to electro-immobilization and physical restraint. Appl. Anim. Behav. Sci. 15:315-324.

Sutherland, MA, A McDonald, and JJ McGlone. 2009. Effects of variations in the environment, length of journey, and type of trailer on the mortality and morbidity of swine transported to slaughter. Vet. Rec. 256: 13-18.

Terlouw, EMC, C Courquet, V Deiss, and C Mallet. 2015. Origins of movements following stunning during bleeding in cattle. Meat Sci. 110:135-144.

Terlouw, EMC, C Bourquet, and V Deiss. 2016a. Conscious, unconsciousness and death in the context of slaughter, Part 1, Neurological mechanisms underlying, stunning, and killing. Meat Sci. 118:133-146.

Terlouw, EMC, C Bourquet, and V Deiss. 2016b. Conscious, unconsciousness, and death in the context of slaughter, Part 2, Evaluation of Methods. Meat Sci. 118:147-156.

Troeger, K. and W. Woltersdorf. 1989. Measuring stress in swine during slaughter. Fleischwirtsch. 69 (3):373-376.

Van de Perre, V., Permentier, L., De Bie, S., Verbeke, G. and Geers, R., 2010. Effect of unloading, lairage, pig handling, stunning and season on pH of pork. Meat Sci. 86:931-937.

Van de Wal, PG. 1978. Chemical and physiological aspects of pig stunning in relation to meat quality - A review. Meat Sci. 2:19-30.

Velvarde, A, JL Ruiz de la Torre, C Stub, A Diestre, and X Manteca. 2000. Factors affecting the effectiveness of head-only electrical stunning in sheep. Vet. Rec. 147:40-43.

Verhoeven, MTW, MA Gerritzen, LJ Hellebrekers, and B Kemp. 2016(a). Validation of indicators to assess unconsciousness in veal calves at slaughter. Animal. doi:10.1017/5173/16000422.

Verhoeven, MTW, MA Gerritzen, M Kiviers-Poodt, LJ Hellebrekers, and B Kemp. 2016(b). Validation of behavioral indicators used to assess unconsciousness. Res. Vet. Sci. 101:144-153.

Warrington, PD. 1974. Electrical stunning: A review of literature. Vet. Bulletin. 44:617- 633

Warriss, PD, SN Brown, and SJM Adams. 1994. Relationships between subjective and objective assessments of stress at slaughter and meat quality in swine. Meat Sci. 38:229-340.

Warriss, PD, SN Brown, JE Edwards, and TG Knowles. 1998. Effect of lairage time on levels of stress and meat quality in swine. Animal Sci. 66(1): 255-261.

Waynert, DE and JM Stookey. 2000. Vocal behavior in cattle. The animal's commentary on its biological process and welfare. Appl. Anim. Behav. Sci. 67:15-33.

Wenzlawowicz, MV, A Schutte, KV Hollenbon, AV Altrock, N Bostelman, and S Roeb. 1999. Field study on the welfare and meat quality aspects of Midas pig stunning device. Fleischwirtschaft. 2:8-13.

White, RG, JA DeShazer, CJ Tressler, GM Borcher, S Davey, A Warninge, AM Parkhust, MJ Milanuk, and ET Clems. 1995. Vocalizations and physiological response of swine during castration with and without anesthetic. J. Anim. Sci. 73:381386.

Wotton, SB, NB Gregory, and ID Parkman. 2000. Electrical stunning of cattle. Vet. Rec. 147:681-684.

APPENDIX I: DESIGNING FACILITIES FOR OPTIMAL HANDLING

Pen space and Stocking Density

Pen space allocations may vary depending upon weather conditions, animal sizes, and holding times such as overnight or a few hours during the day.

All species should be able to lie down if held overnight.

As a rough guideline:

Cattle: These stocking rates will provide adequate room for "working space" when animals are moved out of the pen (Kline *et al.*, 2018).

Cattle may be overstocked if they do not have room to lie down and are held overnight

- 20 sq. ft (1.87 sq. m) should be allotted for each 1,200 lb (545 kg) animal.
- 22 sq. ft (2.04 sq. m) should be allotted for each 1,400 lb (635 kg) animal.
- 23 sq. ft (2.13 sq. m) should be allotted for each 1,500 lb (680 kg) animal.
- 24 sq. ft (2.22 sq. m) should be allotted for each 1,600 lb (720 kg) animal.

Swine

- 8 sq. ft (0.74 sq. m) should be allotted for each 275+ lb swine (125 kg) (Swine Care Handbook, National Pork Board, 2018)
- 11-12 sq. ft (1.03 – 1.12 sq. m) should be allotted for each mature sow
- Up to 40 sq. ft (3.74 sq. m) should be allotted for each mature boar to reduce fighting. Another alternative is to pen them individually (Swine Care Handbook, National Pork Board, 2018).

Sheep

- 5 sq. ft (0.46 sq. m) should be allotted for each market weight lamb
- 6 sq. ft (0.55 sq. m) should be allotted for each mature sheep

Bison temperament should be taken into consideration when determining pen stocking rate. Bison should have adequate space to lay down if held overnight.

Adequate pen space is important because not only do animals need room to move away from the handler and out of the pen, but U.S. regulations require that they must have room to move to available water (9 CFR 313.2(e)).

Per Canadian regulations, slaughter establishments must provide holding pens designed to allow as many animals as possible to stand or lie down against a wall:

- Cattle and swine, in particular, like to lie along walls.
- As a best practice: if all the animals were moved into one corner, there should be approximately 1/3 of the pen empty.
- The holding pens should provide sufficient space for rest, thermal comfort and to move around freely.
- The space allowance per animal is a more important factor than the group size to reduce aggression as does mixing of unacquainted animals in the same pen.
- There should be sufficient room for animals to move, stand, and lie down simultaneously with unimpeded access to the water supply

Unloading Facility Design

For all species, plants should have sufficient unloading capacity so trucks can unload promptly. Unloading ramps should have a level dock before the ramps go down so animals may walk on a level surface when they exit the truck. A good target for the ramp slope is no more than 20° (it may go up to 25° for adjustable ramps). Stair steps are recommended on concrete ramps because they provide better traction than cleats or grooves when ramps are dirty. Unloading ramps should be designed where trucks can back up flush and square to prevent gaps where animals can be injured.

- For cattle, the recommended stair step dimensions are 3 ½ in (10 cm) rise and a 12 in (30 cm) long tread. If space permits, an 18 in (45 cm) long tread will create a more gradual ramp. For market swine, a 2 ½ in (6.5 cm) rise and a 10 in (26 cm) tread works well. On adjustable ramps which allow for changes in the degree of angle, cleats with 8 in (20 cm) of space between them are recommended. All flooring and ramp surfaces should be non-slip to avoid injury.

Canadian regulations cite the following ramp slope angles for different species:

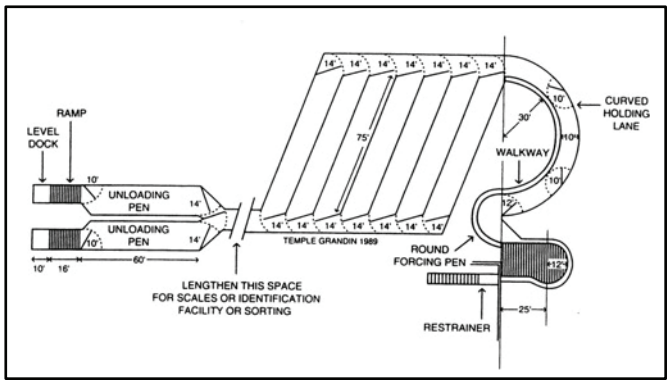
- Swine: 20°
- Cattle: 25°
- Sheep: 35°

Note: Unloading design should follow industry best practices outlined in the BQA Transportation Manual, 2020; TQA Handbook (National Pork Board, 2020); and Canadian Livestock Transport Program.

Handling Facility Layout Considerations

The diagram below illustrates a cattle lairage and chute system.

- Animal movement is one-way and there is no cross traffic.
- Each unloading pen can usually hold a full truck load. The pens may also be made double the width to hold two truckloads in each pen. Unloading pens are recommended to facilitate prompt unloading. Long, narrow diagonal pens eliminate sharp corners and provide one-way traffic flow. The animals enter through one end and leave through the other.
- The basic layout principles are similar for all species, but there is one important difference: cattle and sheep crowd pens should have a funnel entrance, but swine crowd pens must have an abrupt entrance because swine will jam in a funnel.
- A crowd pen should never be installed on a ramp because animals will pile up in the crowd pen. If ramps have to be used, the sloped portion should be in the single file chutes. In swine facilities, level stockyards and chute systems with no ramp are most effective. Facilities should be designed with level flooring with a slope or grade sufficient for drainage only.

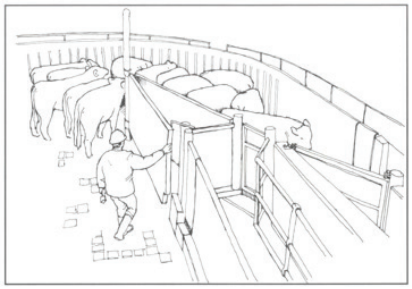


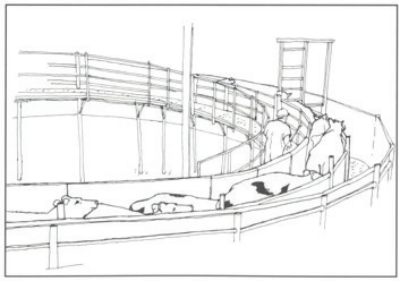
Example of chute system

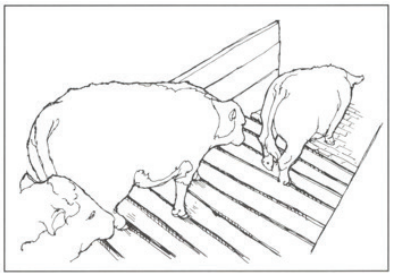
As a guideline, the recommended radii (length of crowd gate) are:

- Cattle: 12 ft (3.5 m)
- Swine: 8 ft (2.5 m)
- Sheep: 8 ft (2.5 m)

The crowd pen or bud box and curved chute facilitate movement of livestock and take advantage of the natural tendency of animals to circle. A curved chute also prevents them from seeing the other end while they are standing in the crowd pen. A curved chute with too sharp a bend at the junction between the single file chute and the crowd pen will create the appearance of a dead end. Livestock will balk if a chute looks like a dead end.


Crowd pen


Curved chute


Unloading ramp

Bison Handling Facility Layout Considerations

- Systems designed for handling bison should limit direct exposure of the handler to the bison.
- Facilities should be designed to reduce bison speed during handling via barriers such as gates.
- Pens and alleys should have gates to prevent bison from doubling back.
- Alley gates or set gates should be solid or opaque but with the horizontal supports of the gate exposed to the inside and available as footholds for handlers in systems that require handlers to be in with the bison.
- Bison should be able to move away from the handler as they advance through the handling system
- Systems should be compatible with handling horned animals.

APPENDIX II: TROUBLESHOOTING GUIDE

Finding Distractions that Hinder Easy Movement

Problem: Animal refuses to move through an alley, chute or race.

POSSIBLE CAUSES:

If animals refuse to move through an alley, chute or race, there may be a very simple solution. Once the area is clear and when safe to do so, step into the race to see what distractions may be hindering movement. Any one of the items on the following list may cause animals to stop moving or back up and prevent a properly designed facility from working efficiently. In some facilities, two or three different distractions must be addressed before animals will move easily. Often, identifying the problem requires trial and error.

LOOK FOR:

- **Sparkling reflections on puddles** that can be eliminated by moving a light fixture.
- **Reflections** on smooth metal that can be minimized by lighting changes.
- **Clothing or other equipment hung** on the fence that can be removed.
- **Moving piece of plastic** that can be secured or removed.
- **Fan blade movement** that can be blocked by installing a shield to block the animals' view.
- **Seeing people** moving up ahead. Install a shield so approaching animals cannot see them.
- **Small object on the floor** such as a coffee cup, hose, or paper.
- **Changes in flooring and texture** that can be made uniform.
- **Drain grate** on the floor that can be moved to another location outside races.
- **Sudden changes in the color of equipment or flooring**. Colors with high contrast like yellow are the worst for cattle. Use of uniform and consistent floors and walls can facilitate movement.
- **Race entrance is too dark**. Animals prefer to move from a darker place to a brighter place.
- **Bright light such as blinding sun**. Animals will move from a darker place to a brighter place, but they will not move toward blinding light. Examples of blinding light are looking into the sun or a bare light bulb.
- **Chains that jiggle** and can be fastened.
- **Metal clanging or banging** that can be secured. Rubber stops can be used on gates, for example, to prevent clanging.
- **High pitched noises** and other **loud or reverberating noises** that can be silenced.

- **Air hissing** that can be silenced with mufflers or piped outside.
- **Air drafts blowing** toward approaching animals, which can be redirected away from them.
- **One-way and back-up gates.** Install them two to three body lengths away from the crowd pen. Equip the one-way gate near the crowd pen with a device so that it can be held open when the single file race is filled. Many facilities have too many backup gates. Try tying them open.

Resolving Problems in Center Track Conveyor Restrainer Systems and V-Belt Restrainer Systems for Cattle, Swine, and Sheep

Problem: Animal stops at entrance and refuses to enter.

POSSIBLE CAUSES:

- **Hold-down rack is too low and the animal bumps its shoulder as it enters**. Raise hold-down so that there is approximately 4 in (10 cm) of clearance for the tallest animal. The hold down should be solid to block vision.
- **Entrance is too dark or light is causing a problem**. Install a light that illuminates the entrance. The light must not shine in an approaching animal's eyes or create shadows.
- **Slick floor**. Animals panic when they slip. Rods can be welded to floor to provide a non-slip floor, but make sure the rods are welded flush to each other, not on top of each other. The entrance ramp into the restrainer must be non-slip.
- **Water spray or runoff close to the entrance**. Animals can see or feel the water.
- **Entrance ramp is missing**. Reinstall entrance ramp. Forcing an animal to jump into a restrainer frightens it. See diagrams on www.Grandin.com.
- **Leg spreader is too wide and it bumps the inside of the animals' legs**. This problem only occurs in center track restrainers. See diagrams on www.Grandin.com.
- **No false floor**. On all types of restrainers, animals will be afraid to enter if they see a steep drop off (visual cliff) below the restrainer. Install a solid false floor approximately six inches (15 cm) below the feet of the largest animal. See diagrams on www.Grandin.com.
- **No belly rails**. On center track restrainers, belly rails keep the animal centered over the leg spreader bar. See diagrams on www.Grandin.com.
- **Distractions in plant.** Install a curtain at the exit end of the restrainer. Install metal shields on box-type restrainers to block animals' vision. Look through the restrainer for distractions such as moving conveyor, a yellow apron, or sparkling reflections on a moving piece of equipment.
- **Broken sharp edges in entrance**. Repair or replace entrance parts. Plants should do daily pre- operations checks on restrainers to ensure the entrance is in good repair.

Problem: Animal struggles and vocalizes in the conveyor restrainer.

POSSIBLE CAUSES:

- **V conveyor sides run at different speeds**. Both sides must run at the same speed. To test this, mark each side with tape or a crayon. After three revolutions the marks should be no more than 4 inches apart from each other, or the width of one slat.
- **Hold down too short**. On all types of restrainers, the animal must be completely restrained and riding on the conveyor with its feet off the entrance ramp before its head emerges from under the hold down. The principle is blocking vision until the animal is fully restrained.
- **Broken slats and other parts**. Sharp edges that stick into animals will cause struggling. On the center track restrainer, the metal guides along the conveyor must not be bent. Replace broken or bent slats. Slats must line up and provide a smooth continuous surface.
- **Hold-down too high**. This is most likely a problem when small animals are handled. Install a flexible curtain on the discharge end of the hold down rack to block the vision of smaller animals.
- **Adjustable sides not centered**. Struggling is more likely to occur if the adjustable sides of the center track conveyor push the animal to one side and make it feel off balance. Adjustable sides should be at the same setting on both sides.

Resolving Electrical Stunning Problems

Problem: Animal blinks within five seconds after stunning.

POSSIBLE CAUSES:

- **Electrode is placed in the wrong position and the electrical current fails to go through the brain**. The animal blinks because the stunner failed to induce the grand mal epileptic seizure that is required to induce instant insensibility.
- **The electrical amperage may be too low**. Even though the electrode is in the correct position, there is not enough current passing through the brain to induce a grand mal epileptic seizure. The amperage and/ or voltage should be checked and may need to be increased.
- **Other electrical or maintenance issues with the system or wand.**
- **High electric resistance of the animal**. This is especially a problem in old sows or dehydrated animals.
- **Electrode contact area is too small or the electrodes are dirty**. Increase surface area of electrode or clean them.
- **The animal is too dry, which results in high electrical resistance**. This is most likely to be a problem in cattle or sheep and continuous wetting during the stun may be required in these two species.

Additionally, animals that are dehydrated may have high electrical resistance and be difficult to stun, so proper hydration prior to stunning is important.

Problem: The initial stun appears to be done correctly but the animal blinks or shows other signs of return to sensibility 30 to 90 seconds after stunning.

POSSIBLE CAUSES:

- **The stunning-to-bleed interval is too long**. This is especially a problem with head-only reversible stunning. The solution is to shorten the interval between stunning and bleeding.
- **Poor bleeding** if an animal shows a sign of return to sensibility after it has been bled. This can occur in cardiac arrested animals because there are always a few animals in which the heart is not stopped. Training of the person doing the bleeding will usually solve this problem.
- **Poor initial contact** results in the animal receiving a stunning time that is too short. A common cause is a fatigued operator.
- **Interrupted contact**. The stunning wand or tongs may bounce or slide during the stun and result in a stunning time that is too short. Poor design of the stunning wand is a likely cause. Another cause can be an overloaded stunner operator who is stunning more animals than he can easily handle.
- **Placement of the head electrodes in the wrong position on the head**. Reposition the electrodes so that the electrical current will pass through the brain.

Supplemental Information on Electric Stunning

Cattle

The WOAH (2016) requires a minimum of 1.5 amps applied across the head to induce immediate epileptiform activity in the electroencephalogram (EEG) of large cattle. Typical stunning systems in the U.S. are 60 Hz.

Modifications that would result in higher initial frequencies are not recommended. The frequency may rise after the initial application. A frequency of 60 or 50 Hz should be used unless higher frequencies are verified in cattle by either electrical or neurotransmitter measurements taken from the brain. A more recent study has shown that 1.15 amps sinusoidal AC 50 Hz applied for one second across a bovine's head is effective to induce insensibility (Wotton et al., 2000). A longer application is usually required to depolarize the spine to reduce kicking (up to 15 seconds).

A single 400-volt, 1.5-amp current passed from the neck to the brisket failed to induce epileptic form changes in the brain in cattle. Observations in plants outside the U.S. indicate that a single current passed from the middle of the forehead to the body appears to be effective, but research is needed to verify this.

Swine

Research has shown that too high an electrical frequency will fail to induce insensibility and is most effectively induced at frequencies of 50 Hz (Anil and McKinstry, 1992). Frequencies from 2000 to 3000 Hz failed to induce instant insensibility and may cause pain (Croft, 1952; Warrington, 1974; Van der Wal, 1978).

However, in swine weighing less than 200 lb. (80 kg), research has shown that a high frequency 1592 Hz sine-wave or 1642 Hz square wave head; only stunning at 800 ma (0.80 amp) would induce seizure activity and insensibility in small swine (Anil and McKinstry, 1992). One disadvantage is that the swine regained sensibility more quickly compared to stunning at 50 to 60 Hz. The swine in this experiment weighed one-third less than comparable U.S. market swine and this probably explains why the lower amperages were effective.

Other research has shown that stunning swine with frequencies higher than 50 to 60 Hz is effective. This is the type of stunning used in many large U.S. pork slaughter plants. In this experiment, the swine were stunned with a head only applicator. High frequency stunning has never been verified to induce instant insensibility when applied as a single stun with a head to body electrode. Equipment is commercially available for stunning swine at 800 Hz applied across the head by two electrodes and a second stun with 50 to 60 Hz from head to body. Research has shown that 800 Hz is effective when applied by two electrodes across the head (Wenzlawowicz et al., 1999; Lambooij et al., 2007).

Resolving Captive Bolt Stunning Problems

Problem: Poor captive bolt stun outcomes.

Possible Causes:

- **Stunner has not been maintained**. A dirty stunner will lose bolt velocity. High bolt velocity is required for an effective stun.
- **Damp cartridges for a cartridge-fired** stunner. Cartridges must be kept in a dry place. Cartridges should not be stored long-term in the slaughter room. However, it is acceptable to store cartridges needed for that day's production in the slaughter room.
- **Incorrect cartridges or stunner** for the species, size, and maturity of animal being stunned.
- **An overheated cartridge-fired stunner will lose bolt velocity**. Rotate cartridge-fired stunners to prevent overheating.
- **Worn cylinder bore on a pneumatic stunner**. Even when the stunner has been serviced correctly, the machined cylinder bore eventually wears out and the stunner will lose hitting power. At this point the stunner will have to be replaced. A clean air supply will help prevent cylinder wear.
- **Poor ergonomics of bulky pneumatic** stunners. Adding additional handles will aid positioning. When a pneumatic stunner is used with a conveyor restrainer, it is often easier to position the stunner if it is hung from the balancer on a 30-degree angle.

- **Stunner operator chases the animal's head**. The operator should be trained to wait for the animal to stop moving and then position the stunner.
- **Excited animals**. Careful, quiet handling and driving of animals into the stun box or restrainer will provide calm animals that are easier to stun correctly.
- **Air pressure too low to power a pneumatic stunner or water in the air lines**. Use the air pressure setting recommended by the manufacturer. This usually requires a dedicated compressor, which powers only the stunner.
- **Slick floor** in stunning box causes cattle to become agitated.
- **Poor placement or angle**. Stunner is not placing the captive bolt flush against the head or not placing the bolt in the correct anatomical location for the species.

Resolving CO_2 Stunning Problems

Problem: Stunning is ineffective; animals are not rendered completely insensible.

Possible Causes:

- **Low CO_2 concentration**. Increase the gas concentration.
- Mechanical issues or **CO_2 calibration issues**.
- **Exposure time is too short**. Slow down the number of swine which are moved through the system.
- **The time between the exit from the CO_2 chamber and bleeding is too long**. To prevent recovery from the anesthesia, bleed the animals more quickly. This is most likely to be a problem in small CO_2 machines that have a short gas exposure time.
- **Poor bleeding technique**. If animals show signs of return to sensibility after bleeding, the person doing the bleeding may need more training.

Resolving Head Holder Vocalization Problems

Problem: High vocalization in both upright and rotating restraint devices

Possible Causes:

- **Excessive pressure applied by the restraint box to either the head or the body**. On hydraulic systems, a separate pressure relief valve should be installed on the head holder, which will automatically stop before excessive pressure is applied. On pneumatic systems, the valves should be designed to provide the operator with the ability to stop an air cylinder in midstroke. The valve handle should return to the neutral position, when the operator either lets go of the handle or stops pushing the button on a solenoid controlled valve. On most restraint boxes, new valves and pressure limiting systems can be easily installed. Purchasing a new box is usually not required. Excessive pressure is a major cause of a high percentage of cattle vocalizing.
- **Sharp edges and pinch points**. Vocalization may occur if the animal's skin is pinched by either the head holder or body restraint.
- **Excessive electric prod use**. Train employees to reduce electric prod use. If cattle refuse to enter the box, look for the following distractions that stop cattle movement.
- **Seeing people or moving equipment** through the head holes.
- **Reflections** on shiny metal.
- **Air blowing** into the face of an approaching animal.
- **Water spraying**.
- **Animal left in the box too long**. Perform slaughter promptly after the head holder is applied. In a rotating box, perform the cut immediately after rotation.
- **Body not fully supported in rotating box**. The best rotating boxes have an adjustable side panel and a back rest to prevent shifting of the body during rotation.
- **Slipping on the floor** in either the lead up alley or in the box before restraints are applied. Nonslip flooring should be installed.
- **Sudden jerky motion of all parts of the box**. Use flow controls to slow the motion of all parts of the box. This is especially important for the head holder.

APPENDIX III: WORKER SAFETY TIPS FOR ANIMAL HANDLERS AND STUNNERS

Working with livestock in a plant setting can be challenging and unpredictable. It is essential that safety be a priority when handling and stunning animals. In addition to following all company worker safety procedures, below are a series of safety tips that can help protect employees.

Livestock Facility

- Be alert around the unloading dock. A truck driver backing in may not be able to see you.
- Never enter the crowd pen or other confined space with agitated, excited livestock.
- Man-gates and other devices must be installed so people can easily escape from agitated livestock. This is especially important for areas with solid fences. In concrete fences, toeholds can be formed in the walls to make concrete steps.
- If prods are wired into the house current, they must always be wired through a transformer.
- Inspect latches on stunning boxes to make sure they latch securely. Before the next animal is admitted to the box, check the latch. All safety guards must be kept in place over moveable side exposed pinch points that could be easily touched by employees during normal operation of the restrainer system equipment.
- If a worker has to get inside a restrainer conveyor system to un-jam it, lock it out first per company policy to prevent somebody else from turning it on.
- Facility design in the stunning area should prevent cattle from entering other parts of the plant.

Electric Stunning

- The stunner operator's station must be kept dry.
- The operator should wear rubber boots and stand on non-conductive plastic grating.
- The restrainer frame and worker walkway structure should be grounded to a perfect ground.
- The side of the restrainer that the stunner operator can touch should be covered with heavy insulating material.

Captive Bolt Stunning

- Keep cartridges dry.
- Never hold a hand or finger over the stunner air vent.
- Cartridge-fired stunners must ALWAYS be un-cocked before they are set down.
- NEVER, EVER throw a cartridge-fired stunner to another person.
- If the bolt gets stuck in the skull of an animal, let go and wait until the animal stops kicking to remove it.
- Cartridge-fired stunners must always be kept unloaded when they are being carried.
- Good maintenance is essential with stunners to prevent the bolt getting stuck or excessive recoil, which can strain and injure the operator's hands, arm, or back.
- The use of a cartridge gun holder is considered a best practice. Do not lay a gun on the edge of a stun box.
- Never test-fire a cartridge-fired stunner in the air. Without any resistance, the bolt can break and become a projectile. Follow manufacturer recommendations for test firing.

Firearms

- Always point the muzzle of guns away from people.
- Guns must not be loaded until ready to shoot.
- Maintenance is critical.

 FSIS Notice 56-06 *Firearms at the Worksite* should be referenced, and all local, state and federal laws adhered to.

Safe Livestock Handling

- Handle livestock quietly. Excited animals are more likely to cause accidents.
- Stay out of the blind spot behind the rear end and kick zone to the side of large livestock. Livestock are more likely to kick an unseen handler.
- Do not try to stop an animal that is running and has separated from the group.
- A single, lone, agitated animal can be very dangerous and may cause injury during handling. Many serious livestock handling injuries are caused by a single agitated animal.
- Escaped livestock should not be chased. An animal that is loose on the plant grounds may return to the stockyard if it is left alone. If an animal gets loose inside the plant, employees should stay quiet while one designated person either stuns it or eases it out a door.

Safe Bison Handling

- Only experienced handlers with a means to escape should enter a pen with bison.
- Release pressure when bison are agitated and allow them to calm down.
- Too many handlers can become threatening, reduce the number of handlers if they are becoming agitated.
- Auditors may be asked to move to get out of the flight zone of the bison to ensure safety for the handlers.
- Raised voices and additional noise can agitate bison and create an unsafe environment, handlers should remain calm with minimal noise.
- Never enter a trailer with bison.