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ANIMAL WELFARE

INTRODUCTION

Animal welfare is widely defined as physical and mental well-being of animals. It can be measured by indicators that include behavior, physiology, longevity, and reproduction.

The term animal welfare can also mean human concern for animal well-being or a position in a debate on animal ethics or expressed via standards and regulations supported by science to certain extent.

Concerns for animal welfare are usually based on ethics, awareness that non-human animals are sentient and that consideration should be given to their well-being, especially when they are used by humans. These concerns can include how animals are farmed and killed for food, how they are used for scientific research, how they are kept as pets, and how human activities affect the survival of endangered species. First societal rules, how to treat animals were reflected in religions

An ancient object of concern in some civilizations, animal welfare began to take a larger place in Western public policy in 19th-century Britain. Today it is a significant focus of interest in veterinary science, animal sciences, bio-medical research and has growing meaning globally.

In Western culture and philosophy animal welfare and use of animals is based on so called “contractarian utilitarianism”. Translated to practical language it means animals use by humans is morally justifiable if the overall benefits are larger than losses. In that case benefits include these to humans (animal products) and animals (protection, care, food, shelter) as well. Based on that view Killing animals (e.g. for food) may be justified if the farming conditions are not detrimental to animal welfare and the killing is humanely performed.

ANIMAL WELFARE CONCEPTS

In 20th century there were attempts to express animal welfare more precisely in general definitions and concepts, The most known concept is covering basic animal needs is concept of Five freedoms. The Five freedom concept has been modified to assess animal welfare at certain point of its life.

The newer more recent concept of “life worth living” introduced by British Farm Animal Welfare Council looks at the welfare of an animal during its entire life ‘A life worth living’ is a statement about an animal’s quality of life (in an animal life context) during its lifetime, including the manner of its death i.e. life of chicken broiler in certain production system taking account all phases of production chain.

According to that concept – the balance of an animal’s experiences must be positive over its lifetime. Any pain, suffering, distress or lasting harm must be necessary (or unavoidable), proportionate and minimal. The system of husbandry and care should provide animals’ needs (basic) and certain wants (animal’s preferences)
The notion of a life not worth living is one with which veterinarians and many livestock farmers are familiar in the context of disease or injury. How can we usefully determine when an individual animal – rather than a group of animals - has a life that is not worth living? The term ‘worth’ is a measure of value to the animal so the guiding principle should be to determine the extent and balance of an animal’s quality of life.

Of particular relevance are the following. Does the system or practice induce severe negative mental states, frustrate normal behaviour, preclude positive experiences or cause physical debilitation? Does the system fail to meet the physiological and mental needs of the animal? Examples of a life not worth living are an animal suffering a severe debilitating disease that is untreatable, a severe physical state such as starvation or dehydration, and severe negative mental states, such as chronic, intense pain, fear or distress. In each case, a good stockman would either treat the animal swiftly or euthanize it promptly and humanely.

**Image: Social behavior of cattle.**

**Image: Cattle reared on a pasture-based system. Source: Steps**

**QUALITY OF DEATH**

Whilst majority in the global society continues to accept that animals can be killed for food, there is a responsibility on that society to ensure the process causes no unnecessary pain, injury, distress or suffering.
Historically much of the focus when addressing animal welfare at slaughter has been on the method of killing. However, from the animal’s perspective this may only be the final stressor in a sequence of equally or more stressful events such as transport and handling of animals to the slaughterhouse, unloading into a new environment inspection, further handling and restraint.

In 2003 the Farm Animal Welfare Council in their review of welfare at slaughter in the UK identified that in addition to the Five Freedoms, welfare of animals at slaughter should take into account the whole process. The basic principles that must be observed to safeguard good death are:

- Pre-slaughter handling methods and facilities which minimize stress
- The use of competent, well trained and caring personnel
- Appropriate equipment that is fit for purpose
- An effective process that induces immediate unconsciousness and insensibility, or an induction to a period of unconsciousness without distress; and
- A guarantee of non-recovery from that process until death

This framework is important in ensuring that when assessing any slaughter system the whole process is considered, rather than just the killing method.

**ANIMALS BEHAVIOR**

**INTRODUCTION**

Pre-slaughter handling greatly influences the welfare of animals. If a design of slaughter premises does not go hand in hand with good handling practices, there will be a significant challenge in safeguarding good welfare for the animals. According to the OIE standards “Animal handlers should be experienced and competent in handling and moving farm livestock, and understand the behaviour patterns of animals and the underlying principles necessary to carry out their tasks”.

Understanding of cattle behavior is fundamental to recognizing signs of stress and pain, and thus handling them efficiently during this stage. In addition, recognizing the needs of cattle and their relation with rearing environment is essential to providing them with resources in the facilities and during handling that improve welfare. Consequently, there will be equilibrium between ethical production and economic profitability.
We usually distinguish animal’s behaviour as:

- **Innate behavior** – pre-programmed reactions: a calf is born with the potential to express these types of behaviors, as they do not depend on experience and are species-specific;
- **Learned behavior** – depends on experiences lived by each animal, originating from individual experiences.

Animals behavior is very much influenced by capacity or limitations of their senses and therefore we talk about **sensual modalities** too.

**CATTLE BEHAVIOUR**

Cattle originate from the Auroch (*Bos primigenius*) which inhabited Europe and large parts of Asia and North Africa. The Auroch are thought to have been domesticated about 9000 years ago. In India a subspecies of the Auroch was domesticated to give rise to cattle with the characteristic hump and dewlap – *Bos indicus* or zebu type cattle. The hump-less cattle that originated elsewhere are known as *Bos taurus*.

Cattle, like their Auroch ancestors, are grazing animals with a diet that would naturally consist of grasses and grass like plants; herbs, leaves and bushes.

*Bos indicus* and *Bos taurus* breeds have adapted to cope with very different environments and have been selected by man for hundreds of years for different characteristics.

But with common ancestors most basic behaviours are the same. As such it is always shaped to safeguard animal’s survival.

**CATTLE INNATE BEHAVIOR**

Cattle are ruminant animals and in extensive conditions graze for approximately 9 hours a day. This period can be influenced by season, grass height, animal category and breed. Cattle’s diet in extensive conditions basically consists of grasses. Rumination takes around 75% of time spent grazing (6 - 7 hours), and it is interchanged with regurgitation when the bolus returns to the mouth, is chewed and swallowed again. Daily, cattle ingest between 25 and 80 liters of water, and this volume may vary with environment, animal, diet (the greater the percentage of concentrate ration the more water is ingested).
Social (group) living

Cattle are social animals. This trait is a result of ancestral natural selection for benefits such as predator protection. If cattle are alone, the probability of one of them being attacked by a predator is greater than when it is in a group. Escaping is another advantage of group living as several animals running at the same time are difficult for predators to chase.

Cattle raised extensively (on pasture) tend to form groups of cows and their calves, while bulls gather in small groups separately from female cattle. Cattle tend to synchronize their activities and do things together to some extent; they eat, walk, rest, and sleep together. Cattle can recognize up to 70 other animals in the herd and their position in the social rank.

Image: Cattle gathering in group.

To follow that natural pattern of togetherness cattle should be handled in groups. Segregating one animal from the group is stressful. When cattle are socially isolated this tends to alter their behavior and reactivity. They are becoming restless, nervous, more agitated or even aggressive.

Image: Cattle in isolation. Source: Steps

Social dominance

Cattle always tend to establish a social order within the group. This hierarchy is established through fights among animals, with strength and aggressiveness determining dominance order; although, subtle flee-submissive behaviors contribute to the group’s social organization. Height, weight, age, gender, temperament and horns are among the factors that also interfere with dominance formation and maintenance.
In free-range, adult herds of cattle there are several hierarchies among adult males females and juveniles. As they age, young males fight adult females and eventually dominate them.

The hierarchy tends to be linear and large herds probably break down into a series of smaller hierarchies. There is evidence that dominance hierarchies in young beef steers are formed soon after weaning and that they remain stable even when the groups are moved to other pens. Dominance and eating behaviour have been observed in beef cattle where only one animal at a time could eat, and it was found that high-ranking cattle had fewer meals but tended to spend more time per day eating.

Aggressive interactions in cows appear to be ritualised. Once the dominance relationship of any pair of animals is learned, it eliminates the need for further combat. The subordinate animal retreats from the dominant at the slightest threat and physical contact is of minor importance as long as the animals can see each other's posture.

With time, social order may change among a few animals in the herd. If a dominant animal suffers some sort of injury that compromises its state, soon it loses social position within the group and a new social order is established. Mixing unfamiliar cattle results in fights that intend to determine a new hierarchy status among the newly introduced animals. Reinstatement of social organization of new groups may take several days. Therefore, if possible groups of cattle transported to slaughterhouses must be formed by animals that were raised or lived together (familiar), and mixing of unfamiliar animals must be avoided. Attention to this characteristic can minimize fights and improve welfare of cattle, as fights lead to stress and injuries.

**Image:** Mixing unfamiliar groups promotes fighting among animals

**Leadership**

Leadership is a feature in groups of cattle. The lead animal is the one followed by other animals in the group when moving to seek water, shade, a grazing area or another resource. Normally, leaders are mature female cattle, though group movement can be initiated by different animals in different circumstances.
An illustration to distinguish dominance and leadership is that a lead animal is the one followed by the group to a water trough; while the dominant animal is the one displacing animals already in the trough in order to access and drink water.

One study looked at patterns of leadership during grazing movements which were divided into following, independence and leading. It was found that high-ranking animals tend to lead, medium ranks tend to follow and low-ranking animals tend to be independent. An interesting suggestion was that it was the active movement of high-ranking animals and the independent movement of low-ranking animals that governed the voluntary formation in grazing patterns. When cattle are driven, the least dominant animals will be first and last, with the dominant animals in the middle of the herd.

CATTLE LEARNED BEHAVIOR

Cattle have good short- and long-term memories, as they can remember events that happened during rearing and can be conditioned to a handling routine. They learn abilities in the environment where they live and can be trained with rewards. Cattle’s response to handling at the slaughterhouse is directly related to the type of handling they experienced during their lives at the farm.

Cattle that had limited human contact at the farm or that were subjected to aggressive handling tend to show strong fear reaction and this can interfere with handling at the slaughterhouse. Therefore, we must promote changes in handling practices at the farm, providing more frequent positive human-animal interactions between handlers and cattle, which can lead to better quality of life for the animals and ease pre-slaughter handling.

The rearing environment influences cattle behavior significantly. Animals reared in extensive systems, independently of their breed, tend to be more reactive than those reared in enclosed environments or confined systems. Lack of human contact in the initial rearing phase results in more fearful animals, which at times are also aggressive toward humans. It is better if calves receive special care and positive stimuli from humans immediately after birth in so called imprinting period as that directly affects their behavior when adults.

Herds from some farms may be more difficult to handle than others, and this is due to the way animals were cared for during rearing. At the slaughterhouse, cattle from the same breed but from different herds can be more difficult to handle than others.
Cattle have the ability to recognize and distinguish positive from aggressive handlers. For this reason, it is better if only a small number of people carry out more aversive procedures at the farm, while the others are in charge of daily farm duties.

Cattle can also habituate to non-painful recurring procedures, such as weighing, but not to repetitive painful events. Positive handling procedures must be carried out from the time of calf’s birth, preventing it from becoming averse to human presence.

The following is a brief summary of recent research findings related to learned behavior of cattle and is useful to bear in mind:

• Aversive procedures, such as restraint, will make subsequent handling more difficult
• Early handling experiences are important; early gentle and positive handling events produce calmer cattle
• Cattle handled at two sensitive times, after birth and after weaning, both effect subsequent response, so there is some evidence of “imprinting times” but they have not yet been fully established
• There is ability in cattle to recognize people who have treated them positively or negatively in the past
• On the farm, as few individuals as possible should be responsible for the most aversive procedures, make others responsible for day to day procedures
• It takes about 30 minutes for a cow’s heart rate to return to normal baseline levels after an intensive handling stress
• Cattle adapt well to repeated non-painful procedures, such as moving through a race for weighing, but not to repeated painful events
• There are genetic differences in temperament, and temperament is heritable
• Cattle with “excitable” genetics need to be introduced more gradually to novel experiences than cattle with “calm” genetics
• Highly reactive herd animals will have behaviors such as constantly rotating ear positions, raising the head quickly from the ground when grazing, excessive tail flicking even when no flies are present, flinching when touched, or moving away when approached by people
• Mixing known calm leaders in to a group improves overall handling
CATTLE SENSORY MODALITIES

Cattle rely mainly on senses of vision, olfaction and hearing to assess stimuli, and thus respond to different events such as changes in the environment and threats; for example, when exposed to a sudden noise, cattle’s first reaction is avoidance or escape. After assessing the situation, if it is not perceived as dangerous, the animal will lose interest in it.

Vision

Cattle have slit-shaped pupils and weak eye muscles, which inhibits their ability to focus quickly on objects. Cattle can distinguish long wavelength colors (yellow, orange and red) much better than the shorter wavelengths (grey and green).

Cattle are dichromats i.e. they have only two of the three main types of neural cells in retina. Dichromatic vision may provide better night vision and aid in detecting motion. Cattle have poor perception of depth and need to lower their head to see clearly. Because of this poor depth perception and lack of definition, cattle will often baulk and refuse to cross a shadow or drain grate (perhaps seeing it as a physical objects) and are best moved through diffuse light.

Binocular vision – Cattle’s eyes are located laterally on the head, and only see with both eyes (binocular vision) in a narrow area straight ahead (40°–50°), where they have clearer sight and better depth perception.
This is the reason cattle turn and lower their heads to see clearly handler, or some objects in details. An unloading ramp, a trailer entrance or a drain in the alley at the slaughterhouse can have different flooring that attracts cattle to observe these in details.

**Image:** Cow dimensioning unlevelled flooring during unloading (binocular vision). Source: Steps

**Monocular vision** – Cattle do have with their eyes positioned on the side of the head panoramic vision of 300 - 310° which allows for good predator awareness. Despite the wide set of their eyes, however, they do have a blind spot directly behind them.

This panoramic lateral vision, achieved by each eye independently, does not provide depth perception. However, cattle can sense movement even with their heads lowered, while grazing, which helps detect the presence of predators in their natural habitat.

**Image 1:** Monocular vision in cattle **Image 2:** Blind spot in cattle.

**Blind area** – This blind spot is located straight behind cattle’s body and a small area in front of their nose, where they cannot see. These areas must be avoided to optimize handling, preventing cattle from getting distracted while trying to situate the handler (details described in the chapter on Handling).

Cattle have good night vision that helps detect movements. Uniformity of colors (walls and floor) in areas of high circulation of animals can facilitate handling.
Olfaction

Cows identify their calves using smell, although visual and sound recognition become more important as calves grow older. Adult cattle also smell each other during social behavior.

Communication by olfaction is important for sexual activity of cattle. In addition, olfaction contributes to social hierarchy (dominance) information exchange, where submission pheromones are released from a subordinate to a dominant animal. Cattle exposed to alarming situations tend to group and may release pheromones through urine, saliva or other mechanisms, to warn others about the condition they are exposed to; cattle may become fearful of these signs thus promoting difficult handling.
Hearing and communication

Cattle are very sensitive to high frequency sounds when compared to humans. When hearing, cattle move their ears searching for source of noises, positioning them in the same direction as the source of sound, even when not turning their heads directly towards the source. One can determine the direction of cattle’s focus by assessing the position of their ears. This characteristic is easily observed during handling, when animals alter ears position between handlers and other cattle in the group frequently.

![Bull trying to detect a source of sound](image)

Cattle in the process of evolution lived in open fields where they could always see the rest of the group around. That resulted to very limited need to use vocal communication. Limited vocalization within the herd has been important for survival as vocalization would always attract attention from predators.

At the slaughterhouse, vocalization among cattle is associated with aversive events, such as prodding (especially when using high voltage), stunning failure, and excessive pressure during handling. Therefore, cattle vocalization in pre slaughter and slaughter is an important parameter in an assessment of practices.

At the slaughterhouses excessive particularly high pitch noise i.e. compressors’ discharge, whistling should be avoided. There are noises that even at the same intensity are more adverse than others; for example yelling, disturbs cattle more than sounds from banging of metal.

BEHAVIOR, GENETICS AND AGE

Animal behavior is determined by the interaction between environments and genetics, with differences among breeds. In general, *Bos taurus indicus* is more reactive than *Bos taurus taurus*. Likewise, crossbred zebu cattle may be more reactive during handling than pure blood or crossbred European cattle.

However, Brahman or Zebu cattle are the most inquisitive and will investigate or follow a person or a dog. A common practice used in Australia to move groups of Brahmans is allowing them to follow a person. The tendency to follow a person is greater in Brahman compared to British or European Continental breeds. Nevertheless, some studies found that if Brahmans are handled gently they can become extremely docile. The breeds that are the most reactive had the strongest tendency to approach novel objects. This is only true when the animals voluntarily approach the novel object. During forced movements where the animals are being driven toward a novel object just the opposite is true. The excitable flighty individuals will be most fearful and they will be more likely to freeze or balk.
The rearing environment can however influence cattle behavior more significantly than genetics. Animals reared in extensive systems, independently of their breed, tend to be more reactive than those reared in enclosed environments or confined systems.

Most beef cattle handled to slaughter will be under 30 months, most dairy cattle will be at least 5 years and bulls can be even older depending on whether they are raised for beef or used as sires. Nearly all cattle will be coming from highly socialised groups. Older cattle are vastly more experienced but this also means they are more accustomed to a routine. Being loaded onto transport and taken to an unfamiliar Mart or Lairage is a major change for them and it is little surprise that sometimes they will exhibit antagonistic behaviour.

SOCIAL BEHAVIOR OF YOUNG BULLS

The most dangerous dairy bull is a bull that has not been properly socialized to his own kind. When a young bull calf becomes mature at age two, he needs to challenge the top bull in the herd. If the bull calf has been raised alone and has not had the opportunity to interact with other cattle, he thinks he is a person and he wants to exert his dominance over the "herd". This can result in dangerous attacks on people.

Scientists found that bull calves raised in groups were much less likely to attack people than bull calves raised in individual pens. Bull calves raised on a cow were the least likely to attack. When they are raised with their own kind, they know who they are and they are less likely to think that people are part of the herd.

The major causes of bull attacks are mistaken identity or improper behavior that has been learned. A bull will perform a broadside threat prior to attack. He will stand sideways so the person or other bull can see how big and powerful he is. Sometimes a person can make a bull back off by responding with the human variation of a broadside threat which for people is a frontal stance. Alternatively, the person may just back slowly away from the bull. NEVER RUN away and do not turn your back on him.

REMEMBER

- Recognizing the behavior of cattle is essential to improve handling practices;
- Cattle perceive their surroundings mainly using vision, hearing and olfaction;
- Cattle see clearly and have depth perception only in a narrow area in front of their heads (binocular vision), and have ample and panoramic lateral vision to detect movements although without details (monocular vision);
- Cattle have a blind area where they cannot see or recognise movements;
- Cattle are sociable animals and therefore should be handled in groups;
- The type of rearing has a larger influence on cattle behavior than genetics;
- Cattle from some farms are more difficult to handle than others and this outcome is a consequence of the way animals were cared for at the farm.
BEHAVIOUR OF SHEEP

INNATE BEHAVIOR

Social (group) living

Like other animals, sheep react to the situations they are placed in according to instincts that have been developed over thousands of years. While it can be argued that domestication has decreased their instinctive behavior, they still show their instincts in many ways, daily.

The dominance hierarchy of sheep and their natural inclination to follow a leader to new pastures were pivotal factors in sheep being one of the first domesticated livestock species. Their only means of survival for thousands of years was to run from danger and to band together in large numbers for protection – to flock.

![Image: Sheep on a pasture](image)

Even with domestication, sheep retain these defense mechanisms, they run from perceived danger, and they band together for protection. Exploitation of these instincts is what makes a shepherd dog valuable. Sheep see the dog as a predator, or danger, so they band together for protection and move away from the danger. By controlling the dog, a shepherd controls the flock.

During flocking, sheep have a strong tendency to follow. A leader may sometimes be the first individual to move. Flock behavior in sheep is generally only exhibited in groups of four or more sheep; fewer sheep may not react as you would expect if they were in a larger group.

Flocking and running away behaviour changes in ewes immediately after they give birth. A ewe, docile and scared of a dog all year long will become extremely aggressive toward a dog right after birth. Sometimes, although not often, the ewe will also be aggressive towards a shepherd.

Because of their instinct to stay close together, sheep will move toward another sheep or a perceived friend. They learn that a farmer can be a friend, particularly if he feeds them. By using this combination of instinctive and learned behaviour (a) follow the friend, (b) shepherd is a friend, shepherds have controlled sheep movement for centuries. In this case the sheep will follow other sheep that are actually moving to see a friend (the shepherd who feeds them). The secret is to allow the sheep that come to you to actually eat grain. If they are not provided with any feed they will soon figure out that they are being fooled and will not respond. An unknown handler unloading and handling sheep at the slaughterhouse would be seen as predator.
Interestingly, in regions where sheep have no natural predators, none of the native breeds of sheep exhibit a strong flocking behavior.

**Dominance hierarchy and leadership**

Sheep establish a dominance hierarchy through fighting, threats and competitiveness. Dominant animals are inclined to be more aggressive with other sheep, and usually feed first at troughs. Horn size is a factor in determining flock hierarchy, especially among rams. Rams with different size horns may be less inclined to fight to establish the dominance order, while rams with similarly sized horns are more inclined to fight. In sheep, position in a moving flock is highly correlated with social dominance, but there is no definitive study to show consistent voluntary leadership by an individual sheep.

Anecdotal information and observations of leader sheep suggest that leadership ability runs in bloodlines and is equally distributed between males and females.

It is assumed that these are more intelligent animals that have the ability and instinct to lead a flock in difficult conditions. They have an exceptional ability to sense danger. For example there are many stories in Iceland of leader sheep saving many lives when blizzards threatened shepherds and flocks.

**LEARNED BEHAVIOR**

Sheep can remember the faces of more than 50 other sheep for up to two years. They can even recognize a familiar human face. The hidden talents of sheep revealed by a study in the journal *Nature* suggest they may be nearly as good as people at distinguishing faces in a crowd.

According to researchers in Australia, sheep can learn and remember. Researchers have developed a complex maze test to measure intelligence and learning in sheep, similar to those used for rats and mice. Using the maze, researchers have concluded that sheep have excellent spatial memory, and they can retain this information for a six-week period.

That supports use of certain designs (i.e. 180 degrees curved races to create the impression of returning) when constructing large throughput slaughterhouses.

**Vocalization when in danger**

When in imminent danger sheep rarely vocalize. They bulk together and run or in some situations stay quiet. Keeping quiet and not moving (i.e. pretending to be dead) helped to confuse some hunting predators used to chasing moving prey. Sheep also have an amazing tolerance to pain. Because they do not show pain they are less vulnerable to predators that look for those who are weak or injured.

Separation of one animal from the flock causes a high level of stress. An isolated sheep removed from a flock vocalizes in order to locate the rest of the flock and find its way back as soon as possible.
SENSORY MODALITIES

Vision

Sheep depend heavily on their vision. They have horizontal slit-shaped pupils, and good peripheral vision with visual fields of approximately 270° to 310°. Same as in cattle we recognize sheep's binocular, monocular vision as well as the blind spot (image below). Many breeds have only short hair on the face with facial wool (if any) confined to the poll and or the area of the mandibular angle. However, they have poor depth perception. They cannot see immediately in front of their noses. Some vertical vision may also have been sacrificed in order to have a wider field of vision. For example, it is doubtful that a sheep would be able to see something in a tree.

Contrary to previous thought, sheep perceive colors, though their color vision is not as well-developed as it is in humans. Sheep will react with fear to new colors.

Vocalization and hearing

Sheep have excellent hearing. They can direct their ears in the direction of a sound. Sound arrives at each ear at slightly different times, with a small difference in amplitude. Sheep are frightened by high-pitched and loud noises, such as barking dogs or firecrackers.
Smell

Sheep have an excellent sense of smell. They are very sensitive to the scent of different predators. Smell helps rams locate ewes in heat and ewes locate their lambs. Sheep also use their sense of smell to locate water and determine subtle or major differences between feeds and pasture.

PIGS BEHAVIOR

INNATE BEHAVIOR

All behaviors that pigs perform such as walking, looking, feeding, grouping, fighting and fleeing, among many others, contribute to their survival. Several factors may influence behaviors of animals:

Pigs are omnivores, naturally feeding on grass, roots and fruits, and altering their diet according to the availability of resources. They have powerful teeth and jaws to chew and can be predators but also prey. Daily, pigs spend an average of 17 hours resting, 5 hours sleeping and only 1 to 3 hours foraging. Pigs weighing between 50 and 150 kg may drink approximately 5 to 10 liters of water in a day, varying according to the animal, environmental factors and diet.

They are sociable animals, and normally live in groups of 2 to 6 sows with close bonding with their litters. Male pigs (boars) have a tendency to live isolated most of the time, but may gather into groups of males at times.

Image: Sows with respective litters living in a free-range system (SISCAL)

As gregarious animals, pigs are best handled in groups. When isolated, they alter their behavior and reactivity, becoming more agitated and aggressive, as separation from the group is highly stressful. Handling pigs in small groups is recommended, which provides the handler with more control over the animals.

Naturally, a group of pigs establishes a hierarchy or social organization. The hierarchy is established through fights among animals, and strength determines the dominance order. This explains the fact that mixing unfamiliar pigs results in fights that intend to determine a new hierarchy status among them, and clarification of social organization in the group may take several days.
LEARNED BEHAVIOR

Pigs have good short- and long-term memories, as they can remember events that happened during rearing until moments preceding death. They can be conditioned to a handling routine, learn abilities in the environment where they live and can be easily trained with rewards. Thus, pigs’ response to handling at the slaughterhouse is directly related to the type of handling they experienced during their lives at the farm.

An example of this behavior can be seen in pigs that had limited human contact at the farm or that were subjected to aggressive handling, such as pushing and beating. All this will produce fear responses and difficult handling at the slaughterhouse.

Thus, we must promote changes in handling practices at the farm and more frequent human-animal interactions, leading to better quality of life for the animals and ease during pre-slaughter handling.

SENSORY MODALITIES

Pigs rely mainly on senses of vision, olfaction and hearing to assess stimuli, and thus respond to different events such as changes in the environment and threats; for example, when exposed to a sudden noise, their first reaction is avoidance or escape. After assessing the situation, if it is not perceived as dangerous, the pig will lose interest in it.

Pigs exposed to alarming situations tend to group and may release pheromones through urine, saliva and other mechanisms, warning other pigs about the condition they are exposed to; other pigs may become fearful of these signs thus promoting difficult handling.

Vision

Pigs’ eyes are located laterally on the head, and thus have areas of binocular and monocular vision and a blind area. They can see colors well, but have limited depth perception. Pigs also have good night vision that helps detect movements. Uniformity of colors (walls and floor) in areas of high circulation of animals can facilitate handling.

**Binocular vision** – With binocular vision, pigs see with both eyes straight ahead (for a width of 30 - 50°), where they have clear sight and depth perception. For a pig to see something clearly requires the object to be directly in front of its face. This is the reason pigs turn and lower their heads to face the handler, objects or variations in the environment. An unloading ramp, a trailer entrance or a drain in the alley at the slaughterhouse are examples of flooring alterations that require pigs to use their binocular vision.
Monocular vision – The monocular vision is ample and panoramic, and can reach up to 300° around the pig’s body, depending on ear positioning. Thus, pigs can detect movement even with their heads lowered, when nosing or rooting. This lateral vision, achieved by each eye independently, does not provide depth perception, and pigs only see clearly if their heads are facing the object they aim to detect, using binocular vision.

Blind area – This blind spot is located straight behind the pig’s body, where they cannot see or detect movements. Movements in this area must be avoided to optimize handling, preventing pigs from getting distracted while trying to locate the handler (details described in the chapter on handling). A pig also cannot see an object directly in front of their snout.

Olfaction

Smelling is one of the most important senses for pigs, used also for individual recognition and social interaction. Olfaction contributes to hierarchy formation in the group (dominance), for example, release of submission pheromones from a subordinate to a dominant pig.

Image: Use of olfaction for environment recognition
Hearing and communication

The vocal signs are the most important means of communication among pigs. A total of 20 different calls have been identified, following six vocalization patterns easily recognized by humans. Each call has different functions, for example:

- **Grunts** – a series of short grunts given in response to familiar events, for example, when pigs are rooting. A short single grunt is produced when the pig is disturbed;

- **Alert vocalizations** – they are repeated by other pigs that then freeze or flee;

- **Acute vocalization** – given by a scared pig;

- **Long vocalization** – given by an injured or stressed pig. The vocalization duration and intensity reflect the severity of the condition. The higher the intensity, the greater the pain and suffering.

**REMEMBER**

- Recognizing the behavior of pigs is essential to facilitating handling practices;

- Pigs perceive their surroundings mainly using vision, hearing and olfaction, reacting according to innate and behaviors and those learned from previous experiences;

- Pigs see clearly in a narrow area in front of their heads (binocular vision, with depth perception);

- They have ample and panoramic lateral vision (monocular vision) to detect movements, without details;

- Pigs have a blind area where they cannot see or perceive movements;

- Pigs that had positive experiences at the farm are easier to handle.
PRE-SLAUGHTER HANDLING

INTRODUCTION
Welfare of animals in pre-slaughter handling as well as in other procedures depend on three key components: These are understanding of animals and their behavior or staff knowledge, environment – or design of slaughter premises and tools that are fit for purpose.

![Diagram showing the key components of pre-slaughter handling]

Good pre-slaughter handling relies upon people having a basic knowledge of the animals they handle, but more importantly an understanding of how their own behavior can influence the effectiveness of the handling process. Aggressive attitudes can trigger even more aversive reactions from animals and make handling more difficult.

**A good handler is also a good observer!** Prior to handling, ideally, one should observe the agitation level and temperament of animals, and use this as an indicator of how to approach each group of animals. The way animal will respond to handlers, and move in the desired direction (and how fast) will vary very much.

To each slaughterhouse, cattle from variety of rearing systems are supplied. These animals tend to have different previous experience. Some animals are easily to handle because they experienced good handling at the farm and learned to respond adequately to handlers.

However, some animals can be more difficult to handle which is usually associated with animals genetics, poor handling or fact that they were reared in free range conditions with seldom interactions with handlers.

Both research studies and anecdotal observations suggest that animals responses to being suddenly placed in a novel environment or the reaction to sudden novel stimulus are two of the most accurate behavioral tests of nervous system reactivity.

It can be observed that the most reactive animals of a group will appear more sensitive to changes in the environment and are usually the first animals to orient toward novel sights or sounds.
ANIMALS AND ACTIVITY LEVELS

In the farm environment an animal’s activity or arousal level ranges from sleep at one end, to fight or flight reactions at the other.

When cattle have to be handled the objective is to raise activity levels to the point where they are moving in the right direction at the right speed.

If handlers increase arousal levels significantly, animals become alarmed, fearful and perhaps even aggressive. They are more difficult to direct and therefore control; handling takes longer and stress levels increase. **Awareness is a basic handling principle**, even in situations where animals are in a low state of agitation.

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**THE FLIGHT ZONE**

We have learned in chapter on behaviour that behavioral features related to handling include the flocking instinct, visual field, social hierarchy and genetics. Flight zone, and previous experience also influence the response of animals.

Cattle, sheep and pigs protect an area around themselves, called the “flight zone”. The flight zone is defined as the distance in which an animal can tolerate the presence of an unfamiliar individual or a threat prior to initiating escape. Whenever the flight zone is invaded, the animal tends to re-establish a safe distance from the threat. But under critical circumstances, when there is not enough space to escape, animals may freeze or fight.

The size of the flight zone is variable and depends on species, breed, previous experience and way of handling.

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**Image:** Calm handling reduces stress for both animals and handlers. Source: Steps

**Image:** flight zone according to T. Grandin
POINT OF BALANCE

Point of balance is defined as an imaginary line drawn through the animal’s shoulder, dividing it to two. The point of balance is used by the handlers to control and direct movement. An animal moves forward if the handler is positioned behind the point of balance. If the handler is positioned front of the point of balance an animal it will move backwards.

CATTLE HANDLING

The flight zone of cattle can vary from 1 m to 50 m. It can be easier observed when cattle are in a penned area. In holding pens at slaughterhouses, cattle (particularly flighty) form a group and keep a safe distance - flight zone from by passing handlers.

Contrary to those, cattle from smallholdings or backyards exposed to daily contact with owners, dairy cattle or draught animals including buffaloes can have a very little or no flight zone at all.

Image: Cattle keep themselves in safe distance from a handler; Steps

An understanding of the flight zone is essential in handling and controlling cattle’s movement. In practice following hints are as follows:

- Handler should be positioned outside or on the edge of the flight zone avoiding standing in the animal’s blind area;
- To move animal ahead he should step forward - just within the flight zone boundary
- As the animal walks forward, he should walk along remaining inside the animal’s flight zone;
- And observe when moving outside the animal's flight zone and standing calm animal also stops.

Since cattle are handled in the groups, it is not always possible to enter the flight zone of an every animal. However, the handler must be positioned in a way that all cattle in group can see him.

As soon as the handler enters an animal’s flight zone, its reaction is to flee - run. If there is not enough space ahead, the animal will try to pass the handler and escape.

If handler moves too deep and too quickly into the animal's flight zone animal will run away faster If it has nowhere to go it will turn and attempt to run back past the handler.

If cattle are confined, and feel threatened, they may attack when the handler gets too close.
Handlers can increase or decrease the size of the flight zone, and to some extent control the response of the animal, by their approach and body posture. Being quiet and calm reduces the size of the flight zone; increasing levels of noise or activity from the handler will increase the size of the flight zone.

The handler will use this point of balance to control movement and direction of cattle guiding them in the desired way. Cattle move back and forward, depending on the handler’s position in relation to point of balance:

- If handler is **ahead of the point of balance and inside the flight zone** (position 1), the animal will move backward;
- If handler is **behind the point of balance and inside the flight zone** (position 2), the animal will move forward;
- If handler is **outside the flight zone** (position 3), the animal will stop. See image below.

The point of balance principle is widely used in handling cattle in a narrow races or chutes, where cattle movement is limited to forward and backward. In such situation to avoid handlers, cattle always move in opposite direction to moving handlers. The sequence of numbers in the figure below demonstrates handler’s positions moving cattle in desired direction.

The handler enters the flight zone of animals in chute (position 3 to 1) and stand aside in front of the first animal in line (position 1);

handler than walks from position 1 to position 2 passing the point of balance of each animal from front to back, prompting animals to escape and to move forward;

When at the end of chute, the handler exits the flight zone (walking from position 1 to position 3)
Same principles are used when getting animals out of holding pens or stockyards.

1) Group’s flight zone
2) Handler enters the flight zone.
3) Passes first 5 animals’ point of balance
4) Splits the group to two


Occasionally, animals are resistant to exiting the pen. Moving animals in small groups i.e. 2-3 animals often helps to solve the problem,

After splitting the group in the holding pen, the handler must walk them to the alley, keeping the handling flag up so all animals see it. This approach encourages animals to advance, avoiding returns. Using voice during handling helps to keep animals moving, but yells and abrupt movements must be avoided.

It is always easier to move smaller groups, it is important to remember that the handling flag must not be used to hit animals. Handling of cattle must be done in calm manner, without too much noise, rush or sudden movements. Animals must be aware to handler’s commands. Excessive agitation may lead to panic and loss of control. Calm and confident these are core qualities of a good handler.
TIPS ON HANDLING WHEN UNLOADING CATTLE

At the arrival to the slaughterhouse any paper work has to be sorted out as soon as possible so unloading of animals is carried out without delay. It is recommended that slaughterhouse facilities provide a shaded and well-ventilated area to park loaded vehicles prior loading to minimize risk of heat stress while waiting for unloading.

The lorry must be well parked not allowing gaps between load compartment and unloading ramp, which can hinder animals passing by.

Handlers should observe whether there are any cattle lying in the load compartments. It is necessary to make sure that prior unloading all animals are standing to avoid cattle stepping over each other.

- Handlers should verify whether there is space ahead of the animal prior to persuading it to stand up;
- They should use voice and noise, clap hands or slap vehicle’s wall to encourage cattle to stand up. When needed, make use of handling flag or rattle;
- When an animal is not in a condition to stand up, handlers should inform veterinarian or manager to decide further steps.

For better unloading, if there are compartments in the lorry these shall be opened in the ramp-to-cabin sequence (positions 1 to 3). When opening the first gate, allow sufficient time for the nearest animal to recognize the new environment and lead the remaining cattle. It is important to observe these animals exiting and open gate in the second compartment while animals from the first compartment are still leaving (position 2). Cattle will pay attention to the exiting animals and will feel encouraged to follow. This procedure shall continue until unloading is finished. Ideally, animals should be unloaded walking, with no rushing and keeping visual contact among themselves. Thus, handling equipment aids must only be used when really necessary.

![Image: The opening of gates synchronized with cattle exiting the compartment facilitates unloading. Source: Steps](image)

Special care must be provided when handling cattle in double deck trailers with unleveled flooring.

**HANDLING TOOLS**

These are tools that aid handling of cattle. When used correctly, they encourage cattle to move in the desired direction.

Some groups of cattle may require more persuasion than others to move. Essentially, the level of persuasion must be increased when not achieving a response from the animal, and this is the appropriate moment to use handling aids, such as:

A. **Handling flag** – it encourages movement, directs animals, it can increase the threat and also helps to block cattle’s vision. Because the flag is flexible, its movement catches the animals’ attention. The flag is perceived by cattle as an extension of a handler’s body that enlarges the threat. The flag should not touch the animal.
The flag can be used to turn an animal in the desired direction by moving it alongside animal’s head (position 1) and body (positions 2 and 3) in desired direction.
Ideally flag is adjusted to type of cattle handled. Large flags are used to handle less reactive cattle or larger herds, while small shorter flags are used for flighty cattle.

B. **Sound stimuli (noise)** – Use of combination of movement and noise in handling is a common practice at farms and most animals respond to it. Associated to sound, handler’s movement and position strengthen cattle’s response. Importantly continuous constant noise will not alert animals as much as intermittent noise. If animals are already moving there is no need to use pad rattle. When handling highly reactive animals the rattle (especially one made of metal) is not recommended.

C. **Bare hands handling** – touching animals back by bare hands helps move less flighty cattle. The intensity of the force applied must be adequate.

**Electric prod** – It shall be used ONLY as a last resort, when all other handling aids failed. The use of prod is regulated in many countries and it is always limited only to emergency handling in the raceways leading to the restraining box or area in situations when:

- animals refuses to move, and there are no distractions ahead of it
- on the rear limbs of adult cattle, above the ankle to avoid kicking and risks of accident;
- for a maximum period of one second, with intervals between prod applications.

The use of electric prod must NEVER be used on sensitive parts such as the anus, genitals, nose, eyes and udder.

An electric prod MUST NEVER be:

- used repeatedly, if the animal does not respond
- connected directly to the main power supply

The use of electric prod must be controlled to promote minimum stress and pain to cattle.

**HEALTH AND SAFETY WHEN HANDLING CATTLE**

**Skilled** stockman should always recognize the signs and sounds of the cattle they are handling. These signs include body postures, agitation and arousal, head and tail positions. Seriously distressed cattle often vocalize.

Higher risk of in injury occurs when handling:

- Cattle are not handled frequently.
- Cattle that are alone, isolated and away from their herdmates.
• Cattle with bad past experiences.
• Bulls
• When cattle are being loaded and unloaded for transport.
• Cattle in unfamiliar surroundings.
• Some specific breeds.
• Bad tempered or fractious cattle
• Where the handler lacks the necessary experience, agility or ability to assess the possible risks.

Handlers should be aware of:

• Vocalisation
• Highly agitated and aroused cattle
• Head and Tail Position
• Bulls
• Cows with calves at foot
• Horned cattle

![Image: Positions of head and tail of cattle. Source Health and Safety Authority Ireland](image1)

![Image: Kicking movement (defensive animals) Source: Ohio State University](image2)
Tips for good handling:

- Observe the group’s reactivity to define the way animals should be handled;
- Be calm and keep control during handling;
- Move slowly into the cattle’s flight zones;
- Pay attention to your positioning in relation to the animals’, using the point of balance and avoiding the blind area;
- Handle small groups at a time. A smaller number of cattle allows for more control over the group, avoiding accidents;
- Avoid isolating an animal;
- Turn the water off prior to moving the animals through the sprinklers, as water reduces cattle’s visibility and irritates their eyes (chloride);
- Avoid leaving animals for long periods in the alleys (e.g. lunch break, changing handlers’ group). This condition causes unnecessary agitation
- Working synchronically with slaughter throughput rate avoids interruption of animals’ movement.

REMEMBER:

- Cattle must be unloaded as soon as they arrive at the slaughterhouse;
- Take advantage of the flight zone and point of balance to influence, move and control cattle movement;
- Move cattle in the group
- The use of any handling tool must be cautious;
- The electric prod is only acceptable as a last resort, used only when the animal has space to move forward, for a period of maximum 1 second and on the rear limbs above hock;
- NEVER apply an electric prod on sensitive parts of cattle, such as genitals, anus, nose, eyes, among others.

SHEEP HANDLING AND TRANSPORT

INTRODUCTION

A thorough understanding of sheep behavior is the first step towards developing an effective method of handling sheep. Their strong flocking and following behavior tends to make sheep easy to handle, relative to other livestock species. Conversely, sheep will prove difficult to handle if you force them to act in ways that are not natural for them. When handling sheep the same basic principles of flight zone and point of balance apply as in handling of cattle.

Being a prey species, the primary defense mechanism of sheep is to flee from danger when their flight zone is entered. Cornered sheep may charge and butt, or threaten by hoof stamping and adopting an aggressive posture. This is particularly true for ewes with newborn lambs.
Most sheep are flighty animals so it is best to handle them carefully moving on the edge of their flight zone. If the flight zone is penetrated too deeply, they will run away fast.

**Image:** Different levels of arousal of sheep; sleep, graze, walk, fright flight. Walk - an ideal level of arousal in handling sheep. Source: Eblex, UK

Sometimes their behavior can be unpredictable and dangerous. Sheep are not large, but they are quick on their feet. Pile-ups can result in small enclosures, causing injury to the animals, especially the small or weak ones.

**Image:** Flight zone of flock of sheep moving in an opposite direction as shepherds. Source: Temple Grandin

**CATCHING SHEEP**

There are situations in which you need to catch an individual sheep. If you do not have a handling system to assist you, you can use gates and panels to make a small catch pen. Once the sheep are in the catch pen, manoeuvre them into a corner and use your arms or a portable gate to form a visual barrier. Always approach sheep calmly and slowly. Cup your hand under the jaw of the sheep you want. Grab the bony part of the jaw, not the throat. Point the sheep's nose upward to stop its forward motion. If you keep the sheep's head up, you will be able to maintain control of it. Sheep have a lot more power when their head is down.

**Images:** Holding a sheep - Source: HSA
If you cannot get close enough to the sheep to grab it under its jaw, you can reach for its hind leg or rear flank. Reach for the hind leg above the hock, then move your other hand up to control the head as soon as possible. Adult sheep are able to kick strongly, so this method works best for small sheep or young lambs. To catch an adult sheep, it is better to grab the rear flank. You should never catch a sheep by its wool. Not only is it painful to the sheep, but it can cause bruising to the carcass.

Images: Catching sheep by its wool is painful and causes bruising. Sources: HSA and Eblex

Restraining sheep

There are many different ways to restrain a sheep, depending upon what you need to do to it. Once you've caught the sheep, you can press it against a wall or straddle it to limit its movement. A halter is one of the easiest ways to restrain a sheep.

SHEEP TRANSPORT

According to research on transport, sheep are animals that cope with average transport conditions better than pigs and cattle. However there are risks associated with poor management of sheep transport. Loading and unloading can be problematic especially to and from lorries with 4 -5 decks.

Images: Transport and unloading of sheep. Source: HSA

The maximum angle of loading and unloading ramps should be 20 degrees. The research on stress concludes that the highly variable results in research studies of transport may be due to different levels of “fear” stress. Sheep accustomed to loading and handling may be less stressed by transport, especially if trips are short where fatigue and physical stress would be lesser factors.
According to research and observations space allowances for sheep during transport in m²/animal should be: 0.2 to 0.3 m² for shorn lambs <55 kg liveweight, >0.3 m² for shorn lambs >55 kg, 0.3 to 0.4 m² for unshorn lambs <55 kg, >0.4 m² for unshorn lambs >55 kg, 0.4 to 0.5 m² for pregnant ewes <55 kg, and >0.5 m² for pregnant ewes >55 kg.

There is research that shows no difference in bruising when 35 kg sheep were transported at 0.22 m²/head vs. 0.40 m²/head; This evidence refutes the common belief that sheep must be packed in a truck to prevent bruising.

Roeber et al. (2001a) concluded that handling and transportation play a very important role in overall sheep management. They found that: (a) At-slaughter-plant condemnations for 1998 through 2000 revealed that injuries resulted in 3.7% and 7.8% of carcass condemnations in mature sheep and lamb/yearlings, respectively. (b) Improper handling or transportation can result in bruising, broken bones, condemnation and even death. (c) Proper handling facilities and techniques minimize stress to the sheep.

The US National Sheep Quality Audit determined that the third largest quality-defect loss ($6.00 per affected lamb) in the US market sheep population was carcass trim loss due to bruises. According to Blackwood and Hurst (2004), around 25% of sheep are bruised before slaughter. The main causes of bruising are sheep riding up onto the one in front because handlers are pushing them to move faster than they can go.

“Rest stops” during transport benefit lambs mainly by reducing the observable effects of food deprivation. Cortisol concentrations confirm transport to be a stressful event which is not lowered by rest. Immune function data suggest that “rest stops” help to maintain immune function.

Research on the effects of transport of sheep by road include the following:

- Knowles et al. (1993) studied the effects of 9 and 14 hr of road transport and subsequent recovery in lairage of hill lambs; and reported there were no measurable differences between the responses of the lambs transported for 9 vs. 14 hr; and that recovery after transport, in lairage, required 24 hr for rehydration and 96 hr for liveweight.

- Knowles et al. (1996) studied lambs shipped from the UK to France by lorry and concluded that, for journeys longer than 24 hr, an 8-hr rest in lairage with access to water and food was beneficial, and allowed material re-alimentation and rehydration before further transport for up to 10 hr.

- Broom et al. (1996) investigated the physiological effects of road transport of sheep and determined that loading and the start of driving produced large increases in cortisol and prolactin concentrations (in the first 3 hr of a 15-hr journey) but during the remaining 12 hr, the stimulatory effect of transport was small.

- Cockram et al. (2004) videotaped, simultaneously, activities on a vehicle during transport of sheep and determined that “driving style” had a major influence on the welfare of the animals (e.g., risk of injury). Sharp braking, cornering and various other driving events that unbalance the animals increase the risk of injury.
Long distance transport (18 hr and 24 hr) of lambs from the UK to France was investigated by Knowles et al. (1994). They found: (a) High levels of plasma beta-hydroxybutyrate, free fatty acids and urea, both before and after the journeys, indicated that the animals were in a catabolic state. (b) The behavior of the sheep after the journeys indicated that they were all alert and physically fit; they showed great interest in any food that was available and were only secondarily interested in drinking, and then resting. Knowles (1998) reported that complete recovery from 14 hr of transport stress takes almost 5 days.

Most research indicates that a rest stop must last for at least 8 hr to provide enough time for sheep to eat and drink. Sheep will eat before they drink; so if the rest stop is too short, they will not have time to drink.

**Transport of lambs**

- Lambs of less than one week of age may only travel for a maximum of 100km (approximately 62 miles).
- Lambs less than 20kg must travel on suitable bedding for thermal comfort.
- A lamb with a navel which is not completely healed is considered unfit for transport.

Richardson in his factsheet “Avoiding heat and cold stress in transported sheep” emphasizes checking on the weather before transport, knowing what you can do to reduce the effects of severe weather on the sheep at any time during the trip, and changing the timing of the trip if necessary. He provides further recommendations on transport of sheep as follows:

- Ensure that all animals intended for transport are fit to be transported.
- Stop and check on the sheep after the first hour of the trip and every 2.3 hours afterwards.
- Protect sheep during transit from exposure to severe weather conditions.
- Sufficient ventilation must be available at all times.
- Appropriate measures must be taken to prevent engine exhaust from entering the area occupied by the sheep.
- Ventilation should be adjustable from the outside of the vehicle so that adjustments can be made without unloading the sheep.
- For trips in excess of 24 hours reduce loading density to 85% of maximum to allow room for sheep to lie down.

**Precautions in cold weather**

- Sheep need to be protected from freezing rain and wind blowing into the sides of the truck because it increases their heat loss and can cause death from hypothermia, even at temperatures above freezing.
- Young and recently shorn sheep are particularly susceptible to frostbite and loss of body heat during transportation.
- Remove wet bedding after each trip to prevent it from freezing onto the truck.
Signs of Animal Discomfort (Cold Stress) During Transportation

- Wet sheep
- Sheep eating available bedding
- Fluids frozen to the face or nostrils

During Winter Travel

- Increased bedding or insulation is necessary in cold weather.
- Increased loading density beyond recommendations can predispose individual animals to frostbite if it prevents them from repositioning in the truck.
- Cover openings to protect sheep from cold winds caused by movement. Wind chill lowers the effective environmental temperature and can cause frostbite.
- Protect sheep on the side of the truck that is exposed to a cold crosswind.

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Precautions in hot and humid weather

- Take precautions to avoid stress, suffering and possibly death caused by the combination of high temperature and high humidity.
- Sheep require sufficient floor space to allow for adequate ventilation and comfort.
- Severe heat build-up may result from overcrowding. Reduce loading density to 85% of maximum in hot/humid weather.
- Keep frequency and length of stops where sheep are not off-loaded to a minimum during transit to prevent rapid build-up of heat inside the vehicle.
- Protect shorn sheep from prolonged exposure to direct sunlight to prevent sunburn.
Signs of Animal Discomfort (Heat Stress/Overcrowding) During Transportation

• An overcrowded load will not settle; sheep continue to scramble for footing and the load continues to be noisy for prolonged periods of time. Sheep involuntarily lie down and are then unable to get up.

• Sheep pant when overheated; animals standing with their necks extended and open-mouth breathing are in a dangerous situation.

During Summer Travel

• Handle sheep carefully because exertion in hot/humid weather is particularly stressful and increases the chances of heat stroke.

• Allow every animal to rest when over-exerted.

• Sufficient ventilation must be available at all times while the sheep are in the vehicle.

• Whenever possible, avoid trips during hot/humid periods.

• When high heat and humidity are forecast, schedule transportation at night and in the early morning.

• Avoid periods of intense traffic congestion.

• Do not park a loaded vehicle in direct sunlight.

• When necessary to stop, minimize the duration of the stop to prevent the buildup of heat inside the vehicle.

• Sheep can be cooled by watering the floor of the vehicle or by using a fine mist spray. If you have an overheated sheep, gently run cold water over the back of the head.

UNLOADING OF SHEEP

Sheep have to be unloaded immediately upon arrival at the slaughterhouse. If that is impossible, the vehicle must be parked in a shady and well-ventilated area. Sheep have to be monitored frequently depending on the weather conditions and duration of previous transport.

Unloading ramps have to be of at least 2-3x the of animal width. They have to have non-slippery floors full side walls and there should be no obstructions or strange objects on the way. Sheep have to be allowed to get out of the lorry on their own way. Once the first animal moves out of the lorry the others will follow due to their following instinct.

Ramps fences, pens, must have no protrusions sharp edges or poorly maintained surfaces to avoid bruising and other injury.

When being unloaded, sheep must not be rushed or stressed to avoid panic, trampling, baulking and smothering. Each animal should be observed and those sick and injured penned separately in isolation pens for further observation/treatment.
Images: Unloading of sheep

PIG HANDLING
FLIGHT ZONE

Pigs also do have a “flight zone”. Whenever the flight zone is invaded, the pig tends to re-establish a safe distance from the threat. But under critical circumstances, when there is not enough space to escape, the pig may freeze or fight.

The size of the flight zone can vary according to species, genetics and prior experiences. As pigs are omnivores and have tusks (teeth), they are prepared to attack and defend themselves against a predator. Thus, their flight zones are smaller when compared to ruminant species such as sheep and cattle. Pigs of docile genetic lines and animals that have undergone positive experiences during rearing at the farm may have an even smaller flight zone.

Since handling is carried out in groups, it is not always possible to enter the flight zone of every pig. However, try to position yourself in a way that pigs can keep visual contact.

Depending on the manner in which handlers approach the animal, they can interfere with the flight zone of an animal and alter the speed of fleeing. If behaving in a calm and silent manner, the handler can reduce the animal’s speed of reaction; ascending levels of noise or movement from the handlers will increase the speed.

Point of balance

The point of balance is a limit determined at the pig’s shoulder (scapula). The handler will use this point of balance to control movement and direction of pigs guiding them in the desired way.
• If handler is **ahead of the point of balance and inside the flight zone** (position 1), the pig will **move backward**;

• If handler is **behind the point of balance and inside the flight zone** (position 2), the pig will **move forward**;

• If handler is **outside the flight zone** (position 3), the pig will **stop**. See the figure below.

![Handler's positions during handling of pigs using the point of balance and flight zone](image)

**Image: Handler’s positions during handling of pigs using the point of balance and flight zone**

**HANDLING TOOLS**

These are tools and/or handlers’ attitudes that help handling of pigs. When correctly used, these resources encourage pigs to move in the desired direction.

Some groups of pigs may require more persuasion than others to move. Essentially, the level of persuasion must be increased when not achieving a response from the animal.

**Handling tools can be classified as:**

- **A) Rattle pads, paddle, voice, clapping and compressed air** – these resources assist moving of pigs mainly by the sound they produce and the way they are used. Emission of continuous sound will not produce as much response from the animals as intermittent sound. So continuous and routine use of these resources, particularly the rattle pad, must be avoided especially on animals that are already moving in the desired direction.

![Images: Use of plastic bottle rattle to assist in handling of pigs, Use of paddle to encourage moving, Compressed air as a tool to drive pigs](images)

**Images: Use of plastic bottle rattle to assist in handling of pigs, Use of paddle to encourage moving, Compressed air as a tool to drive pigs**
B) Handling boards and plastic panels – their main function is to limit and/or block pigs’ vision and encourage them to move forward. Another function of this type of tool is to prevent pigs walking in an undesirable direction.

C) Stimulus with own hands – stimulating movement by using physical contact with the pig. The intensity of the force applied and area where the pig is touched must be adequate and controlled.

D) Electric prods – these deliver electrical current to the animal. The use of this method is ONLY acceptable as a last resort and exclusively on pigs that persist in refusing to move. The use of this equipment is legally controlled in many countries and is allowed only at the alley leading to the stunning box or restrainer. Same rules as in cattle apply to pigs.
UNLOADING OF PIGS

Pigs must be unloaded as soon as they arrive at the slaughterhouse. Research has shown that there is an increase in the stress level and higher incidence of carcass defects in pigs waiting for unloading for more than 30 minutes in areas with high temperatures.

In circumstances where waiting is unavoidable, the slaughterhouse must provide an area that is ventilated and protected from the sun to minimize thermal stress for the pigs.

Although unloading is less stressful than loading, the incidence of hematomas and bruises in the animals can be elevated when handlers are not qualified and handling tools are used inadequately.

For calm and quiet handling, which is less stressful to the animals and results in lower incidence of lesions, **pigs must be unloaded one compartment of the trailer at a time**, allowing sufficient time for the first pig to recognize the new environment and lead the remaining pigs.

During unloading, the **use of rattle pads and/or compressed air** is recommended for encouraging pigs to leave the trailer. In addition to these tools, a **handling board** may be used at the unloading ramp to help in herding the pigs to the holding area.

Image: Unloading, of pigs from the compartments and adequate use of handling tools

If a truck is fitted with a hydraulic ramp, its use facilitates handling and makes the unloading process faster and less stressful for the animals. Low-lighted areas, steps and/or gaps between truck and ramp, as well as poor ramp design (steep angle, slippery floor and open sides) can increase pigs’ resistance to leave the trailer.

REMEMBER:

- **Take advantage of the flight zone and point of balance to influence, handle and control pigs’ movements**;
- **The use of handling tools** (rattle pad, plastic panel, compressed air, hands, voice, paddle, plastic or wood board) **must be cautious to facilitate handling and prevent aggression**;
- **The electric prod is acceptable as a last resort and used only when the animal has space to move forward, for a period of 1 second, on the rear limbs**;
- **NEVER** apply an electric prod on sensitive parts of the pig, such as anus, genitals, snout and eyes.
INTRODUCTION

For animal welfare and public health reasons, it is of fundamental importance that animals are not moved or transported unless they are in good physical condition and perfect health. Animals severely injured or thin, sick, fatigued or that cannot move without undergoing additional suffering are not suitable for transporting to the slaughterhouse.

It is essential that animals arrive at the slaughterhouse free of injuries, diseases and intense stress (distress). Cattle and sheep that are injured, shows signs of illness or severe distress should be segregated during unloading. The veterinarian and/or professional responsible should be consulted and a procedure for emergency slaughter is recommended to be carried out as soon as possible to prevent further suffering of the animal.

ANTE MORTEM OF CATTLE AND SHEEP DURING UNLOADING

Unloading of cattle and sheep must start as soon the truck arrives at the plant. Animals must not be kept waiting for unloading in the transport compartments, especially when exposed to sun. The unloading team must be trained and qualified to identify sick or injured animals and assess its severity upon arrival to provide differentiated care to these animals. When there is a sick or injured animal identified on the lorry, the lorry has to be unloaded first.

Animals with minor lesions but able to walk with no signs of pain; have to be be calmly unloaded and moved to observation pens at the slaughterhouse. If isolation causes more stress to injured cattle, then such an animal may be held with others, as long as the group is provided with more space in the lairage and it is monitored.

Cattle unable to walk or that are non-ambulatory must be slaughtered under emergency slaughter procedures. According to the OIE standard Injured or sick animals, requiring immediate slaughter, should be killed humanely and without delay, in accordance with the OIE recommendations. Animals that cannot move must never be dragged, pushed or thrown as well as forced to move.

When removal of an animal from inside the trailer is not possible, emergency slaughter carried out at the place where the animal is found, has to be carried out. That option has to be considered only if it does not jeopardize operator's safety. If stunning equipment is available such an animal has to be stunned first and then bled. Sheep unable to walk should be slaughtered on the spot or under certain conditions loaded onto trolley and moved to the place where they are slaughtered immediately.

Emergency slaughter equipment must be maintained in good condition and at a location of easy access, nearby the unloading area.

The slaughterhouse should have a written animal welfare policy describing adequate procedures to handle non-ambulatory cattle. It must also have adequate equipment to carry out these procedures in a humane manner and competent personnel to identify and execute these tasks promptly.
An animal, regardless of its condition, must never be dragged by the horns, ears, head, tail, legs or other body parts. These procedures are unacceptable.

![Image: Unacceptable handling practices that cause suffering to cattle.](image)

**ANTE MORTEM INSPECTION OF CATTLE AND SHEEP IN THE LAIRAG**

The *ante mortem* inspection must be performed daily at the slaughterhouse with to check health and welfare of animals and required documentation. Official veterinarian has the responsibility for inspection of cattle welfare and taking adequate action in case of sick or injured animals. In addition, continuous monitoring of animal welfare must be carried out by staff working in the holding area.

![Image: Ante mortem inspection in the holding area. Source: Steps.](image)

If an animal is injured or showing signs of sickness in the lairages - holding pens, the team must segregate an animal into an observation pen. An alternative is to remove healthy cattle from the pen and carry out emergency slaughter of the ill or injured animal where it is penned.

Keeping a trained team at the unloading area is essential for assessment and identification of animals showing signs of disease and injuries at the arrival at the slaughterhouse, as well as for separating cattle humanely.

A good observer does not need to agitate the cattle or to push them to stand up and inspect in order to observe bruises or injuries. A comprehensive assessment of the pens is sufficient. It must be remembered that the main purpose of lairage, in addition to performing the *ante mortem* inspection, is resting the animals prior to slaughter.
Signs of health:

- Head up and alert;
- Clear eyes, wet nose and no excessive salivation;
- Manure of normal consistency with no blood;
- Urine with a yellow-straw color;
- No apparent locomotion problems;
- Normal and quiet breathing;
- Interaction and activity with the environment;
- Pink and healthy gums and mucosa;
- Absence of continuous mooing or bellowing of cattle, or bleating of sheep, teeth grinding, convulsion or spine (back) arching;
- Absence of signs of pain, abscesses, wounds, contusions, fractures.
- Absence of heat or cold stress signs.

Image: Healthy bull

<table>
<thead>
<tr>
<th>Heat stress signs</th>
<th>Cold stress signs</th>
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<tbody>
<tr>
<td>Sweating</td>
<td>Shivering</td>
</tr>
<tr>
<td>Altered heart rate and breathing frequencies</td>
<td>Erected hair</td>
</tr>
<tr>
<td>Restlessness e agitation</td>
<td>Arched posture</td>
</tr>
<tr>
<td>Salivation</td>
<td>Lethargy</td>
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<tr>
<td>Exhaustion</td>
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</table>
CASUALTY CATTLE AND SHEEP

A casualty animal is one that is walking but is otherwise in good health except for a minor, non-acute condition; this may include conditions such as minor wounds, minor lameness and animals that are small or lack condition.

For public health and operational reasons, these animals may need to be slaughtered and dressed at the end of a shift and therefore specific periods should be set aside during the day’s kill for them to be dealt with.

During the day lairage staff must inspect casualty animals frequently and where the condition of any individual is deteriorating, these animals should be moved for immediate slaughter or killed in the pen.

Image: Casualty cattle and sheep

Immediate emergency slaughter

Animals suffering from severe open injuries must be killed humanely as soon as possible.

It is recommended that the emergency slaughter is carried at the sanitary slaughter room, or depending on the severity of animal’s injury at the place where animal is (i.e. on the lorry) The veterinarian is responsible for proper situational assessment.

Image: Cattle severely injured must be assigned to immediate emergency slaughter. Source: Steps
PROCEDURES FOR EMERGENCY SLAUGHTER

Animal to be slaughter under emergency slaughter procedures should be slaughtered on the spot or moved to sanitary slaughter room. Animal can be moved only if the suitable trolley is available and the moving would not cause any additional pain or suffering to sick or injured animal. Any dragging by rope or pushing is unacceptable.

When conditions impose safety risks for the operator, animal restraint must be performed as quickly as possible using ropes or other restraining devices. It is important to eliminate any risks of injuring and strangulating the animal.

Emergency slaughter shall be carried out by bleeding. If stunning gun is available animal should be stunned prior bleeding. For more details read the chapter on mechanical stunning of cattle.

ANTE MORTEM INSPECTION OF PIGS ON ARRIVAL

The unloading team must be trained and qualified to identify and separate those animals that are sick, injured or seems to show abnormal behavior. Special attention should be paid to handling of those animals that are immobile and incapable of walking, and assist the veterinarian or person responsible for the ante mortem inspection to proceed with immediate emergency slaughter, reducing the time animals are subjected to pain and safeguarding food safety.

Image: Dragging animal that is unable to walk is unacceptable. Source: Steps

Image: Inspection of animals at unloading
Tools recommended for handling of immobile pigs

**BOARD** – position the stretcher or board at the pig’s side, roll the animal over or push the stretcher underneath it and continue by pulling the stretcher or board out of the trailer with a rope or chain, placing it inside a cart **Pull the board, NEVER the pig.** This procedure must be used only for short distances. The cart must always be positioned near to the unloading ramp.

**CART** – this is essential for moving immobile pigs. A cart with open sides, to form a ramp, facilitates loading the board. The cart size must meet the board dimensions. Once the board is placed on the cart, the lateral walls must be closed to prevent pigs from attempting to escape.

The cart may be manually pulled or suspended on rails running from unloading to the stunning area. The cart must be kept in good repair, with routine maintenance and available for use.
The slaughterhouse must have a written protocol to handle fatigued and non-ambulatory pigs. It must also have adequate equipment for humane handling of these animals.

When removal of a pig from inside the trailer is not possible, or this procedure would cause more suffering and distress to the pigs, the emergency slaughter must be carried out in the truck, as long as adequate stunning and bleeding methods are used.

A pig, regardless of its condition, must never be lifted by the ears, head, tail, legs, or dragged and moved forcefully, which can cause suffering to the animal.

**ISOLATION OR OBSERVATION PENS**

When pigs are too small or have tail bites, non-erupted large hernias, prolapse or other small injury they should be separated into isolation (observation) pen for assessment by a veterinarian. Normally, due to public health safety and operational reasons, this slaughter procedure happens at the end of the work shift.

![Image: Pigs segregated into the emergency pen with tail bites, hernia and rectal prolapse, respectively](image)

The emergency pen must provide a comfortable environment promoting greater chances for recovery. This pen must have a lower stocking density, with protection from group disputes and easy access to water.

![Image: Emergency pen used for assessing clinical signs of animals segregated at unloading](image)

Often there are drinkers available in the pen but some injured animals may have difficulty walking to the drinker, aggravating dehydration. Thus they need individual care to promote recovery.

Handlers at the holding area must always be alert to these animals, and if, for any reason, the condition of a pig worsens, staff must perform the emergency slaughter as soon as possible to prevent further suffering.
Keeping these pigs in areas with intense circulation of animals (alleyways, unloading area) should be avoided, as exposing them to these areas will impair recovery.

**ANTE MORTEM INSPECTION IN HOLDING PENS**

The *ante mortem* inspection is performed daily at the slaughterhouse with the goal of verifying hygiene-sanitary conditions and welfare of animals. The veterinarian has the responsibility for inspection and makes provision of resources to safeguard the welfare of pigs, taking any action when injuries or diseases are present, not allowing slaughtering of these pigs with the remainder of the group in the regular slaughter line.

The inspection of animals in the holding area should be performed frequently by the team responsible for carefully monitoring the welfare of pigs and taking the correct approaches at this area of the slaughterhouse.

When a pig is found sick or injured in the holding pen, the team should move it to the emergency pen, as long as this procedure does not cause unnecessary suffering and distress to the animal.

![Image: Ante mortem inspection in the holding area](image)

A good observer does not need to agitate the pigs to make them stand up and inspect for bruises or injuries.

**PROCEDURES FOR EMERGENCY SLAUGHTER**

There are three main methods for emergency slaughtering of pigs, which are: electrical stunning (*electronarcosis and electrocution*) and mechanical stunning (*penetrating captive bolt gun*), followed immediately by bleed out.

The emergency equipment must be stored in a location of easy access. Ideally, the equipment must be near the unloading area and checked at least weekly by technicians to ensure that it is in good condition and with records of maintenance. For more details on electro narcosis and electrocution read relevant chapters.

Mechanical stunning with penetrating captive bolt gun

This method consists of applying a concussion force sufficient to induce immediate loss of consciousness and sensibility to pain.
The effect of all types of captive bolt guns is based on the impact of an object, the bolt, against the skull of an animal. If the force (impact) from the bolt is powerful enough, it will cause concussion of the animal, which is characterized by **disruption of cerebral function**.

It is essential that the bolt penetrates entirely into the animal's head. The gun must be positioned at a 90 degree angle and in direct contact with the animal's head to reach the targeted area.

A gun in perfect working condition is essential for performing effective stunning. This requires proper daily cleaning and weekly maintenance. It is also very important to use the correct cartridge according to the gun's make and model, following the manufacturer's recommendations.

Monitoring of mechanical stunning

**Pigs correctly stunned show:**

- Immediate collapse (drop);
- No rhythmic breathing;
- Eyes with a fixed and glazed expression;
- No corneal reflex;
- Intense involuntary pedaling.
Pigs subjected to mechanical stunning have a quite evident clonic phase (intense), characterized by involuntary movements and pedaling, which interferes with bleeding (immediate) and increases the risks of accident for the operator. Thus, this must ONLY be performed as an emergency slaughter procedure.

The mechanical method for emergency slaughter with a captive bolt gun should not be used for adult animals, such as boars and sows, because of the skull thickness.

**LAIRAGING (KEEPING ANIMALS IN HOLDING PENS)**

**INTRODUCTION**

The main purpose of the lairage is to hold sufficient animals to allow the processing line to operate efficiently so that it never stops or slows down. Time in the lairage may give animals some opportunity to rest and recover from transport, but they are unlikely to fully adapt to the new environment in the short time they are there. The special requirements for dealing with unfit animals are covered in another information note.

**LAIRAGING OF CATTLE AND SHEEP**

Time cattle spend in the lairage has usually focused on food hygiene and operational needs, but more recently the effect on the animal’s welfare has become an important consideration.

OIE standards require that cattle and sheep shall be rested before they can be slaughtered.

Research in South America (Chile) has investigated the impact on welfare parameters of long lairage conditions and to what extent cattle actually benefit from periods of “rest” in the lairage.

Lairage times of 3, 6, 12 and 24 hours were evaluated with transport times of 3 or 16 hours. In the variables studied, there was no indication that increasing the lairage time at the abattoir had a beneficial effect on the animals. As lairage time increased, energy levels were depleted if animals were not fed. There was also evidence to suggest that during longer lairage times cattle may became more dehydrated.

This study reflects similar findings from work carried out in Europe and North America, where minimum lairage times (i.e. 6 or 12 hours) are not required.

Long transport and lairage times (48 hours) are also associated with carcase weight loss and reduced killing out percentage, as well as elevated pH and increased shear values, which indicate muscle toughness.

In general the effect of lairage time on the cattle’s and sheep welfare will be variable depending on factors such as transport time, transport conditions, genotype, previous feed regime and general fitness. Given these variables, the way forward in the future is for lairage staff, management and veterinarians on site to be given the ability to increase or decrease lairage times to optimize the cattle’s welfare based on the actual needs of the load, batch or indeed individual.
According to OIE standards waiting times in lairages should be minimized and animals should not be kept in lairages longer than 12 hours. They can be kept in lairages for longer periods under specific conditions i.e when food is provided.

Image 1: Lairage at the Santori Beef plant  Image 2: Short period holding pens for sheep

OIE standards state that all animals must have the minimum space required for all animals to freely lay down, stand up and turn around at same time.

In practice size of animal and also the length of time spent in the lairage should be taken into account.

As mentioned before in the lairage, cattle and sheep should be held for a relatively short period of time. They need space to carry out only a few basic activities e.g. thermoregulation, excretion, movements such as standing up, lying down walking to the water and feeding through and turning around.

Except that cattle also need space to avoid threats and aggressive behaviour from other cattle. There is little science that indicates what would be the optimum space for cattle within the lairage environment, and many recommendations have evolved through requirements either on farm or for transport.

However a number of formulas have been developed based on animal shape, size and weight. These have been adjusted to calculate space needed for basic body positions (see Table)

- **lateral recumbency**: animal lying on its side, legs fully extended
- **semi recumbency**: animal on its side with legs tucked close to the body
- **sternal recumbency / standing**: where the animal has its legs directly beneath it or is standing

<table>
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<tr>
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<td>1,30</td>
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<tr>
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<td>1,00</td>
<td>1,15</td>
<td>1,30</td>
<td>1,43</td>
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</tbody>
</table>
Animals need to be able to move between standing and lying. Cattle in particular need ‘lunging space’ to get up from a lying position. From field data on dairy cattle the approximate minimum space needed for cattle to rise is very similar to that for lateral recumbency and this has been verified with more sophisticated 3-dimensional modeling.

As lairage time increases more cattle and sheep will tend to lie down and an estimated 80% of animals might lie at any one time, particularly overnight when there is less activity in the lairage. Therefore for cattle being held overnight in the lairage the minimum space area per head has to be close to the recommended space needed for lateral recumbency. Holding pens where sheep are kept overnight have to be filled up to 80% of their normal capacity. In reality most of the lairages are designed more generously as human activities such as ante-mortem inspection, handling and sorting of animals as well as and cleaning have to be carried in the lairage too.

SEPARATION

The need to separate out unfit animals is covered in chapter on fitness. As a general principle it is important that where cattle are likely to suffer pain, injury or distress by being penned with certain groups or individuals then they should be kept separate, for example, mature bulls or cattle of significantly different size.

Mixing cattle from different farm social groups is detrimental to the animals’ well being and increases the incidence of Dark Firm Dry - DFD meat (17.5% in steers and 23.5% in bulls) particularly when cattle are held for long lairage times (over 12 hours).

The impact of mixing will be influenced by sex, previous handling experience and possibly genotype. In cattle, it is the animal doing the mounting behaviour that is at greatest risk from fatigue and if possible very active animals should be removed from the group, or the group should be slaughtered as a priority.

**Image 1**: Isolation pen at the Santori Beef plant

WATER

Provision of water in holding pens in the lairage is a basic need, irrespective of how long the journey has been to the slaughterhouse or how long the animals are to be held. According to the OIE standard clean drinking water has to be provided to cattle at all times. Water is vital for life and it’s important to be aware that in the run up to the transport process, handling, penning before loading etc. cattle might not have had adequate opportunity or desire to drink. The slaughterhouse lairage is therefore the place where cattle that are thirsty can satisfy their need. When cattle are fasted or on severely limited rations (as is usually the case before transport and slaughter), they increase water intake to compensate.
The means of delivery (bowls or troughs), the number of drinking points, cattle stocking density and water quality will all affect the actual availability of water. For example water intake is generally higher if large troughs are used.

Lairage staff must be made aware that although water may be in the pen, there may be some cattle who are at greater risk of dehydration because of competition or lack of mobility.

The basic signs of dehydration in cattle are:
- Pale gums
- Reduced skin elasticity (the pinch test)
- Licking surfaces

Dehydrated animals should be slaughtered as a priority.

FOOD

It is stipulated in the OIE standards that cattle held in the lairage for more than 12 hours prior to slaughter, must be fed on arrival and in appropriate periods. Up to this point there are sound reasons why cattle need not be fed, if they are slaughtered soon after arrival as:
- The rumen acts as a reservoir of nutrients and water. Cattle can therefore go for relatively long periods without food before there is a significant impact on their welfare.
- For hygiene purposes cattle need to arrive at the evisceration point ideally without a full gut.
- Feeding in the lairage may lead to fighting, particularly if feed and space is limited.

SHADE AND SHELTER

Cattle and sheep are relatively hardy animals and can cope with a wide range of climatic conditions provided they are fit and healthy.

According to climate conditions in Turkey it could be assumed that heat stress is more likely to be a problem than cold stress.

_Bos indicus_ cattle are naturally better adapted to the heat. Thin skin and a white colour are better at reflecting the sun rays. The hump and the dewlap increase the animals’ surface area over which heat can be lost and _Bos indicus_ animals generally have larger sweat glands, which are more efficient.
Bos taurus types generally have darker coat colours and a thicker coat for insulation, therefore more prone to heat stress. However over longer period of time they will develop an adaptive response to increasing environmental temperatures.

Sheep particularly unshorn and well fed will suffer from heat stress significantly, therefore water has to be provided and these animals must be slaughtered as soon as possible after arrival at the slaughterhouse.

In the lairage when temperatures are high, cattle and sheep will benefit from shade, however there has to be good air flow around the cattle. Misting or water spray systems for cooling cattle may cause a greater welfare risk when there is high temperature, high humidity and poor air flow.

DESIGN PRINCIPLES

Lairages should be designed in a way that minimize the handling of the animal. The optimum outcome in terms of lairage layout is to be able to move animals from the unloading point to the holding pen and on to the point of slaughter as directly as possible. The number of turns and corners should be minimal and the route the animals take should encourage forward movement.

When designing or modifying the handling system it is essential that it is looked at from the animal’s point of view for two main reasons:

1. Handling systems look, sound and feel very different when walked where the cattle walk.

2. The cattle will move better when the system is physically within their capabilities; depending on the size of animals being handled there may be optimum dimensions for different parts of the system.

Inclines

Cattle and sheep have their centre of gravity at the shoulder; they find walking down a steep incline (such as an unloading ramp) or a large step difficult, as they naturally need to slow their pace to avoid falling forward. Moving up a steep incline is a physical challenge as weight needs to be pulled up and forward. To avoid animals slowing down, systems should be designed so that cattle are moving on level ground as much as possible.

Floors

Floors need to be non-slip. Cattle will slow down and be reluctant to move on a surface that does not give them confident footing. Good footing is essential in high traffic areas such as raceways and crowd pens, and areas of high risk such as inclines and gateways.

Grazing animals, like cattle and sheep, can see depth to some extent but because of their limited vision they have to stop and put their heads down to see clearly. Cattle also have vision that is sensitive to contrasts of light and dark. This is why they are often reluctant to cross changing light patterns, drains, steps, puddles of water, gutters and other areas where there is a high contrast change.
Cattle and sheep are also less confident moving on floor surfaces they are not used to, i.e. concrete and metal. The floor surface needs to be visually uniform; cattle will slow down or stop to move over or around floor areas that look different to them. Any changes need to be eliminated from the main cattle handling routes to make handling easier.

**Passageways**

Cattle and sheep move in groups and are motivated to move by the sight of other cattle moving forward. Passageways must be wide if groups of cattle or sheep are expected to be moved quickly. Solid sides prevent cattle being distracted or alarmed by the sight of unknown animals, human activity, equipment or machines. As with floor surfaces, at key handling areas the wall surface should be the same throughout.

**Corners and Turns**

Cattle have long bodies and they need space to turn. Tight right-angles and corners, for example out of the pen into the passageway, may be physically difficult for some cattle to negotiate. Cattle need at least a cattle and a half-length directly in front of them to make the turn easy.
Sharp right-angles within handling systems can create apparent dead ends from the animal’s point of view, they see no way forward and will stop. Pens that are angled improve cattle flow. With curved raceways the curve must not be too tight. From the cattle point of view it should look like there is a way out just around the corner, not a dead end.

**Lighting**

Research has shown that cattle, like other animals, have a tendency to move towards more brightly lit areas. Experiments indicate that lighting should be even and diffuse. Strong contrasts of light and shade will stop forward movement, for example, as animals move from an outside area into a building. Artificial or natural lighting that shines right in the face of the cattle will also cause them to slow down or stop.

**Noise**

Cattle are able to detect sound that humans cannot. Both cattle and sheep have a very good sense of hearing and are very sensitive to certain high-pitched noise from machinery and equipment. Loud, intermittent noises close to handling areas can also produce a startle or panic response and should be eliminated.

**Crowding Pens**

Crowd pens for cattle and sheep that lead into the main race to the stunning pen are usually either rectangular or circular in shape. Both can work provided the cattle can and sheep see a clear way up the race and cannot jam at the race entrance. A funnel design works with cattle when using a circular handling pen. Solid sides prevent animals seeing, and wanting to go back towards the lairage and other animals. The crowding pens must not be overfilled, cattle need space to turn and see where they need to go. Cattle should not be pushed with the crowd gate.

**Restraining box**

Cattle can be reluctant to enter the restraining box. This is often because there is a sudden change of floor and wall material (concrete to metal) or lighting (outside to inside).
To encourage forward movement the contrast needs to be minimised as much as possible, such as making the floor the same material or introducing a metal panel side before the box.

The box should have non-slip, level and firm footing and there should be no gaps at floor level to distract cattle.

The design of the box needs to create the illusion to the cattle that there is a way out or at least enough length so that they are encouraged to walk forward and not stop short of the front of the box.

Similiar principles would apply before getting sheep from chute into the V shaped conveyor restrainer. False floor of same or similar structure has to be installed at least one and half length of the body into the restrainer conveyor.

**LAIRAGING AND LAIRAGE DESIGN FOR PIGS**

The environment in the holding area must provide all **conditions contributing to minimize stress**, even knowing that the majority of the pigs cannot entirely habituate to the new environment within a short period of time.

![Image: Conditions in the lairage area adequate to the welfare standards](image)

The holding time of pigs in lairage has usually been determined by the operational requirements, health and food safety. However, results from several studies have shown that long resting periods negatively affect animal welfare and meat quality.

Upon arrival at the holding pens, some slaughterhouses adopt the procedure of washing pigs and provide them with water. The water provision is essential to:

- Allow pigs to partially recover from dehydration after transport;
- Reduce heat stress caused by physical efforts and crowding during transport;
- Facilitate excretion of gastrointestinal contents to avoid rupture during evisceration and contamination of the carcass.

**LAIRAGE TIMES**

Pre-slaughter handling causes intense stress to the pigs, demanding that the animals rest prior to slaughter. The holding area must provide a calm environment and have adequate arrangements for handling, minimizing stressful factors.
However, long periods in the holding pens can compromise the welfare of the pigs and carcass yield, increasing the incidence of:

- **Injuries caused by fighting;**
- **DFD (dark, firm, dry) meat;**
- **Bacterial contamination.**

When pigs arrive at the holding pens, they tend to lie down and rest from the physical stress caused by the transport. After a period of 2 to 4 hours, the animals start showing signs of recovery and interact with other pigs in the group.

Under these conditions, pigs will explore the environment socially, interacting with other animals in the group, and when these are unfamiliar (due to mixing of groups) they will attempt to establish a new social hierarchy by fights, which leads to excessive energy expenditure and lesions to the skin.

![Image: Skin lesions caused by fights resulting from a long resting period and mixing of pigs](image)

**FASTING TIME**

Fasting time is determined from the time of the last solid feeding (ration) at the farm to the time of slaughter. It is essential that pigs have free access to water up to slaughter time.

The fasting procedure aims to meet hygienic-sanitary regulations as pigs should have the low volume of gastrointestinal content at arrival to the slaughterhouse, in order to reduce contamination risks during evisceration, as well as to improve their welfare and reduce mortality rate during transport. **The increase in mortality during transport** of pigs with large volume of gastrointestinal content can be related to the following causes:

- The pig is monogastric and if transported with full stomach may regurgitate or vomit and thus asphyxiate;
- The blood circulation during digestion is directed to the gastrointestinal system as the remaining organs function with reduced blood volume. If pigs are exposed to stressful situations such as transport, the oxygen supply to the brain may not be sufficient leading to death;
The increase of the stomach size due to feed intake can put excessive pressure over the cava vein in the abdominal cavity and, with this, reduce the blood return that may be insufficient for circulation and oxygenation of vital organs;

Due to increased stomach size, there can also be pressure over the diaphragm, impairing breathing by limited lung expansion and consequent tachycardia.

When fasting is well managed, there is a positive impact on the welfare and meat quality. However, in order to define the ideal time, one must take into consideration the fasting time at the farm, during transport and lairage time at the slaughterhouse.

The recommended period from the time of feed withdrawal until slaughter is about 12 hours. The fasting period should be no longer than 18 hours in total (fasting at the farm + transport + lairage at the slaughterhouse); a prolonged fasting time (above 24 hours) promotes excessive energy expenditure and loss in carcass yield, as well as an increase of final pH values (24h post mortem) and interference with meat quality.

Image: Mortality during transport – pigs with full stomach : Steps

Fasting time at lairage at the slaughterhouse

Reducing lairage time at the slaughterhouse to 2 to 4 hours minimizes the negative effects of fasting on meat quality and carcass contamination, when compared to those animals kept in the holding pens for long periods of time.

Fasting is of major importance mainly for preventing Salmonella contamination, from shedding during transport and cross contamination in the holding pens at the slaughterhouse. Thus, using long lairage periods in the pens at the slaughterhouse can intensify contamination by Salmonella due to the fact that pigs defecate frequently while exploring the environment, increasing contamination of the respiratory tract.

WATER PROVISION

Water is vital for any living being, and thus provision of water in all pens during lairage is of extreme importance. Everyone working in this area is responsible for offering clean, uncontaminated water in sufficient amounts according to group size, especially because by this time, pigs have not had access to water since the beginning of the loading procedure.
**Water must be available at all times.** Drinker type and amount, number available and amount of water will affect the intake of the entire group. For this reason, staff working in the holding area must be attentive to water availability, functionality of drinkers as well as their positioning, because there may be animals with a risk of dehydration due to competition or difficulty reaching the drinkers.

*Image:* Drinkers in the holding area at the slaughterhouse. Drinkers must be maintained clean and with water available.

Pigs need sufficient space to express their basic behaviors such as standing up, lying down, turning and walking, in addition to having conditions to explore the environment while searching for water. Otherwise, these animals compete for space, generating stress and increasing levels of aggressiveness and fights.

**There is limited scientific information indicating the ideal space for pigs in the holding area at the slaughterhouse. Some regulations determine the minimum space allowance as:**

- **European Union** – 0.55 to 0.67m² / pig (100 kg)
- **United States** – 0.50m² / pig (100 kg)

**MIXING OF PIGS**

Mixing of pigs from different social groups harms their well-being as a consequence of fighting to establish a new social hierarchy, particularly when the lairage period is long (more than 4 hours).

Countries in northern Europe generally raise pigs without mixing them from farrowing to slaughter; whenever this is not possible, research shows that mixing pigs in the truck has better results, with decreased fights, compared to those that are only mixed at the slaughter house. This effect occurs because during transport, instead of fighting, pigs focus their attention on keeping equilibrium to prevent falling. The contact with the new group has already taken place by the time they arrive at the slaughterhouse.
Protecting from adverse weather

Pigs naturally suffer with climate variation, especially in relation to heat, because they have a small number of sweat glands, and have difficulty exchanging heat and regulating body temperature.

Physical efforts (exercise) during loading, transport and unloading of pigs increases heat stress; thus, the holding area at the slaughterhouse must compensate by allowing heat losses. The holding area must be covered and provide water, ventilation, and cooling system if necessary. Additional information is described in the chapter about thermal comfort.

REMEMBER:

- Lairage time in the slaughterhouse must cause minimum stress;
- Try to keep a calm environment in the pens;
- Provide water that is clean and of good quality ad libitum during the entire lairage period;
- Provide adequate space in the pens to facilitate pigs’ recovery;
- Avoid mixing of groups of pigs, diminishing fights and directly improving animal welfare and meat quality;
- An adequate fasting period will reduce mortality rate and contamination risks and will have a positive impact on animal welfare;
- Total fasting time must not exceed 18 hours.

STRUCTURE OF THE HOLDING AREA FOR PIGS

The layout or design of the holding area has a significant impact on handling quality, line speed and working conditions. When designing or modifying this area, we must not only address the dimension of structures and set spaces, but also understand handling so as to meet the animals’ needs and their interaction with people and facilities.

Holding pens must be of appropriate dimensions for the number of pigs to be slaughtered. This planning avoids future problems with unplanned building expansion that may compromise the quality of the new facilities.

Thus, the holding area must be planned to encourage pigs to move and facilitate handling, from the time of unloading to the slaughter area, focusing on diminishing stress and eliminating risks of bruises.

When seeking to facilitate handling of pigs at pre-slaughter, it is essential to design the holding area from the pig's point of view and not the human’s, as the pig's vision height and angle in relation to the environment are different from the way humans perceive it.
FEATURES IN THE HOLDING AREA

Unloading ramps

The unloading ramp should be built in an area protected from sun and rain. Side walls must be solid to prevent pigs from being distracted by the transit of people and other animals.

The floor must be non-slippery and may be covered with rubber, cement or metal. Any non-slippery material placed over the floor (such as mesh) must be regularly maintained and kept in perfect condition to prevent injuries to the animals’ hooves.

Ideally pigs must not walk over angled ramps during unloading; when unavoidable, they should have a maximum angle of 15 - 20 degrees. Ramps that are too steep make handling difficult, which becomes slow, and increases the risk of pigs slipping and falling. This causes both animal welfare and carcass quality problems.

The ramp should be frequently washed to prevent accumulation of manure and thus reduce the risk of slips and falls during unloading.

Proper ramp maintenance should include avoiding holes, steps, cracks, gaps (spaces between the truck and the ramp), rough edges and any other sharp material or obstacle that can bruise the animals or hinder unloading.

Flooring at the holding area

From the place of unloading to the stunning area, the floor must be uniform and non-slippery. Consistent color and texture must be maintained so the animals feel safe while handled, resulting in calm movement and minimizing risks of slipping and falling. Consistent flooring will encourage the animals to walk at a steady pace without reducing speed or stopping.

Pigs have limited depth perception and are therefore reluctant to cross areas with light contrast, drains, holes, steps, puddles, and other surfaces which have contrast in color and texture.
Alleys in the holding area

Pigs are motivated to walk in groups, so they are able to see other pigs that are moving ahead. **Wide alleys with solid sides** are recommended to facilitate handling as they eliminate visual contact with pigs in the holding pens and even with people and equipment around them. This layout avoids stops due to distractions and allows for more efficient handling of the animals. Also, gates and walls in these alleys must be as uniform as possible, avoiding contrasts in color, texture and lighting along all the way.

Image: Wide alleys with solid walls, preventing distraction of the pigs: Steps

Corners and curves

Pigs are strong, heavy, have an elongated body and need space to make turns. Facilities with narrow alleyways that change direction with acute angles can be difficult for some pigs to move through. Angles and corners that are too sharp make the direction in which pigs are moving unclear. To encourage pigs to move forward, they need to see the path they must walk clearly. If it looks to them as if there is no way out ahead, they are likely to stop.

Image: Alley with ample curve is appropriate for moving pigs: Steps

Layout of holding pens

The layout of holding pens in relation to alleys and distance between the pens and the stunning box must be designed in a way to facilitate movement of pigs and promote continuous and rapid flow to supply the slaughter line.

The **holding area facilities in a diagonal design** are built with pens laid out at a 45 degree angle in relation to the alley. This angle in relation to the central alleyway facilitates entrance and exit of the pigs, contributing to easier and more efficient handling.

Image: Diagonal layout of a holding area facility Source: adapted from Grandin (2008)

Using **long, narrow pens** also helps to encourage pigs exiting in addition to reducing stress. Long pens, when **subdivided in smaller sizes**, can assist handling even more and reduce fighting among the animals.
Pens with the capacity to hold a large number of pigs usually lead to difficult handling and promote higher incidence of fights due to mixing of animals from different groups and social hierarchy disruption. In addition, maintaining the group in a calm and quiet manner during subdivision into smaller groups, as the handler guides them to a central alley can be more difficult.

**Image:** Long and narrow pens with subdivisions; Long pens without divisions housing a larger number of pigs, mixing the groups

**Lighting**

Often there are pigs which refuse to continue walking; this can be a natural behavior as they are unfamiliar with the environment and need to stop, look, smell, and recognize the new surroundings.

However, there are situations where the pigs refuse to walk and the problem is due to insufficient lighting in the environment, for example when pigs are driven from a well-lit area to a dark area.

It is best to move pigs through areas with **uniform lighting** and try to avoid lighting aimed straight toward to the animals’ eyes (including reflections, and especially bright lights). This will assist handling.

**THERMAL COMFORT OF PIGS**

One of the biggest challenges during pre-slaughter handling is maintaining control over the environmental conditions in the holding area, in a way to promote thermal comfort and provide opportunity for recovery from physical stress, which pigs are subjected to during loading, transport and unloading.

As pigs have a deficient thermoregulatory system, with keratinized sweat glands, high amounts of fat tissue and an elevated metabolism, it is important to maintain adequate ambient temperature, with a direct effect on the welfare of the animals.
Pigs, like humans, are homeothermic and sustain body temperature within specific limits (38.7 to 39.8°C), independently of variation in the ambient temperature. Nonetheless, heat needs to be continuously exchanged with the environment in order to regulate and maintain this body temperature, and this exchange is efficient only when ambient temperature is within the thermoneutral limits.

**Image:** Natural behavior of pigs to lose heat and keep body temperature within the thermal comfort zone

**PRINCIPLES OF THERMOREGULATION**

The control of body temperature is achieved through several mechanisms, the majority being triggered by thermoregulatory centers located in the hypothalamus, skin thermo-receptors and deep tissues. When a pig's body temperature alters and is detected by the hypothalamic center, mechanisms are triggered to sustain a normal body temperature near to 39°C.

For efficient thermoregulation, the amount of heat produced by the pig must be equal to total heat lost to ambient conditions.

**TOTAL HEAT PRODUCED BY THE PIG = TOTAL HEAT LOST TO THE AMBIENT**

When ambient temperature decreases, pigs’ temperature may be out of the thermal comfort zone; thus, the body triggers mechanisms to generate heat. With increasing ambient temperature, these mechanisms are triggered to lose heat. Under these conditions, both physiological and behavioral alterations may occur as the animal seeks to maximize heat exchange efficiency.

**HEAT EXCHANGE MECHANISMS**

The homeostatic system promotes thermal balance by regulating the body temperature within tolerable limits for perfect physiological functioning. There are four mechanisms through which a pig can exchange heat with the environment, as follows:

Radiation

This mechanism allows for heat exchange (loss or gain) through electromagnetic waves and occurs when the pig passes heat to a cooler environment or absorbs radiation in the form of a wave. Examples of radiation sources that can promote heat production are: sun, light bulb and fire.
The intensity of heat exchange by radiation depends on:

- Temperature differences between the pig and the heat source;
- Body surface area exposed and distance to the heat source;
- Surface color – Pigs with light skin color reflect a greater portion of solar radiation reaching their body surfaces, while pigs with dark skin color absorb most incident radiation.

Conduction

Heat exchange occurs by direct contact of a pig’s body with ground, water or other surfaces. In order to lose heat through conduction, the pig seeks to maximize contact of the body surface with cooler surfaces.

The intensity of heat exchange by conduction depends on:

- Temperature differences between the surfaces;
- Area of contact with the other surface;
- Thermal conductivity of surfaces.

Convection

This is the transferring of heat resulting from air movement over the skin or blood circulation surfaces, transporting heat from internal tissues via the body surface of the pig.
The intensity of heat exchange by convection depends on:

- Temperature differences between the pig and the environment;
- Relative speed of the air or the pig.

Image: Heat loss from the pig to the surrounding area by convection: Steps

Evaporation

This is the conversion from liquid to gas (vapor) state. Control of respiratory evaporative heat loss (by panting, fast breathing) is one of the most important mechanisms for pigs exposed to high temperatures to lose heat, and can account for up to 60% of body heat loss. The greater the respiratory frequency of pigs, the higher is the amount of heat dissipated to the environment.

Image: Heat loss from the pig to the surrounding area by evaporation; Steps

Sweating is another way of losing heat; in pigs, this mechanism is practically absent since they have a reduced number of sweat glands, that are inefficient.

The intensity of heat exchange by evaporation depends on:

- Temperature differences between the pig and the environment;
- Relative humidity.

HEAT EXCHANGE

Heat exchange by radiation, conduction and convection depends on temperature differences between the pig and its environment. In contrast, evaporation is not only related to variation of temperature, but is also greatly influenced by relative air humidity surrounding the pigs.
As ambient air temperature increases, the pig loses less heat by radiation, conduction and convection, and evaporation becomes the predominant cooling mechanism. But as relative humidity increases, the pig loses less heat by evaporation.

Each method for heat exchange varies considerably according to:

- Climate factors (temperature, relative air speed and humidity);
- Climate conditions (seasonal variations and period of the day);
- Facility features (ventilation, flooring type, solar incidence);
- Factors intrinsic to the pig (age, sex, genetics, skin color);
- Stocking density (truck or pen).

**TEMPERATURE AND COMFORT – THERMONEUTRAL ZONE**

Each rearing phase of pig production has a recommended range of ambient temperature where the pig maintains body temperature constant with minimal thermoregulatory effort. This is called the **Thermal Comfort Zone (TCZ)**, where feelings of cold or hot are not present and pig performance is optimized.

The **thermoneutral zone** defines the range of temperatures for thermal comfort of a pig and its limits are known as ambient **lower critical temperature (LCT) and upper critical temperature (UCT)**: pigs need to gain or lose heat to keep their body temperature constant above and below these limits.

In a **cold environment**, the lower critical temperature is that at which the organism triggers thermoregulatory mechanisms to increase heat production and retain body heat, thus compensating for heat loss to the environment. Likewise in a **hot environment**, the upper critical temperature is that at which the pig activates mechanisms to lose heat when production is greater than the losses. Within this range, mechanisms such as fast breathing and peripheral blood vessel dilation assist in the process of dissipating heat.

The figure below shows optimal thermal conditions (thermal comfort zone) and the critical temperatures (lower and upper), delimiting the thermoneutral zone.

Pigs’ lives may be endangered under extreme temperatures. However, most pigs can resist low temperatures for a reasonably long period and recover. But short periods of high temperatures can be fatal.

The table below shows optimal and critical relative temperature and humidity for pigs during the grower and finisher phases.

<table>
<thead>
<tr>
<th>Live weight (kg)</th>
<th>Optimal temp. (°C)</th>
<th>Critical temp. (°C)</th>
<th>Relat. humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td>LCT</td>
</tr>
<tr>
<td>20-35</td>
<td>18</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>35-60</td>
<td>16</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>60-100</td>
<td>12</td>
<td>18</td>
<td>4</td>
</tr>
</tbody>
</table>
COLD STRESS

The lower critical temperature for pigs weighing 60 to 100 kg is around 4°C. However, if body temperature drops 7 to 8°C below normal, the pig becomes hypothermic, and may die if this condition persists and no action is taken. In cold stress conditions, pigs tend to crowd, avoid exposure to wind and reduce water intake to maintain the body heat that is produced. Under these conditions, the body triggers mechanisms to maximize heat production such as muscle tremors (shivering).

HEAT STRESS

The upper critical temperature for pigs weighing 60 to 100 kg is around 27°C. If the pig’s body temperature rises above the average value considered normal (near 39°C), this leads to heat stress or hyperthermia. A body temperature reaching 4°C above normal can lead to a pig’s death. In circumstances of heat stress at the slaughterhouse, the pig alters its behavior seeking cooler surfaces and air flow, spreading in the pen and increasing water intake. However, if these exchange mechanisms are not sufficient, the condition is aggravated and the pigs start losing heat by panting.

RECOMMENDATIONS TO HANDLE PANTING AND TIRED PIGS

The following procedures are recommended for animals that arrive at the slaughterhouse with severe heat stress:

- Move the pig as little as possible to prevent aggravating heat stress;
- Use a cart to transport the pig from the unloading area to the holding pen;
- Leave the pig resting in the emergency pen, in a calm and cool environment. This helps heat exchange and recovery of the animal;
- Place the pig to rest near the drinker;
- Wet the floor where the pig is resting to assist with heat loss by conduction;
- Be careful not to wet the pig directly to prevent aggravating the condition and causing thermal shock (cold water in contact with hot body surface).
Ideally, under conditions of severe heat stress or tiredness, the pig must not be moved and allowed to rest in a place close to the unloading area, as long as this is calm, cool, with access to water and with no transit of people.

THERMONEUTRAL ZONE IN THE HOLDING AREA AT THE SLAUGHTERHOUSE

The main goal of the holding area is to promote maximum thermal comfort to allow for recovery of pigs and facilitate handling. Considering these factors, the facilities and equipment at the slaughterhouse must control for environmental variables.

Influence of fogging systems in the holding area

The main purpose for using water mist (fog) in the holding area is promoting better environmental conditions for the animals, minimizing thermal stress, as it decreases body temperature and cardiovascular tension and calms the pigs.

Fogging systems are efficient only when the water used is cooler than the pigs' body temperature and the area is ventilated to promote flowing of cool air over the animals. In some regions where ambient temperature is elevated and with poor ventilation, fans can be installed in the resting area. Correct positioning of these fans is fundamental to assist in removing the hot air from around the pigs and improve heat exchange by convection.

The use of fogging and ventilation must take into consideration monitoring of pigs' behaviors in the pens on both cold and hot days.

International recommendations for use of fogging indicate application in regions with temperatures above 10º C and relative ambient humidity less than 80%, and the best use program consists of two fog applications 30 minutes post arrival and 30 minutes prior the pigs exiting the holding pens.

Maintenance of fogging systems

Regular maintenance of the fogging nozzles, to control proper pressure and exit of water, is essential for saturation of air with humidity (formation of fine mist) and to promote thermal comfort for the pigs.

When fogging nozzles are clogged and/or do not have enough pressure in the water, there is a formation of small drops (showering) and water drips over the pigs that become more active in the holding area. It is common to observe that pigs avoid this area and therefore become crowded elsewhere.
REMEMBER:

- Keep an adequate density, avoid stops during the journey and transport pigs during periods with moderate temperatures; these measures can reduce thermal stress and prevent mortality during transport;
- Pigs in the slaughterhouse can suffer from heat or cold stress;
- The handling team needs to be trained to recognize these signs of stress in the pigs and be responsible for promoting ambient conditions that allow recovery;
- Ambient temperature and humidity in the holding area at the slaughterhouse must remain within the thermoneutral zone;
- The holding area must be covered (shade), well ventilated and equipped with a fogging system to prevent thermal stress that can lead to death;
- Pigs that arrive at the slaughterhouse with severe thermal stress or tired must be handled carefully to prevent aggravation of suffering.

RESTRAINT, STUNNING AND BLEEDING OF CATTLE

INTRODUCTION

For stunning to be effective the shooting position must be accurate. With large animals, such as cattle, basic methods of confining or restraint have been in existence for many years.

The simplest method of restraint is to fix the head using a head collar or halter, however this is only practical where the throughput of the slaughterhouse is very small and where the cattle can be easily roped.

In most slaughterhouses the minimum that is required is some form of stunning box or pen that confines the cattle for shooting, this is a legal requirement in many countries in the world. In addition to simple confinement of the animal, many boxes are now fitted with fixed or moveable devices which restrict movement of the body, neck and head.

PRINCIPLES

When cattle are restrained for stunning the aim is to:

- Reduce, forward and backwards movements of the animal
- Reduce sideward and vertical movements of the head
- Present the head in an ideal position for stunning
- Keep the stress levels of the animal to a minimum
Since restraint is not normal for any animal it can be a very stressful process. In practice there is a need to balance the risk of distress, injury and suffering to the animal through the restraint process, and the risk of distress and suffering that might occur through inaccurate stunning position.

Cattle will also be isolated from other animals when confined within the stunning box and this period of isolation on its own can cause distress even in relatively placid animals. It is important that cattle are never allowed into the stunning box or restrained until everyone is ready and that cattle must never be left waiting in the stunning box.

**TYPES OF BOXES AND RESTRAINT DEVICES**

Stunning boxes can be supplied direct through a manufacturer or designed and built by the slaughterhouse themselves and fall into four basic categories.

1. **Simple box**

   The cattle are confined within a concrete or metal pen and there is an exit door to eject the animal once it has been stunned. The exit doors either slide vertically upwards or pivot round. Such boxes are acceptable but the operators need to be highly skilled to consistently and accurately stun animals, as the animal’s head is free and fully mobile.
2. **Passive restraint**

Passive restraint is where the box has no moving parts but there is a fixed shelf or similar which prevents the animal putting its head down and encourages the animal to put its head in an accessible position for the operator. There are some boxes that have fixed wedges within the box to reduce body movement.

*Image: Passive shelve keeping head up 6 Source: Elders*

3. **Semi-passive restraint**

Part passive restraint is where there is a combination of moving and non-moving parts to help position the head. For example stunning box is equipped with moving side neck yoke that prevents animal to move its head to sides.

4. **Active restraint of the head**

Active restraints of the head work in two stages; a yoke that catches the neck and a chin lift that raises the head and jaw upwards. Because they hold the animal rigid they must be used in conjunction with other body restraint devices such as a side push or belly lift to prevent animals “hanging” once they are restrained.

5. **Active restraints of the body**

Both rump pushers and side pushers are mechanically operated and reduce the space in the box either in width or in length. A box fitted with a rump and side pusher can also be made longer and wider than would otherwise be possible, this extra space encourages cattle to enter more freely. These devices are essential when the slaughterhouse deals with cattle that differ significantly in size and type, and are useful with all types of boxes whether they are fitted with head restraint devices or not.

**REDCUING STRESS AND IMPROVING RESTRAINT**

If the stunning box and any restraint is working well the majority of cattle should enter the box willingly and there will be little need for the use of electric goads. Whilst in the box cattle should not vocalise and the total time from entry to stun should be short.
However, handling cattle at this point in the system is often the most difficult as effectively they are being separated from the herd, moving into the different environment of the slaughterhouse and into what may appear to them as a closed box.

To reduce the stress, animals must go into any box willingly. Stress levels increase if an animal stops and refuses to enter or several attempts are required to restrain it. Cortisol levels increase the longer it takes to restrain the animal.

MECHANICAL STUNNING

INTRODUCTION

Ever since man learned to club an animal to immobilise it before delivering a lethal wound, stunning has often been the first step in the slaughter process in many parts of the world.

Stunning was at first adopted to produce immobility rather than insensibility, but with the emergence of the animal welfare movement the focus switched to the animal's welfare with the aim of producing insensibility to pain as the priority.

Captive-bolt stunning equipment has been in existence for around 80 years and is a mechanised version of the first percussive instrument designed specifically for slaughter, the pole-axe.

Image: Pole-axe used for stunning of cattle 150 years ago in the UK

PHYSIOLOGICAL EFFECTS

Both types of captive-bolt stunning gun (penetrative and non-penetrative) are percussive in an action; that is they involve the striking of one body, the bolt, against another, the animal's head. If these percussive forces are strong enough they will produce concussion in the animal.

Cerebral concussion is usually a short lasting disturbance of neural function which results in:

• Sudden, often relatively brief impairment of consciousness
• Paralysis of reflex activity
• Loss of memory

There is information on the physical effects of stunning but the precise ways in which physical forces affect the neurological function of the brain are much less certain.
The brain is a relatively incompressible organ, a blow to the head sets up high velocity distortion waves. The frequency of these pressure waves will vary in different parts of the brain and this may be an important factor in inducing insensibility.

There may also be transference of pressure waves from brain to spinal cord and the ‘contra-coup’ effects of the brain making impact with the skull.

The exact position and angle of the head when a blow is delivered can also affect the mechanics of the impact and possibly the acceleration of the head, and the brain within the skull. This may account for the variation in how the brain might be affected.

There are several theories of why the state of concussion occurs (reviewed by Shaw 2002):

Currently the “Direct mechanical insult to the neurons” theory which says stunning leads to a sudden depolarisation of neurons followed by a short period of excitation (tonic/clonic) seizures and finally a quiescent phase due to neuronal paralysis is the most favored.

It supports the fact that in most cases concussion causes only functional damage and therefore it is reversible.

However where there is too much energy imparted to the brain by the impact, this will generate movement of the cerebral hemispheres and increase the chance of tissue damage, or deformation, between the cortex and the skull. Some believe it is this which produces global ischemia of the brain and permanent loss of brain activity.

**PHYSICS**

Not every blow to the head, to either a human or an animal, will produce a state of unconsciousness. To achieve the unconscious state relies upon transferring enough energy from a moving object, the bolt, to the animal’s brain.

The energy of a moving object is known as *kinetic energy* and the amount of energy produced is proportional to the mass of the moving body and its velocity. The relationship is expressed in the formula:

\[ KE = \frac{1}{2}mv^2 \]

- Kinetic energy is measured in joules (J)
- The mass of the object (m) is given in grams (g)
- The velocity of the object (v) is given in metres per second (ms\(^{-1}\))

A simple calculation (see Table 1) illustrates that it is the velocity of the projectile which has a much greater influence on the kinetic energy delivered, and therefore the effectiveness of the stun, than the mass of the object.
There has been a progressive improvement in the performance of many makes and models of captive-bolts compared to those available 20 years ago. However, even in a modern stunner, any factor which reduces the bolt velocity, such as poor maintenance, can seriously affect the performance and the likelihood of an effective stun.

### EQUIPMENT

All captive bolts work along similar basic principles. There is a steel rod either with or without the mushroom type head with a flange and a piston which make up the bolt.

The bolt is contained within a barrel, with the piston fitting tightly into a combustion chamber and the bolt being surrounded by compressible recuperating sleeves.

When fired, the power source propels the piston forward.

The bolt then emerges through the opening at the muzzle and either strikes or penetrates the skull. The bolt is retained by the flange (hence the name “captive-bolt”) and the energy is absorbed by the recuperating sleeves.

Stunners can be fired with a trigger mechanism or fired on contact with the animal’s skull.

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**Table: Effect of bolt velocity and mass on the effectiveness of stunning**

<table>
<thead>
<tr>
<th>Bolt Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 ms⁻¹</td>
</tr>
<tr>
<td>Mass of Bolt</td>
</tr>
<tr>
<td>$KE = \frac{1}{2}mv^2$</td>
</tr>
<tr>
<td>Result*</td>
</tr>
</tbody>
</table>

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*Image: Non-penetrating captive bolt - Source: Accless and Shelvoke*
Power Source

The power required to propel the bolt forward is from either a blank cartridge or compressed air.

a) Cartridge – these vary in strength and are classified by the amount of propellant they contain, measured in grams. It is essential that the correct cartridge is used for the make and model of stunner and appropriate for the size of animals to be stunned. Cartridges can be identified by calibre (e.g. 0.22 or 0.25), colour and head stamp.

b) Compressed Air – power is provided via a high-pressure air compressor. The equipment is heavy and not easily maneuverable and needs to be suspended by a counter-balance arrangement over the box.

The cattle need to be well restrained. However, a higher throughput of animals is possible and there is less maintenance.

Non-Penetrating Captive-Bolt

Non-penetrating captive-bolt stunning produces a depression of the frontal tissue and bone as well as some haemorrhage, particularly beneath the impact site in the temporal and frontal lobes.

The use of a frontal non-penetrating captive-bolt results in immediate loss of consciousness in all animals and rhythmic breathing is absent.

Research work on the depth and duration of unconsciousness for adult cattle after a non-penetrating captive-bolt has not been reported; the duration of insensibility for calves is about 20 seconds. There is sufficient field evidence to demonstrate that concussion is immediate but not long lasting. If energy is insufficient there will be a high percentage of animals that will require a re-stun.

Non-penetrating captive-bolt stunning is not recommended for young calves and mature very old cows and bulls. It is thought that in young calves the skull is soft which absorbs energy and reduces efficiency. In the case of mature animals, the skull is brittle and the energy is dissipated over the frontal bone.

As there is no invasion of the skull and direct damage to the brain the period of unconsciousness can be short lived.

The stun to stick time is critical and animals must be bled without delay; within 20 seconds from stunning.

Penetrating Captive-Bolt

The penetrating captive-bolt delivers a percussive force to the animal’s head to produce concussion, but also produces physical damage within the brain due to the bolt. The bolt should penetrate to its maximum limit to combine the effects of concussive forces and physical damage.

In experimental work it has been shown that evoked responses are eliminated immediately and all traces of brain activity are absent within approximately 60 seconds. Respiratory activity also usually ceases immediately after stunning. A flat, isoelectric, EEG is accompanied by uncontrolled kicking movements. Some heart activity, if the animal is bled immediately, may continue for about 4 minutes.
In the research situation the duration of unconsciousness is likely to be up to 10 minutes or longer, which means at a theoretical level the stun-stick interval is not critical. However in the practical situation there are significant variables and legislation and guidelines require animals to be bled without delay, no longer than 60 seconds from stunning.

**Image: Penetrating captive bolt, Source: WSPA**


Stunners can be fired with a trigger mechanism or fired on contact with the animal's skull. The trigger-fired, penetrating stunners are perhaps the most versatile; being suitable for a wide range of different types of animals and situations.

**STUNNING POSITION**

**Image: Stunning position when using penetrative captive bolt**

The stunning position for cattle using penetrating captive-bolt equipment is on the middle of the forehead at the crossing point of two imaginary lines between the base of the horns and the opposite eyes.

The stunning position for a non-penetrating captive-bolt is 2cm above the intersection of two imaginary lines drawn from the rear of the eyes to the opposite horn buds. **The muzzle must be placed at right angles to the skull directing it to the centre of the brain.**
**SIGNS OF AN EFFECTIVE STUN**

The outward signs in cattle that a stun has been effective are the same with both non-penetrating and penetrating captive-bolts.

Monitoring Points are:

- Immediate collapse and no attempts to stand up
- Immediate and sustained absence of rhythmic breathing
- Absence of righting reflex
- Fore legs and hind legs flexed initially; fore legs will then straighten and become extended
- Eyes must not be rotated; a rotated eyeball indicates a deep stun is not present and there is a risk of return to consciousness
- No reflex response to a nose prick or ear pinch
- Absence of corneal reflex

*Image: Stunning position Source: Elders*

*If the animal does not show these signs then it must be re-stunned immediately.*
**Failure to Stun**

In the practical situation there may be occasions when the animal is not effectively stunned this could be the result of:

- Incorrect stunning position
- Not enough power e.g. wrong cartridge size or drop in air pressure
- Stunner malfunction
- Poor maintenance

A back-up stunner should always be close to hand should the main equipment fail. If the first stun fails the next attempt should always be in a different position because the swelling and damage caused by the first attempt reduces the effect of a second impact in the same place.

**General considerations (According to the Article 7.5.7) of the OIE standards**

The competence of the operators, and the appropriateness, and effectiveness of the method used for stunning and the maintenance of the equipment are the responsibility of the management of the slaughterhouse, and should be checked regularly by a Competent Authority.

Persons carrying out stunning should be properly trained and competent, and should ensure that:

a) the animal is adequately restrained;

b) animals in restraint are stunned as soon as possible;

c) the equipment used for stunning is maintained and operated properly in accordance with the manufacturer's recommendations, in particular with regard to the species and size of the animal;

d) the equipment is applied correctly;

e) stunned animals are bled out (slaughtered) as soon as possible;

f) animals are not stunned when slaughter is likely to be delayed; and

g) backup stunning devices are available for immediate use if the primary method of stunning fails.
RECORDING PERFORMANCE

Regular objective measurements should be made to monitor accuracy of the stunning. Ideally this should be at roll-out from the box to record the effectiveness of the stun, and examination of the heads of the same group of animals that were observed.

Operators should not be judged purely on the level of double stuns seen at the head rail, otherwise there is a danger that they could be discouraged from delivering a second stun where there was some doubt about the effectiveness of the first. However, consistent high levels of second stuns should be investigated.

In European studies with bulls, approx. 4% of a sample of 100 bulls needed a second stun and in other studies the incidence of second stuns ranged from 4-6.6%. A second stun rate of 5% or less is seen as acceptable when auditing performance and less than 1% as excellent.

There are a number of key factors which need to be right:

• The stunning pen needs to be fully enclosed. Solid sides all round so that cattle can see no movement or distractions from operators or activity in the slaughter hall. The most common problem is usually small gaps at the bottom of the pen where cattle roll out. Cattle will stop and put their head down rather than walking in.

• The floor of the box needs to be non-slip. Steps and slopes designed to improve roll out from the box can be counter-productive as cattle scramble to get their footing.

• Where there are additional devices to restrain or position the animal these must be operated and applied smoothly. Their principle action is to hold the animal in place once it has voluntarily stood in approximately the right position, not to force the animal into position.

• Controls can be pneumatic or hydraulic (the latter are quieter), but in either case it should be possible to apply the restraint smoothly rather than with jerky bumping movements.

• Cattle are calmer in restraint when only mild to moderate pressure is applied to hold the animal rather than to squeeze it tightly. Excessive pressure may cause injury and animals tend to fight against it.

• The box needs to be well lit, but not in a way that light shines directly into the animal’s eyes or creates reflections and shadows. In many slaughterhouses where there are natural lighting conditions these change through the day and during the seasons. Having a number of different lights on separate circuits which can be used by the slaughter team can help cope with the variation.

• When cattle move from the raceway to the box there is often too much contrast and change, for example moving from concrete floors and sides to an all metal stunning box. In this case simply running sheeting on one side of the race and on the floor will make the change less abrupt.

• The box must not look like a dead end. Field studies demonstrate that cattle will stop about 0.75m from a solid wall so the box needs to create an illusion to the animal that there is somewhere to go.
• It is difficult to eliminate all noise from the environment around the stunning box but keep it to a minimum. Maintenance of the box is essential to reduce banging and noise from air leaks or similar.

• The box must be free of any sharp angles or projections that might cause injury. There should be no abrupt angles on any of the restraint devices that can create pressure points when applied.

BLEEDING AFTER STUNNING

The use of non-penetrating captive bolt equipment in stunning cattle induces an unconsciousness for a certain time period. Therefore, it is essential that bleeding be carried out immediately post-stunning to prevent any recovery of an animal. The bleeding should be carried out within 20 seconds from stunning.

Images: 1) An absence of rhythmic breathing, fixed and glazed eye
2) No corneal reflex.
3) Relaxed jaw with exposed tongue (protruding).

BLOOD LOSS AND DEATH

Blood loss deprives brain of oxygen and nutrients and causes its death.

Cattle’s anatomy of blood supply to brain is very different from one in other farm animals i.e. sheep. As we see on the picture (below) cattle brain blood supply is provided via carotid arteries running on both sides of the neck and vertebral arteries that are running in the spinal cord. It is estimated that more than 20% of blood supply to the brain is via the vertebral artery.

In order to cut both vertebral and carotid arteries in many parts of the world bleeding is carried out by so called chest stick.

That is performed by cutting the large vessels that emerge from the heart (carotid and vertebral arteries), at the base of heart; thus, excessive blood loss deprives the heart from pumping a sufficient blood volume to tissues, including the brain, leading to hypovolemic shock. The cerebral function is gradually lost until animal’s death.

Image: Bleeding by chest stick
Although accepted, when performing transversal section of neck the vertebral arteries are not cut delaying onset of a death as blood supply to the brain is partially maintained; in transversal cut of the neck both carotids and jugulars have to be severed.

**Image:** Bleeding by severing neck transversally

When bleeding is carried out after the stunning it should be

a) rapid, profuse and complete

b) completed before animal regains consciousness

The time needed to reach unconsciousness and death of a cow only by blood loss depends on method of bleeding, previous handling, blood clotting, sharpness of the knife and positioning of the incision.

It is estimated that loss of consciousness starts within 20 seconds after sectioning the blood vessel emerging from the heart.

**Stun-to-stick time interval**

It is recommended that a maximum 20 second interval between stunning and bleeding occur when using non-penetrating captive bolt guns, causing cerebral concussion. Animal should be left to bleed at least for 30 seconds before any other procedures are carried out. Before that it has to be assured that animal is death by checking negative corneal reflex and absence of rhythmic breathing or other peripheral reflexes.

**BLEEDING PROCEDURE**

**CHEST BLEEDING**

Chest sticking of cattle is recommended because of the more rapid loss of blood supply to the brain and because the method is more repeatable and reliable in all animals:

The operator needs to stand to one side of the animal, and should never put their head between the animal's forelegs - if there is some reflex kicking they could be hurt.

With the first knife, the skin must be opened at the base of the neck. To prevent contamination this knife must be then cleaned and sterilized. With a second (sterilized knife) the blood vessels must be cut as they come out from the heart. As the position cannot be seen the operator needs to feel up between the neck muscles into the chest cavity between the first pair of ribs. A good cut will produce a rapid flow of blood. If there is not a rapid flow it means the blood vessels have not been cut completely and the vessels must be cut again. The stun to bleed time should not exceed 20 seconds for non-penetrating captive-bolts and 60 seconds for penetrating captive-bolts. It is recommended that the carcass should be left for at least 30 seconds from when the animal has completely finished bleeding before starting any dressing operation or applying electrical stimulation.

**BLEEDING BY TRANSVERSAL NECK CUT**

It should be performed by transverse cut of the neck at the C1 – C2 (cervical vertebra) level, and severe both carotids. Knife should be sharp and double size of the cattle’s neck. Cut
across the neck of an animal should be made in one swift move. Reciprocal move is acceptable.

If a good flow is not observed, the blood vessels should be cut again as they may not be entirely severed.

No slaughter procedure subsequent to bleeding can be carried out until animal’s death is ascertained.

REMEMBER WHEN BLEEDING IS CARRIED AFTER THE STUNNING:

- All cattle must be unconscious at bleeding and must remain so until the moment of death;
- Verify whether an animal presents signs of insensibility prior bleeding. If in doubt re-stun an animal
- For a fast bleeding, severing the main large vessels at the base of heart is a preferred method; Bleeding can be performed by severing neck and both carotids at the C1-C3 level.
- Only after the animal is confirmed dead should skinning and other procedures be initiated;
- Stunning, verifying signs of insensibility and bleeding of cattle are procedures that must be carried out as soon as possible and follow each other as soon as possible.
PIG RESTRAINT, STUNNING AND BLEEDING

RESTRAIN

RESTRAINT IN A GROUP PEN

For this type of system, a small group of pigs is moved into the stunning pen and the electrodes are applied to each animal. The time interval between placement of electrodes and bleeding must be as short as feasible; to achieve this, the process must be carried out individually (stunning + shackling + bleeding), and the second pig in the pen only stunned after ensuring that bleeding of the first pig was performed correctly. This method is very common in smaller slaughterhouses, which work with a low line speed.

It should always be checked that the group of pigs next to be stunned has sufficient space to walk into the pen. The size of the group must be adjusted in relation to the stunning pen to avoid exceeding this specification. The floor must be non-slippery and provided with uniform light, encouraging entrance of the animals.

RESTRAINT IN A RESTRAINER CONVEYOR

To achieve maximum efficiency during electrical stunning, the pig must be immobilized to allow adequate positioning when applying the electrodes. However, separating pigs from the group to form a single file in the restrainer is stressful and agitates the pigs.

Research has demonstrated an increase in stress levels when comparing pigs going through the restrainer from pigs handled and stunned using other methods. Pigs that are moved through the file chute to the restrainer show a significant increase in heart frequency, as well as lower meat pH values, demonstrating that the stress from handling during restraining can also interfere with meat quality.

Recommendations to minimize stress while in the alleyway and restrainer are:

- Avoid stopping as much as possible, as the flow of pigs must be constant and the period which they are kept in the restrainer must be the least possible. Coordination between the operator responsible for applying the electrodes and the handler bringing pigs in the restrainer is required to accomplish this;
• Be patient when a pig refuses to follow the group. **Do not rush! Give the pig time to calm down.** And, when returning to the pen, try again moving the pig with others;

• Maintaining consistent lighting and flooring in the alley and restrainer avoids distraction and stop points. If needed, extend the restraining floor toward the alleyway (see Figure) to encourage the pigs to move forward;

• Maintain group uniformity to increase stunning efficiency and restraint of animals, facilitating correct placement of electrodes;

• Adjusting the size of the group being moved to the restrainer according to the line speed and number of pigs that can be held will ensure more control over the process.

![Image: Adjust the size of the group as a function of line speed and alley and restrainer holding capacity Source: adapted from Grandin (2008)](image)

**V-type restrainer**

When using a V-type restrainer, pigs are immobilized by conveyor belts positioned alongside their bodies, leading them to the electrical stunning area; the two systems commercially available for electrical stunning that may or not may be automated are: head-only stunner (both sides of the head or “two points”) and head-to-heart stunner (both sides of the head + cardiac region or “three points”).

![Image: V-type restrainer with manual application of electrodes](image)

With this system, a gap in the floor or a “visual cliff” is formed and pigs cannot see a solid floor underneath, which is the reason for many pigs stopping at its entrance. At this point, there is a high use of electric prodding, causing more panic to the animals in addition to bruises from pigs mounting on top of each other.
The use of a **false floor, not reflective**, leading in to the conveyor belts (see Figure) is an option to minimize this situation and improve flow of animals. The extension of this floor may vary with the restrainer size, but it is important to remember that its function is only to encourage the pig to enter into the restrainer and not to scare it, which may hinder restraint.

![Image: False floor underneath the restrainer, Restrainer conveyor without supporting pigs’ feet](image)

The restrainer and its lateral belts must be adjusted according to the average size of the pigs and **always maintained at synchronized speed**. This will avoid excessive pressure and distress to the pigs, as well as bruises to the carcass.

**Midas restrainer**

The **Midas restrainer** consists of a system carrying the animal through a chest-conveyor belt that is connected to a three-point electrical stun/kill system. Several studies have shown that both the stress level during pre-slaughter and meat defects in pork are reduced when using this type of restrainer.

![Image: Midas restrainer system](image)

It has been observed that pigs in the Midas system feel more comfortable, as they are transported by the chest with no lateral compression. High stunning efficiency is another important advantage of this system, as it uses software linked to the electrodes that calculates the exact electrical current to be delivered in relation to the individual pig’s resistance. This promotes well-being and at the same time, prevents unnecessary current flowing to the body, reducing meat quality losses caused by excessive electrical current.
REMEMBER:

- Minimize pigs’ stress at the restrainer entrance by adjusting flooring and lighting uniformity, preventing stop points and distractions, to facilitate flow of animals;
- Aim for group uniformity in order to restrain pigs properly and improve stunning efficiency;
- Plan and design facilities from the animals’ point of view thus facilitating handling and minimizing carcass quality losses.

HEAD-ONLY ELECTRICAL STUNNING

Electrical stunning methods, when used correctly and adjusted to adequate electrical parameters, minimize animal suffering and have a minor negative effect on carcass and meat quality. However, when used incorrectly they can cause pain and suffering, increase the incidence of fractures, blood splashing (spotting) and meat defects (e.g. pale, soft, exudative (PSE) meat), and lead to significant losses for the industry.

Head-only stunning systems have been used for more than 50 years and during this period, design and equipment efficiency have improved. Nonetheless, the majority of head-only stunning systems are based on manually placing the electrodes on the pig’s head. This way, its efficacy depends exclusively on the operator.

HOW IT WORKS

Electrical stunning or electro-narcosis is a reversible method and consists of delivering electrical current to the animal’s head. The conduction of electrical current provokes “grand mal” epilepsy, inhibiting brain activity and depolarizing neuronal cells immediately, leading to unconsciousness and preventing transduction of pain signaling, similar to an epileptic crisis in humans.

A pain stimulus can only be perceived within approximately 50 to 150 milliseconds, whereas electronarcosis in an ideal or laboratory conditions can cause insensibility within 15 milliseconds, ensuring that pigs do not feel pain when electrodes are correctly applied.

The effect of electronarcosis on pigs is temporary, thus the goal is to induce immediate unconsciousness and ensure it persists until the moment of death, which occurs with bleed out.
Usually The apparatus used for electrical stunning has to be equipped with:

- Electrodes
- Visual or audio devices indicating the time interval of electrode application;
- Visible safety device indicating electric current.

**Image**: Monitoring screen displaying stunning parameters visible to the operator

**ELECTRICAL PRINCIPLES**

The electrical current crossing the brain is what causes pig unconsciousness. When using constant voltage, the amount of current conducted to the brain is inversely proportional to the total electrical resistance of the transmission. This effect is known as Ohm’s Law, where:

\[ I \text{ (amperes)} = \frac{V \text{ (volts)}}{R \text{ (ohms)}} \]

The **current** (I) is the flow of electrical charge (electrons) that crosses a given surface, measured in amperes (abbreviated as amps or A); **voltage** (V) is the electrical tension that excites the current across the brain, measured in volts (V); and **resistance** (R) is the impedance for electrical current flow and is measured in ohms (Ω).

The voltage needs to be sufficiently high to overcome the resistance across the trajectory between the electrodes including the pig’s brain, and transmit enough current to produce immediate stunning with instantaneous loss of consciousness.

**Electrical resistance**

The resistance to electrical current transmission can be affected by:

- **Type of material and maintenance condition of electrodes** – the material must be a good conductor of electrical current, resistant to oxidation and corrosion. Cleaning of electrodes must be carried out daily. Good maintenance is the basis for correct functioning of electrodes;
• **Design of electrodes** – poor electrode format can interfere with electrical current flow. Electrodes of greater contact surface with the pig’s skin are preferred as they promote delivery of a greater electrical current for adequate stunning. Where there is a lack of uniformity within groups of pigs, use of a “scissor” shape stunner is recommended as it is adjustable to pigs with different sizes;

![Image: Equipment with a “scissor” design – adjustable to different sizes of pigs](image1)

![Image: Electrode format with good contact to pig’s skin](image2)

• **Skin and hair** – presence of hair and dry skin causes difficulties in electrical current flow, increasing the animal’s resistance and interfering with adequate stunning. In this case, wetting the animals prior to stunning is recommended. But excess of water can also be unhelpful due to the fact that a portion of the current may not go through the skin surface, as water has lower resistance;

• **Dirtiness on the pigs** – dirty animals have greater resistance and may cause difficulty with current flow and a decrease in stunning efficiency.

• **Skull thickness** – the greater the skull thickness the greater the resistance. Older pigs tend to have greater resistance and thus the electrical parameters must be adequately adjusted for efficient stunning.

In general terms, the resistance can be reduced to improve electrical current flow by ensuring that **the electrodes are clean and** that the contact area is **wet and with little or no dirt**. A pig weighing 100 kg can have its resistance (across the head) varying from 150 to 350 Ω.

**EQUIPMENT PARAMETERS**

An **electrical current of 1.3A** for at least 1 second is required to induce a generalized epileptic seizure in finisher pigs. From practical reasons the recomended time of application is 1-3 seconds. **A minimum voltage of 250V** is needed to reach this amperage within the recommended period.

When using lower than the recommended voltage, it is not always possible to reach the needed amperage within the desirable period thus, it is possible that pigs are receiving a painful shock prior to becoming unconscious.

![Image: Electrical parameters for effective pig stunning; Steps](image3)
The efficacy of stunning equipment must be monitored daily, evaluating the follow items:

- Signs of efficient stunning in pigs;
- Daily cleaning of electrodes to prevent oxidation and corrosion areas, as well as monitoring current conduction required for reaching 1.3A;
- Do not use the electrical stunner when pigs are not stunned instantaneously;
- Have warning devices to indicate the exact duration for which electrodes are energized;
- Have a visible screen clearly displaying the current and voltage delivered during stunning to the operator.

**ELECTRODE POSITIONING**

For effective stunning, the electrodes must be positioned at both sides of the head and adhered adequately to the skin, in the region near to the ears' insertions. This way, the current will flow using the closest route (from electrode crossing by skin to the skull and brain of the pig) thus reducing resistance in its path.

However, it is observed that some small slaughterhouses have problems with restraining pigs (no restrainer available) and variation in head size making correct placement of electrodes difficult. Different electrode positions have been assessed as alternatives and are acceptable, as follows:

**Position 1 (see images below) is ideal** and the operator must prioritize it, but positions 2, 3, 4 and 5 are also acceptable.

1. Between the eyes and base of ear on both sides of the head

2. Below the base of each ear on both sides of the head;
3. Positioning the 1st electrode between the eye and the base of one ear and the 2nd electrode posterior to the other ear. The electrodes must be placed diagonally to the head.

4. Positioning electrodes on both sides of the head, posterior to ear insertions.

5. Positioning the 1st electrode on the superior region of the skull and the 2nd electrode in between the mandible roots.

The electrodes must NEVER be placed in an area away from the brain or with high sensitivity, such as the snout because it is extremely painful and a portion of the current required for stunning will be deviated from the path to the brain.

The electrodes must NEVER be placed in any other part of the pig’s body, such as posterior limbs, to force them to move or to immobilize them to facilitate stunning.

The correct positioning and daily maintenance of electrodes require specific, task-related ability and thus operators must be trained to perform these steps with efficacy and to avoid the animal feeling pain.

**If the first contact fails and the pig shows signs of consciousness, the operator must repeat the stunning procedure immediately.**

NO animal should go through bleeding conscious. Thus, the slaughterhouse must have a portable stunner in the stunning area (backup equipment) available to be used on pigs that show signs of sensibility.

The pigs must NEVER show any pain reaction, such as vocalization during application of electrodes on the skin. Such vocalization can be a sign that current is not sufficient to cause immediate loss of consciousness.
MONITORING OF STUNNING

Regular and frequent assessment of pigs as they are being stunned is very important, as well as monitoring of the stunning parameters. This practice will ensure that all animals go to the bleeding step unconscious.

When pigs are correctly stunned, they undergo two phases that are called the tonic and clonic phases.

The tonic phase lasts between 10 and 20 seconds and the pig shows:

- Loss of consciousness, with immediate collapse (drop);
- The musculature becomes contracted;
- Anterior limbs flexed and posterior limbs extended (rigid).
- The tonic phase can persist for some seconds; even if electrical current flow ceases, the pigs may still show these signs;
- No rhythmic breathing in the flank and snout;
- Pupils become dilated (mydriasis); No corneal reflex; No reflex to painful stimuli.

The clonic phase starts after the tonic phase, lasting between 15 and 45 seconds and the pig shows:

- No rhythmic breathing;
- Involuntary 'pedaling' or kicking;
- Gradual relaxation of musculature.

If the pig is not bled, the clonic phase will gradually diminish and finally cease; the animal will recover consciousness, showing a return of rhythmic breathing and other reflexes. Thus, it is extremely important for the pig to be bled immediately following stunning.
When using adequate electrical parameters and applying the electrodes in the correct place during 3 seconds, the **average interval for return of reflexes** in pigs is:

- **Rhythmic breathing:** About 37 - 41 seconds. Monitoring of rhythmic breathing can be performed at the snout or flank region, while the pig is at the bleeding table;

- **Corneal reflex:** About 47 seconds. In practice this reflex is difficult to verify and is often confounded with the palpebral reflex, which can be considered a false-positive. Thus, it must not be assessed in isolation;

- **Sensibility response:** About 57 seconds. This reflex can be assessed at the septum-nasal region (compression test), skin or ear (pinching test);

- **Righting reflex and attempt to recover posture:** About 65 seconds, indicating full return of consciousness and sensibility.

**SIGNS OF AN INADEQUATE STUNNING**

The signs below can indicate failure during the electrical stunning:

- No tonic or clonic phase;
- Return of rhythmic breathing;
- Coordinated and focused eye movements;
- Vocalization during and/or after application of electrodes;
- Righting reflex and attempt to recover posture.

To confirm stunning failures, more than one of the signs above would usually occur in combination. However, rhythmic breathing is a particularly good parameter to confirm such a failure.

**REMEMBER:**

- The electrical current is what stuns the pig. A minimum of 1.3 amperes is needed to stun a finisher pig adequately and 3 amperes to induce unconsciousness in adult animals (sows and boars), during at least 3 seconds of electrode application;

- The electrodes must be positioned on the head, near to the brain, with the goal of facilitating current flow and reducing resistance;

- Clean electrodes daily and carry out adequate maintenance on all stunning equipment;

- **NEVER** use the electrodes to immobilize or move pigs;

- Monitor the electrical parameters and check that all pigs are adequately stunned.
HEAD-TO-HEART STUN/KILL – ELECTROCUTION (PIGS)

INTRODUCTION
The electrocution stunning or head-to-heart (“three-point”) system induces animal unconsciousness followed by death induced by ventricular fibrillation. Thus, it is an irreversible method if applied correctly, promoting greater stunning assurance for pigs before bleeding. The electronarcosis or head-only (“two-point”) electrical stunning system induces an unconscious state for a relatively short period, with risk of recovery if the animal is not bled out immediately.

HOW IT WORKS
Electrocution consists of transmitting electrical current first to the brain, rendering the animal unconscious, then to the heart causing cardiac arrest and death. It is very important that the electrical current delivered to the heart is of low frequency, 50 or 60 Hz, to induce cardiac fibrillation.

The stunner can transmit electrical current in two forms:

The first consists of one cycle only, or only one current flow, and involves applying the electrodes to head and to the heart, causing at first immediate unconsciousness; while the electrodes are applied to the head, when the current will reach the heart, it cause ventricular fibrillation and cardiac arrest.

The second consists of two cycles: during the first cycle, electrodes are applied to the head, followed by application to the heart region. It is essential to understand and perform a sequence of electrode applications to the pig. This process can be performed in two ways:

- With the same electrode, but changing area of application (head and heart) using low frequency (50 or 60 Hz);

- Using two electrodes on the head and a third one to the heart, each with distinct current and frequencies.

CARDIAC VENTRICULAR FIBRILLATION
Ventricular fibrillation is characterized as a severe cardiac arrhythmia, or a series of rapid, weak (ineffective) and uncoordinated ventricular contractions, produced by multiple electrical impulses originating from several points in the ventricle. This is a condition in which there is a loss of normal heartbeat rhythm, or in which the cardiac muscle (myocardium) contracts in an uncoordinated pattern.
The blood volume pumped by the heart is compromised by up to 30% (cardiac deficit). When this happens, the heart cannot pump sufficient blood and transport oxygen to the brain, inducing cerebral hypoxia (decreased oxygen supply to the brain) that is followed by death; consequently, there is an increase in the pigs’ unconscious period.

Within a few seconds, cardiac arrest is reached, and under these conditions, the pig’s capability to recover consciousness and sensibility is practically zero.

**EQUIPMENT PARAMETERS**

For electrocution, the amount of electrical current that must be transmitted to the pig’s brain to induce unconscious is the same as used in head-only electrical stunning, or a minimum of 1.3A for finisher pigs and 3A for adult animals, for at least 3 seconds. A minimum of 250V is needed to reach the amount of electrical current for stunning. Inducing [cardiac fibrillation](#) requires application of low frequency (50 or 60 Hz) and a minimum of 1.3 A as alternating current to the heart region for a period of 1 seconds.

**MONITORING OF EQUIPMENT**

Monitoring pigs as they are being stunned, as well as monitoring stunning parameters in the equipment, are needed to ensure electrocution efficiency. Following has to be ensured:

- Observation of main signs of efficient stunning;
- Daily cleaning of electrodes (head and heart) to prevent oxidation and corrosion points;
- Monitoring and maintainance of current conduction of 1.3A to the head and 1.3A to the heart region;
- Availability of functional devices indicating duration for which electrodes are energized;
- Availability of a visible screen clearly displaying to the operator the current and voltage delivered during stunning.

**ELECTRODES POSITIONING**

Correct positioning of electrodes is essential for efficient stunning, and to achieve this, the pig must be controlled (using a restrainer).

The electrodes must be positioned on both sides of the head and adhered adequately to the skin, in the region near to the insertion of the ears. With this, the electrical currents will cross the brain through the shortest path.

The positioning of the cardiac electrode to induce cardiac fibrillation must be at the 3\textsuperscript{rd} or 4\textsuperscript{th} intercostal space, at the left side of the chest, as near as possible to the heart. The electrodes must be applied to the head then to the heart, never do the inverse, because it would be very painful for the animal.
The electrodes must be applied following the ideal position in all pigs. For this, in automated systems, it is essential to synchronize the restrainer and conveyor belts and adjust restraint of the animals according to the average weight and size of the pigs. There is a need to integrate sectors such as production (farms and plants) to exchange information and seek uniformity of groups of pigs for slaughtering.

**MONITORING OF ELECTROCUTION**

Regular and frequent assessment of pigs subjected to electrocution is very important, as is monitoring of electrical parameters. This practice will ensure that pigs undergo bleeding when unconscious and after cardiac arrest.

During electrocution, the pig will present the tonic phase: loss of consciousness, immediate collapse (drop), muscle contraction, and absence of rhythmic breathing, corneal reflex and sensibility to pain.

The clonic phase (with dilation of the pupils and gradual relaxation of musculature) begins after the tonic phase, but with the electrocution method is less evident or even absent..

For more information refer to the chapter on electronarcosis.

**SIGNS OF AN INADEQUATE STUN/KILL**

The signs below can indicate failure in the electrocution:

- **Return of rhythmic breathing**;
- **Coordinated and focused eye movements**;
- **Vocalization during and/or after application of electrodes**;
- **Righting reflex and attempt to recover posture**.

In order to observe whether there is sensibility or conscious recovery, the parameters above must be assessed together, never in isolation. However, presence of rhythmic breathing is a good parameter to confirm failure of electrocution.
All pigs must be bled after electrocution, within a maximum of 15 seconds after removing the electrodes, as there is no guarantee that 100% of the animals undergo cardiac fibrillation followed by death.

**Attention!** Some pigs may present gasping (attempt to draw air) soon after bleeding as a consequence of cerebral death. Thus, gasping must not be confounded with consciousness, if it is not rhythmic.

**REMEMBER:**

- During electrocution, electrodes are first applied to the head to reach the brain, promoting unconsciousness, and soon after an electrode is applied to the heart region, causing ventricular fibrillation and cardiac arrest;
- A minimum current of 1.3A is required to stun a finisher pig adequately and 3A is needed to induce unconsciousness in adult animals (sows and boars), during at least 3 seconds of electrode application to the head;
- A minimum of 1.3A at low frequency (50 or 60 Hz) of Alternating Current applied for 3 seconds is needed to cause cardiac (ventricular) fibrillation followed by death of a pig;
- The electrodes must be positioned as close as possible to the brain to facilitate current flow and reduce resistance, causing insensibility;
- The cardiac electrode must be positioned close to the heart, on the 3rd and 4th intercostal space, to induce cardiac fibrillation;
- Clean the electrodes daily and perform adequate maintenance on all stunning equipment;
- Monitor the electrical parameters and verify the signs of unconsciousness of the pigs subjected to electrocution;
- NEVER use electrodes to move pigs;
- Bleed pigs promptly, within a maximum 15 seconds after removing the electrodes.

**BLEEDING OF PIGS**

**INTRODUCTION**

All pigs must be unconscious at bleed out and must remain so until death. Electronarcosis induces unconsciousness for a relatively short period, thus bleeding must be carried out immediately post stunning to ensure there is no recovery of sensibility to pain prior to the animal dying.

This is the reason that an efficient bleeder, prior to performing the bleed out on the animal, verifies signs of unconsciousness and, when questionable, repeats stunning or informs the person responsible for this procedure.
Always assess the pig’s signs of unconsciousness prior to bleeding

Images: Absence of rhythmic breathing; Absence of corneal reflex; Absence of sensibility to painful stimuli

EMERGENCY EQUIPMENT

For immediately re-stunning the pig in events of operational or equipment failure, the emergency equipment (backup) must be:

- Available at a location of easy and fast access;
- Kept with periodic maintenance, allowing the pig to receive sufficient electrical current and with electrodes in good working condition (no oxidation or corrosion).

Image: Emergency equipment in a location of easy and rapid access to ensure that 100% of animals are unconscious during bleed out

BLOOD LOSS AND DEATH

Adequate bleeding must be performed by cutting the large vessels that emerge from the heart (carotid arteries and jugular veins); thus, excessive blood loss deprives the heart from pumping a sufficient blood volume to tissues, including the brain, leading to hypovolemic shock. The cerebral function is gradually lost until the animal’s death.

The time needed to reach unconsciousness and death only by blood loss varies according to species, number of vessels sectioned and sticking efficiency.
In pigs without prior stunning, when sectioning both carotid arteries and jugular veins, unconsciousness occurs within 25 seconds. However, if only one carotid artery and one jugular vein are sectioned, then this interval increases to 105 seconds until the pig becomes unconscious due to blood loss. When bleeding is performed by chest stick bleeding lasts 14-23 seconds.

- 2 carotid arteries + 2 jugular veins – 25 seconds;
- 1 carotid artery + 1 jugular vein – 105 seconds.
- Chest stick – 14-23 seconds.

**A maximum period of 15 seconds is recommended between stunning and bleeding, because when using electronarcosis recovering of consciousness occurs after about 37-41 seconds. Thus, bleeding when carried out within the adequate interval (chest stick lasting 23 seconds) will ensure unconsciousness of the pig until death.**

As described in the electronarcosis section, when pigs are correctly stunned they undergo the tonic phase (10 to 20 seconds) and clonic phase (15 to 45 seconds). Bleeding must occur before the tonic phase ends, when the pig is having muscle contractions. This will facilitate the procedure and decrease the risk of blood splashing (spotting).

However, when bleeding is performed inadequately, there will be a greater risk of the pig recovering consciousness and sensibility to pain prior to death, resulting in serious welfare problems for the animal.

*Image A: Inadequate bleeding with cut length below recommendations – promotes slow blood loss*

![Image A: Inadequate bleeding with cut length below recommendations](image1.jpg)

*Image B: Adequate bleeding with cut size above 5 cm – promotes rapid blood loss*

The size and correct location of the cut (sticking) determine bleeding efficiency. For example, bleeding performed in the pig’s chest with a cut size smaller than 5 cm, when compared to a 10 cm cut, will lead to slower blood loss and thus, time to reach unconsciousness (and therefore to guarantee continuation of unconsciousness in pre-stunned pigs) due to hypoxia and anoxia will be longer.

If the cut is efficient, it will allow for 50 to 60% of total blood volume loss, and within the initial 30 seconds of bleeding, the pig will lose approximately 70% of total blood volume.
BLEEDING PROCEDURE

Bleeding must be performed by sticking a knife to the chest region where the large blood vessels emerge from the heart.

Steps to perform effective bleeding:

- The knife is stuck at the neck midline, at the depression ahead of the chest bone (sternum bone);
- The skin must be cut with the knife’s tip using light pressure;
- When the knife penetrates, lower the handle so that the blade tip points toward the pig’s tail;
- Section all large vessels that emerge from the heart (carotid arteries and jugular veins);
- The knife’s cut length must produce a large and rapid blood flow. If a good flow is not observed, the operation must be repeated.

Only after bleeding is complete and death reached, should the pig proceed to subsequent stages, such as scalding and dehairing.

REMEMBER:

- The pig must be unconscious at bleeding and must remain so until the moment of death;
- A good bleeder first observes for signs of unconsciousness, and when observed, performs bleeding. If in doubt, always repeat the stunning procedure;
- Both carotid arteries and jugular veins must be sectioned;
- If the cut is efficient, there will be a rapid blood flow and death will follow within a short interval;
- Only after the pig is confirmed dead should later procedures be carried out.

GAS STUNNING/KILLING OF PIGS

In many European countries gas stunning (use of CO2 in air or in different mixtures) is now favored over electrical or captive-bolt methods due to greater benefits for animal welfare (thanks to adjacent automated handling systems) and meat quality. The main animal welfare advantage is that pigs can be handled and stunned in groups rather than individually restrained and stunned as with alternative methods. CO2 systems can also be operated with mechanical push gates that separate pigs into small groups and push them into the stun-box, abolishing the use of electric prodders. When these systems are properly operated, pre-slaughter stress can be reduced.

SYSTEMS

Carbon dioxide is heavier than atmospheric air and, under practical conditions; pigs are lowered into a pit with high concentration of carbon dioxide. There are two main types of carbon dioxide stunning systems for pigs: a dip-lift system and a paternoster system.
The dip-lift system works discontinuously. Small groups (4 to 6) of pigs in a box are lowered directly into the maximum carbon dioxide concentration at the bottom of the pit. After spending a pre-determined time at the bottom (depending on gradient of gas concentrations and appropriate exposure times) the box is again brought up and the unconscious pigs are tipped out for shackling, hoisting and bleeding.

The paternoster system works continuously with gondolas (cradles) like a Ferris wheel where pigs are lowered successively into the maximum carbon dioxide concentration at the bottom of the pit with stops during the procedure through an increasing carbon dioxide gradient as live pigs enter or unconscious pigs leave the gondolas for shackling.

The paternoster system is the most commonly used. The number of pigs contained within each gondola or cradle varies according to the model and age of the system; older models have space to accommodate 1 to 3 pigs, whereas newer ones could take up to 6-8 pigs. The size of the chamber, size of individual cradle, and number of pigs per cradle

Images: Dip and paternoster gas systems; Source EFSA

QUALITY OF STUNNING

The depth of unconsciousness (stun quality) from CO2 gas stunning depends on CO2 concentration, exposure time and the animal. Due to individual biological variation, some pigs may regain consciousness while others not, even if stunned in the same group. To ensure good animal welfare the stun should ensure unconsciousness is induced for a sufficient duration to include not only the stun-to-stick interval but also the time taken for brain death to occur due to sticking.

It was found that during exposure of pigs in a dip-lift equipment to 61-65, to 66-70, to 71-75 and to 76-80% carbon dioxide in air, the time to lateral recumbency (which was considered as a behavioural indicator of unconsciousness) decreased gradually from 38 to 34, 29 and 26 sec respectively.
According to another study anaesthesia starts in 30 to 39 sec after the immersion procedure. During stunning of pigs in a commercial dip-lift system with different carbon dioxide concentrations ranging from 50-80%, no vocalisation from the pigs was heard during the induction phase, whereas expiration was frequently accompanied by a muffled sound during the excitation phase.

Table: Studies on loss of consciousness in different concentrations of CO2.

<table>
<thead>
<tr>
<th>Carbon dioxide concentration (%)</th>
<th>Time to loss of sensibility (EEG) See</th>
<th>Time to loss of brain responsiveness (AEP/SEP) See</th>
<th>Average time to loss of posture See</th>
<th>Number of animals tested</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>11.8±0.3</td>
<td></td>
<td>4 (x2)</td>
<td>Forslid, 1992</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
<td>6 (x2)</td>
<td>Martof et al. 2001</td>
<td></td>
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<tr>
<td>90</td>
<td>14</td>
<td></td>
<td>5</td>
<td>Raj and Gregory, 1996</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td></td>
<td>15±3</td>
<td>42</td>
<td>Holst, 2002</td>
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<tr>
<td>80</td>
<td>21-30</td>
<td></td>
<td>6 (x2)</td>
<td>Forslid, 1987</td>
<td></td>
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<tr>
<td>80</td>
<td></td>
<td>21.2±6.5</td>
<td>44</td>
<td>Ring et al. 1988</td>
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<tr>
<td>80</td>
<td></td>
<td></td>
<td>12</td>
<td>Raj et al, 1997a</td>
<td></td>
</tr>
<tr>
<td>76-80</td>
<td></td>
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<td></td>
<td>Raj and Gregory, 1996</td>
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<tr>
<td>75</td>
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<td>71-75</td>
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<tr>
<td>66-70</td>
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<td>65</td>
<td></td>
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<td>Raj and Gregory, 1996</td>
<td></td>
</tr>
<tr>
<td>61-65</td>
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<td></td>
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</tr>
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<td>60</td>
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<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td>Raj and Gregory, 1996</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1) Each pig tested twice.
2) Each of the 16 pigs in total tested several times in different concentrations.

Anil and McKinistry (1993) found that sticking does not always result in rapid and profuse blood loss in pigs, and the time taken for permanent loss of brain responsiveness varies in commercial practice. Problems with slow bleeding (and consequential delay of death) can occur if the size of the sticking wound is too small. It is therefore imperative for animal welfare that unconsciousness is closely monitored, and pigs re-stunned when necessary; especially as pigs are hoisted upside down and conveyed to a scalding tank for de-hairing within five minutes after sticking in some abattoirs.

**AVERSIVE REACTIONS OF PIGS TO CO₂**

Inhalation of carbon dioxide in concentrations of 50% or more are known to be pungent and cause breathlessness in most human subjects.

Studies have shown that the majority of pigs (75%) avoided an atmosphere of 70% concentration of carbon dioxide and Raj and Gregory (1995) found that pigs withdrew from an atmosphere of 90% in less than 5 sec. This aversion to carbon dioxide atmosphere was found to be greater than the motivation to obtain a reward (apples), even after 24 hours of fasting (Raj and Gregory, 1995). Moreover, 87.5% of pigs preferred to go without water for 72 hours rather than endure exposure to carbon dioxide again.
Same time carbon dioxide is also known to have an analgesic effect and so, another reason for a lower frequency of pigs reactions in the higher concentrations of carbon dioxide has been observed probably because the analgesic effect of carbon dioxide is more potent at the higher concentrations.

Thus, the aversiveness of carbon dioxide, if any, is less in high concentration compared with lower concentrations. It has been also found that pigs remained motionless when they first came into contact with carbon dioxide. Remaining motionless could be interpreted as either a fear response (like tonic immobility or freezing behavior to a potential threat) or that the pigs were unaffected by their environment.

Overall, the results of various studies indicate that pigs adversely react to exposure to carbon dioxide, and they also react to the descending movement of the stunning box itself. Data indicate that they perceive the gas (increased sniffing) and also show signs of aversion: backing away, head shaking and escape attempts. Moreover, pigs that have been removed from an atmosphere of carbon dioxide and then allowed to recover refuse to return into that area, when given the choice. It is also possible that there is an interaction between the gas concentration and aversive reactions, as suggested by the lower aversive responses in the higher concentrations of carbon dioxide. The reason is probably due to a more potent analgesic effect of carbon dioxide in high concentrations compared with lower concentrations.

**STUN STICK INTERVAL AND RECOVERY FROM CARBON DIOXIDE EXPOSURE**

When pigs are returned to atmospheric air after exposure to carbon dioxide, they begin to regain consciousness. The reversibility of stunning of pigs for slaughter in high concentration of carbon dioxide depends on the gas concentrations used and the duration of exposure.

In experiments 1 min of exposure to 80% carbon dioxide induced unconsciousness which lasted for about 1 min. In another study the recovery from 1 min of exposure to 90% carbon dioxide was approximately 60 to 90 sec.

Evaluation of insensibility after an effective carbon dioxide stunning is performed by the clinical methods (corneal reflex, respiration, etc) normally employed to judge the effect of a chemical anaesthetic used for surgical procedures.

Experiments in a full-scale research set-up at a commercial abattoir have shown that, absence or presence of different distinct and easy reliable clinical brainstem reflexes (corneal reflex, gagging, convulsions), can be used for assessment of the efficiency of carbon dioxide stunning during sticking to ensure that no pigs regain consciousness during bleeding.

Based on the research a set of guidelines for monitoring the efficiency of carbon dioxide stunning of pigs has been suggested. At the time of sticking the following signs can be used as criteria for a successful stun:

- Absence of rhythmic breathing.
- Gagging or gasping may be present briefly.
- No convulsions may be present.
• Absence of spontaneous blinking of the eye.

• Corneal reflex may be present briefly in a low frequency (<5%) of the total number of pigs, provided that other reflexes are absent.

Tab: Guidelines for the maximum stun to stick times according to time of exposure to 1) initially 70% CO2 for 10 seconds and then 90% of CO2 in air.

<table>
<thead>
<tr>
<th>Time of exposure (sec)</th>
<th>Sticking within (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>30</td>
</tr>
<tr>
<td>130</td>
<td>45</td>
</tr>
<tr>
<td>140</td>
<td>60</td>
</tr>
<tr>
<td>150</td>
<td>75</td>
</tr>
<tr>
<td>160</td>
<td>90</td>
</tr>
</tbody>
</table>

DESCRIPTION OF EFFECTIVE USE

In dip-lift and pater-roster systems, pigs shall be exposed to a minimum 80% carbon dioxide within 10 sec from leaving atmospheric air. The carbon dioxide concentration at the bottom of the pit shall be a minimum 90%.

Exposure time to carbon dioxide shall be sufficient to ensure that no pigs regain consciousness before death supervenes through bleeding.

A minimum exposure time, which cannot be shortened by the personnel, appropriate to the concentration gradient in the pit must be set.

In order to make sure that all pigs will be stunned properly, a minimum exposure time of 100 sec should be mandatory for all systems. Practical experience has shown that pigs appear less calm during the induction phase when stunned singly and it is recommended that at least 2 pigs are stunned together, provided sufficient floor space is available in the gondola.

Bleeding must be done as soon as possible after the end of stunning and be carried out in such a way as to bring about rapid, profuse and complete bleeding. In any event, the bleeding must be carried out before an animal regains consciousness.

MONITORING POINTS

Carbon dioxide concentrations should be monitored continuously, above the pig’s head while standing, at both 1st stop position and bottom position in paternoster systems and at the position the gondola reaches after 10 sec in dip-lift systems. These concentrations shall be displayed.

In paternoster systems, monitoring of gas concentration in the bottom position should be done 0.2 m above floor level of the gondola.
In dip-lift systems monitoring of gas concentration should be done 0.6 m above floor level of the gondola. A clearly audible or visible warning must be given if the carbon dioxide concentration falls below the required levels.

The stunning efficiency shall be monitored regularly to ensure that no pigs regain consciousness during sticking or bleeding. This can be verified by:

- An absence of rhythmic breathing, although gagging or gasping may be present briefly;
- An absence of carcass convulsions;
- An absence of spontaneous blinking of the eye but a corneal reflex may be present briefly in low frequency (<5%) at the moment when pigs are stuck.

**ADVANTAGES AND DISADVANTAGES**

Carbon dioxide stunning of pigs has the advantage that restraint during stunning is not necessary other than confinement in a cradle or gondola and that more than one animal can be stunned at any one time.

In new Group-wise stunning systems, pigs do not need to be lined up in a raceway. Thus the use of force, such as electrical goads, is not necessary while guiding pigs up to and through the stunning equipment. Furthermore, the pulsatile start-stop nature of movement into the system has been eliminated.

It is possible to have variable stun-to-stick intervals as the increasing duration of exposure to carbon dioxide increases the duration of unconsciousness and onset of death in some pigs.

Under the paternoster system of carbon dioxide stunning or killing, the loading of pigs into the older units is pulsatile; i.e. a pig can only be loaded when there is an empty gondola available in front of it. This stop-start nature of movement into the system is not conductive for handling pigs.

Carbon dioxide is an aversive gas. It induces breathlessness and some pigs may show attempts to escape, back away or head shake.

**RESTRAINT, STUNNING AND BLEEDING OF SHEEP**

**RESTRAINT PRIOR STUNNING**

Sheep are usually restrained either a) in a group pens, or stunning rooms, b) in a restrainer conveyor or c) in a restraining box. As the isolation of an individual sheep is highly stressful, the most frequent methods of restraint are restraint in a group pen or in a restrainer conveyor.

The restraining pen/room is usually filled with sufficient sheep to restrict movement. The stunning operator then individually approaches sheep from a blind spot and carries out stunning. Another operator ensures immediate shackling and hoisting. When there are less sheep in a pen/room more sheep are moved in. This method of restraining is used in both electrical and mechanical stunning (by captive bolt).
However electrical stunning of sheep kept in groups in a pen has the following disadvantages:

- Sheep crowd together and often hide their heads (keep their heads low) under other animals; which makes it difficult to reach and correctly place the electrodes on the head.

- Sheep in a group standing close to the electrodes or the head of a sheep being stunned may receive electric shocks when they are accidentally in contact with that part of the stunned animal that is subject to electrical current.

Images: Restraint in restrainer conveyor. Source: HSA

The second most frequent way of restraining sheep and lamb is restraint in a V shaped restrainer-conveyor. Sheep are moved in groups to a crowding pen that feeds into a single file conveyor. When the first sheep enters the conveyor others simply follow. The speed of the conveyor is adjusted to suit the method of stunning. When electrical stunning is used with an application time of 3-4 seconds the belt needs to be adjusted to slower speeds than used for mechanical stunning.

The same basic rules regarding environment in and around a restraining pen / V restrainer conveyor apply (light, distractions, reduction of noise) as in restraint of cattle.

**ELECTRICAL STUNNING OF SHEEP**

Head-only electrical stunning methods have been in use for over 50 years and during that time equipment design and efficiency has improved substantially. However the majority of head-only stunning systems rely on manual application of tongs to the head and as such their effectiveness is under the direct control of the operator.
HOW DOES IT WORK

It is the current delivered to the brain which stuns the animal. At a constant voltage the amount of current flowing through the brain is inversely proportional to the total electrical resistance pathway. This is known as Ohm’s Law where: $I \text{ (amps)} = \frac{V \text{ (volts)}}{R \text{ (ohms)}}$

Image: Head only stunning of sheep. Source: HSA

The voltage must be high enough to overcome the resistance in the pathway between the electrodes and deliver enough current to produce an effective stun.

Resistance to current flow is affected by:

• Electrode material
• Skin and hair
• Thickness of the skull
• Brain tissue
• Distance between the electrodes.

In general terms the resistance can be reduced to improve current flow by ensuring electrodes are clean, the stunning site is wet (water is a good conductor of electricity) and there is little hair or dirt on the contact site. The resistance across the head of a short fleeced sheep can range between 150 to 400 ohms. In the case of heavy fleeced rams the resistance can range from 200 to 1000 ohms. As that is too high, wetting of the head or clipping hair is carried out to lower the resistance. A poor initial contact or a slow rise in current levels may not stun the animal immediately, and instead the animal could experience an electric shock. Therefore, good electrical contact is necessary to provide an effective stun. Wetting the contact places and the stunning electrodes with water will improve the effectiveness of stunning.

Images: Wetting heads of sheep before or at the time of stunning. Source HSA
EQUIPMENT PARAMETERS

Research has shown that generalized epilepsy can be induced in the brain within 1 second of application of a minimum current of 0.6 amps. EU legislation and OIE standards do however require a minimum current of 1 amp to be delivered to the sheep brain in the stunning procedure. A minimum voltage of 150 Volts (50Hz current) is required to deliver this amperage level in 2 seconds.

CORRECT POSITION OF ELECTRODES

In order to be effective, stunning tong electrodes must be positioned firmly on the head so that they are on either side of the brain. The current can then flow through the skull to the brain by the most direct route. The only correct position of electric tongs/electrodes used in stunning of sheep and lamb is placing the electrodes between eyes and the base of the ears on either side of the head.

Images: Correct position of electric tongs. Source/ HSA

Signs of effective electrical stunning

When sheep have been effectively stunned they go through two clear stages.

A tonic phase which lasts for between 10-20 seconds when:

- The sheep collapses and the whole body of the animal becomes rigid
- Breathing will stop
- The position of the eye becomes fixed
- When current flow stops the tonic seizure continues during which the head is raised and the hind legs are flexed under the abdomen
- Forelegs are usually partially flexed or straighten out.
A clonic stage then follows lasting between 15-45 seconds when there is:

- Involuntary kicking of both fore and hind legs
- Hind legs kick
- Forelegs paddle
- Gradual relaxation.

If the animal is not bled the clonic seizures will gradually subside and finally end. The return of rhythmic breathing signals the start of return to consciousness and other reflexes that indicate recovery. With a stun application of 2-3 seconds the average time for the return of reflexes in sheep is:

- Rhythmic breathing: **starts by 30 seconds**, followed by;
- Corneal reflex: (in practice this reflex is often difficult to elicit and also highly variable)
- Response to peripheral tactile facial stimuli
- Head righting reflex that indicates full recovery of consciousness and sensibility.

*Any of the following indicate an inadequate stun:*

- No tonic or clonic seizure
- Return to rhythmic breathing
- Focused eye movements
- Constricted pupils
- Return of the head righting reflex.

**MECHANICAL (CAPTIVE BOLT) STUNNING OF SHEEP**

Mechanical captive bolt stunning of sheep is based on the same principles as mechanical stunning of cattle. For more information please see relevant chapter on stunning of cattle. To produce good stunning and deliver immediate unconsciousness two parameters are important.
These are:

- Correct position of the stunning gun (captive bolt)
- Sufficient energy

**STUNNING POSITION**

The correct position for stunning sheep depends on whether the animal is polled (hornless) or horned. For polled sheep, the muzzle of the stunner should be placed on the highest point of the head, and on the midline, aiming straight down (see below)

![Diagram of polled sheep with correct stunning position](image)

For horned sheep, the muzzle of the stunner should be placed on the midline, behind the ridge between the horns, and aimed towards the base of the tongue (see below)

![Diagram of horned sheep with correct stunning position](image)

**POWER (SIZE OF CARTRIDGES)**

Cartridges vary in strength and are classified according to the amount of propellant they contain, measured in grains. The cartridges suitable for small animals, such as lambs are coded as 1.25 grain cartridges.

Otherwise they can be colour coded. It is important to refer to the manufacturers' instructions so that the correct cartridges are used for each model of stunner; they are identified by caliber (0.22 or 0.25), colour and headstamp.
The initial effect on the animal is immediate unconsciousness accompanied by what is known as ‘tonic’ activity. The animal collapses, stops breathing and becomes rigid, with its head extended and its hind legs flexed towards the abdomen. This period of rigidity normally lasts for 10 to 20 seconds following stunning.

The forelegs may be flexed initially and then gradually straighten out. However, this depends on the species and the severity of the blow. This tonic activity is followed by a period of involuntary kicking movements which gradually subside. If an animal immediately shows paddling or kicking movements on collapse, it is almost certain that it has not been effectively stunned and it should be re-stunned immediately.

**BLEEDING AFTER ELECTRICAL AND MECHANICAL STUNNING**

The unconscious, insensible state following a stun is short. To ensure death without risk of recovery, stunned animals must be bled without delay. When blood vessels are cut, blood loss deprives the brain of oxygen and nutrients and consciousness will gradually be lost. Further blood loss will damage brain function and lead to death.

**BLOOD LOSS UNCONSCIOUSNESS AND DEATH**

The time taken for an animal to become unconscious from blood loss and eventually die will depend on the number of vessels that are cut and the efficiency of cutting.

Experiments with sheep by Gregory and Wotton show that if sheep are bled by cutting both carotid arteries and jugular veins, unconsciousness occurs in around **14-15 seconds**. If only one artery and vein are cut, it takes **70 seconds** for the sheep to become unconscious. However if sheep are bled by chest stick it takes only **4 seconds** to observe brain unresponsiveness.

**BLEEDING AFTER ELECTRICAL STUNNING**

The maximum stun-to-stick interval can be calculated as follows: Resumption of rhythmic breathing after electrical stunning (**average 30 seconds**) minus time to loss of brain responsiveness after cutting both common carotid arteries and external jugular veins (15 seconds). According to that calculation a maximum recommended stun to bleed time is 15 seconds.
BLEEDING AFTER MECHANICAL (CAPTIVE BOLT) STUNNING

Although chance of recovery is low, sheep must be bled as soon as possible after stunning, ideally whilst still in the tonic (rigid) phase. Bleeding involves severing the carotid arteries and jugular veins, or the blood vessels from which they arise. It is important that all major blood vessels are severed. If only one carotid artery is cut the animal may take over a minute to die.

METHODS

Bleeding should be carried out by an incision made with a sharp knife in the jugular furrow at the base of the neck, the knife being directed towards the entrance of the chest to sever all the major blood vessels arising from the heart. This procedure is often referred to as 'sticking'.

The other method involves incision made close to the head using a blade at least 120mm long to sever both carotid arteries and both jugular veins, i.e. a cut across the throat. Bleeding has to be done by making a deep, transverse cut across the throat close to the head to sever the four major blood vessels in the neck.
RESTRAINING OF CATTLE FOR SLAUGHTER WITHOUT STUNNING

INTRODUCTION

If animals are to be slaughtered without stunning and killed by exsanguination, proper restraint is more important than prior stunning.

The key principles are however same:

- Calm and confident handling that leads to efficient restraint followed by fast bleeding is essential.
- Unprofessional handling and poor restraint will very likely cause animal to struggle and fight back.
- Observations indicated that calm animals lose sensibility and collapse more quickly after bleeding than cattle with visible signs of agitation.

Cattle that fight restraint are more likely to have prolonged sensibility during bleeding, therefore it is important to keep it calm prior restraint as much as possible. Gentle operation of restraint devices facilitates rapid loss of sensibility.

There are several methods currently used for restraining of cattle prior slaughter without stunning. Many of them compromise welfare of cattle to some extent, or require very skilled handler or can be used on certain type of cattle only.

Some of them will cause animal struggling and fighting against the restraint. One such a method is casting of cattle with rope. The method require a combination of a very skilled handler and docile smaller size cattle that has got used to the practice, so the casting would not cause too much stress to it. Generally method should not be recommended for commercial slaughter.

Image: Casting of Cattle.

Cattle – particularly large one who were kept most of their lives in free range conditions and not accustomed to handling should not be restrained by rope casting. Based on the long term observations and research several key principles of the low stress restraint for slaughter without stunning were described.
KEY PRINCIPLES

They are already used at the many slaughterhouses:

- The first principle is that animals are restrained in comfortable upright position before and during the slaughter. Usually in the box type of restrainer
- Cattle movement in the box is restricted by mechanical adjustable rump pusher and head restrainer with the chin lift.
- Cattle neck is well exposed by the chin lift that prevents animal from moving its head on sides.
- Mechanical device that lifts an animal's feet slightly off the ground by belly is a bonus that should ensure that animal is in comfortable position. It is however not an essential part of the restraining device. If the animal's feet are lifted off the floor, the animal's body must be fully supported.
- Using the concept of optimum pressure, the restraining device must apply sufficient pressure to provide the animal with the sensation of being held, but excessive pressure that would cause pain must be avoided.

Image: ASPCA Upright restraining box. Source: T. Grandin

Many existing upright restraint boxes apply excessive pressure. To prevent excessive bending of the neck, the head holder or chin lift should position the animal's forehead parallel to the floor. The animal should stand in the box with its back level. An arched back is a sign of excessive pusher-gate or rum pusher pressure.

Equipping the head holder with a rubber cover will make it more comfortable. The restraining box for slaughter without stunning has been designed based on these principles and it is used in the USA. It is named the ASPCA pen and well known expert Dr. Temple Grandin has been involved in its designing.
Table: behavior of cattle in two different restraining systems i.e. Weinberg rotation pen and ASPCA pen. Source: (Dunn, 1990)

<table>
<thead>
<tr>
<th>Action / Behaviour</th>
<th>Weinberg pen (n= 18)</th>
<th>ASPCA pen (n= 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean time from entering the pen until ready for cut</td>
<td>103,8 sec ± 18,4</td>
<td>11,1 sec ± 11,6</td>
</tr>
<tr>
<td>Total time of struggling before cut (means ± sd)</td>
<td>11,2 sec ± 7,0</td>
<td>1,2 sec ± 3,8</td>
</tr>
<tr>
<td>Number of vocalisations (means ± sd)</td>
<td>4,6 ± 6,1</td>
<td>0,3 ± 0,75</td>
</tr>
</tbody>
</table>

Many practical modifications of ASPCA pen that are built one the same principles while employing mechanical power instead hydraulic would be suitable to use. Moving parts of the restraint device should move with steady smooth motion. Sudden jerky motion causes animals to become agitated.

Some religious groups suggest that the cattle have to be bled in the lateral position while lying on the left side. Restraining an animal and its positioning to the lateral position requires more time, and according to observations causes more stress to animals. It is however still acceptable method of restraint. Positioning of an animal on the side requires more sophisticated hydraulics mechanisms.

Methods of restraint of cattle involving suspending or hoisting it by the feet or legs, or by mechanical clamping of the legs or feet as the sole method of restraint must never be used as they cause animals too much stress and pain.

Immobilizing cattle by breaking their legs, cutting leg tendons or blinding animals in order to immobilize them; severing the spinal cord, for example using a puntilla or dagger, to immobilize animals using electric currents to immobilize animals, are unacceptable practices.

REMEMBER

1. The cattle vocalizing should be minimal. Vocalizing cattle are stressed.
2. Keep cattle calm. Calm cattle bleed out faster.
3. Avoid excessive pressure applied by the rear pusher gate that compresses the animal’s chest against the front of the box.
4. Minimize the time that the animal is fully restrained by the head holder, belly lift, and rear pusher. Time of restraint under 10 seconds is ideal.
KILLING OF CATTLE BY BLEEDING WITHOUT PRIOR STUNNING

INTRODUCTION

Slaughter without stunning is practiced according to specific requirements of religious groups. From practical point of view it often means that the animal is killed by bleeding or exsanguination only.

From an animal welfare standpoint, the major concerns are related to stressful and cruel methods of immobilization of animals that are used in some plants and bleeding carried out with blunt and short knife. Poor quality knife often requires multiply sawing movement of knife on the neck of an animal. When animal is restrained the bleeding has to be carried as soon as possible. A very sharp knife is essential.

Image: Bleeding knife has to be at least one and half ideally twice the width of the throat of cattle or sheep. Tip of the knife should point outwards as to prevent gouging into the wound. Photo courtesy of Judy Moses, Spirit of Humane (spiritofhumane.com)

BLEEDING

Size of the knife is very important too. The razor-sharp knife that has to be at least one and half or ideally twice the width of the throat of cattle. Tip of the knife should point outwards as to prevent gouging into the wound during bleeding. The sharpness of the knife is tested by easily cutting sheet of paper (A4 size) held by one corner by tips of fingers. Cut must be made in a single continuous motion. Reciprocal move (back and forward) is also acceptable. To avoid unnecessary pain the wound must be held opened during the bleeding and the knife must be long enough so that it's tip remains always outside the neck during the cut.

Slaughter performed with short blunt knives and multiple hacking cuts results in a vigorous reaction from cattle. Shorter knives, where the tip of the knife gouges into the wound during the cut, causes unnecessary pain to animal. The cut must severe both carotid arteries.

Calves and cattle take a longer period of time to become insensible than sheep and after bleeding without stunning they are more likely to have a prolonged period of insensitivity. The time from bleeding to loss of sensibility when good cutting technique is used ranges from 17 sec to 85 sec. Some cattle may have prolonged periods of sensibility lasting up to 385 seconds.
Loss of consciousness is usually observed by loss of posture. In situations where the loss of posture cannot be observed for example in the restraining box, a fixed fully dilated pupil can be used to determine complete loss of sensibility.

WELFARE ISSUES

Two major welfare problems can occur during slaughter without stunning. They are a prolonged period where the bovine remains sensible and aspiration of blood into the trachea (windpipe) and respiratory tract. Blood entering the respiratory tract is a welfare concern because the sensation caused by blood entering the respiratory system is likely to be very distressful.

Observations and research indicates that cutting cattle close to the jawbone would eliminate the transmission of unpleasant sensory signals associated with blood contaminating the upper and lower respiratory tract.

When the cut is made close to the jawbone in the C1 position - at the level of first cervical vertebra, the sensory nerve to the respiratory tract is severed. If the cut is made more caudal between C2 and C4, the sensory nerve remains intact and distressful sensations could be transmitted to the brain before the animal loses sensibility.

Cattle’s brain is supplied by blood via carotid arteries that are severed by neck cut and vertebral arteries that are not severed by ventral neck cut. According to research, up to 10% of cattle have delayed onset of insensibility due to clotting of blood in the arteries and formation of false aneurysms during bleeding.

Usually connective tissue would encapsulate the bleeding ends of the carotid arteries and help to form clotting. Carotids partially or completely obstructed by blood clots and continuous blood supply to brain via vertebral arteries creates situation where cattle is observed as conscious 3-4 minutes after cutting the neck.

Image: Blood clots around the carotid artery. Source: Neville Gregory, Haluk Anil

Therefore it is crucial to pay particular attention to cattle during bleeding and if bleeding is not profuse another cut has to be made to ensure rapid and profuse bleeding. According to research cutting neck close to the jawbone at the level of first cervical vertebra - C1 position greatly reduces the formation of false aneurysms. When cattle throat is cut in the C1 position, only 1% of cattle would have arteries occluded.
BLEEDING TECHNIQUE

Image: Bleeding technique with one transversal move of knife

WOUND MANAGEMENT AND POST INCISION PERIOD

During bleeding wound must be kept intact and both edges kept apart. Disturbing the edges of the incision or bumping it against the equipment, will likely cause more pain. The head of an bleeding animal must be restrained in such a manner that the incision does not close back over the knife. Cattle and sheep struggle violently if the edges of the incision touch during the cut. The calm and confident approach during all stages of slaughter is essential as it facilitates rapid loss of sensibility. Immediately after the cut, the head restraining device and rear pusher should be loosened to allow the animal to relax. Often after the head restraint is released, the animal collapses in short while.

Within 17 to 60 seconds, cattle go into a hypoxic spasm and sensibility appears to be lost. There are several ways to assess loss of sensibility. In most cases it is possible to use loss of corneal reflex or rhythmic breathing. Rhythmic breathing can be sometimes confused with gasping and corneal reflex can be sometimes caused by muscle twitch or provoked as involuntary reaction in unconscious animal. Key sign of loss of sensibility is therefore a loss of posture.

Remember the key aspect of the best practice

1. Sharp and long knife is essential for fast bleeding
2. Rapid swift knife stroke with a minimum of sawing motions.
3. Deep cuts is essential
4. Immediately after the cut, COMPLETE release of the head holder, and rear pusher gate ensures that animal will relax.
5. Edges of the wound have to be held apart at all time. If the neck opening is too tight, it may restrict bleed out.
RESTRAINT AND BLEEDING OF SHEEP WITHOUT STUNNING

RESTRRAIN

Sheep when slaughtered by bleeding can be restrained in different ways. The simple methods include sheep standing on the floor and being manually restrained by lifting the head to stretch the neck with one hand and the other holds the knife and performs a transverse ventral cut. Sheep can also be placed on their side in a cradle and held manually by one operator while another stretches the neck and performs the cut. More sophisticated methods include less stressful restraint in a restraining chute (see images below) or restraint in a restrainer conveyor. When restraining sheep in a chute/pen or conveyor it is important that the sheep lies comfortably on its belly with its legs hanging freely from the pen or conveyor. The head is usually restrained by an operator. Upright restraint is the least stressful method as sheep are either automatically lifted by the conveyor belt or they are mechanically lifted in a restraining chute from the standing position. No other forceful manipulation or associated additional stress/distress is caused during restraint in the upright position.

Images: Sheep and goat in upright restraint; Photo courtesy of Judy Moses, Spirit of Humane (spiritofhumane.com)
BLEEDING OF SHEEP

Bleeding has to be done by making a deep, transverse cut across the throat close to the head to sever the four major blood vessels in the neck. Cutting must be done in one swift continuous motion.

Reciprocal cutting (back and forward) is also acceptable. To avoid unnecessary pain the wound must be held opened during the bleeding and the knife must be long enough so that its tip remains always outside the neck during the cut.

Poor quality knives often require multiple sawing movement of the knife on the neck of an animal. A very sharp knife is essential. Sharpness of the knife can be tested by smoothly slicing a piece of standard A4 printer paper that is held by one corner.

Size of the knife is very important too. The razor-sharp knife that is used should be at least one and half or ideally twice the width of the throat of an animal. The tip of the knife should point outwards as to prevent gouging into the wound during bleeding.

Shorter knives, where the tip of the knife gouges into the wound during the cut, cause unnecessary pain to the animal.
INTRODUCTION
The pre-slaughter transport and handling of animals designated for human consumption is directly associated with the quality of meat offered to consumer. A lack of commitment to welfare and care for animals during this stage can lead to production of low quality meat and significant losses of the commercial value of carcasses.

STRESS
Stress is the main indicator to assess the welfare of animals continuously exposed to stressful conditions, such as the pre-slaughter handling to which they respond through a combination of biochemical, physiological and behavioral events. These reactions help the animals to reduce or eliminate adverse aspects of handling and the environment, as an attempt to regain body balance. During exposure to these factors, the body may undergo the following changes:

- **Alert reaction (alarm)** – the body prepares itself for a “fight or flight” reaction by activation of the sympathetic nervous system, that triggers the adrenal gland to secrete hormones such as corticosterone, adrenaline and noradrenalin. These hormones increase heart and respiratory frequency rate, blood glucose concentration, vasodilatation, dilation of pupils and defecation, among other mediated effects;

- **Adaptation or resistance** – after a certain period of exposure to a stressful stimulus and release of more hormones (cortisol, adrenaline and noradrenalin), animals may recover from the alertness reaction and adapt to the new condition;

- **Exhaustion** – if the stressful stimuli are too intense and persist in the environment animals may not adapt to the new condition and the coping mechanisms start failing, depleting energy reserves. Excessive stress (distress) and suffering are outcomes from this condition and may lead to death of the animal.

MEAT QUALITY
Inadequate pre-slaughter handling can negatively influence meat quality due to physiological alterations in the muscle metabolism that the pigs may undergo.

The concept of quality is generally related to intrinsic aspects of the meat, such as appearance, palatability, yield, nutritional composition and food safety. However, there are changes happening in this concept, and some authors already include in quality other aspects that include animal welfare. So ethical quality may refer to conditions which animals undergo during raising, from birth to slaughter. Other important aspects are related to sustainability of production systems and involve social, economic and environmental aspects.

Quality attributes as described by Paul D. Warriss (2000)
- **Composition and yield** – amount of marketable product, percentage of lean meat and fat thickness, carcass conformation;
• **Appearance and technological properties** – color, water-holding capacity, texture, streaks of fat within the muscle (marbling), and muscle physical-chemical composition;

• **Palatability** – tenderness, succulence, flavor and odor;

• **Product integrity** – nutritional quality, chemical, physical and biological safety;

• **Ethical quality** – all procedures related to the welfare of pigs from birth to slaughter.

**FACTORS THAT MAY INFLUENCE MEAT QUALITY**

Specific factors may influence meat quality, interfering with water-holding capacity, color and pH, resulting in a significant economic impact in relation to carcass yield and quality of meat derived products. Therefore, the importance of each factor must be taken into consideration to achieve satisfactory economic results, meet market demands and reduce losses due to defects in meat quality.

**Animal, Health, Handling, Stunning and post mortem variables, Nutrition, Ambient conditions, Animal welfare and Meat quality**

- **Animal factors** – refer to individual characteristics of pigs (genetic, reactivity, age, sex), that may influence stress susceptibility and meat quality. Among the genetic factors, important genes affecting meat quality are the Halothane Gene (hal gene) and the Rendement Napole (RN") Gene or “acid meat gene”;

- **Ambient conditions** – raising system, thermal comfort, density, and farm and slaughterhouse facilities;

- **Nutrition** – physical condition, feed composition and quality, water availability and quality;

- **Health** – absence of diseases and injuries, and feed safety during processing and storage;

- **Handling** – affects the way animals react during raising at the farm and at the pre-slaughter stage. This is particularly important at the pre-slaughter stage when pigs are exposed to many stressful variables such as: fasting, changing environment, loading, transport, unloading, group mixing, handling and restraint;

- **Stunning and post mortem variables** – stunning methods and bleeding directly affect animal welfare and meat quality and are ethically important. *Post mortem* variables (cooling speed, electrical stimulation, maturation and storage type) also influence meat quality, and are associated with the technological aspects of processing.

**POST MORTEM MUSCLE METABOLISM AND MEAT QUALITY**

Drastic changes happen to the muscle when an animal is slaughtered. Blood flow ceases, oxygen and components rich in energy (glucose) do not reach the cells and cellular metabolic products are not removed. Thus, the muscle may use other energy sources in the absence of oxygen, for example glycogen. This is converted to lactic acid, which is responsible for pH dropping.

The glycogen to lactic acid conversion rate is an important factor in the metabolic processes and can directly affect water-holding capacity and final meat color. However, muscle
glycogen reserves in each animal may be exhausted during the pre-slaughter stage as a consequence of many factors:

- Fasting associated with intense exercise (e.g. moving up and down ramps, keeping balance during transport);
- Long transport and lairage periods;
- Inadequate space allowance and insufficient resting time;
- Fighting (e.g. due to group mixing);
- Aggressive handling;
- Agitation due to lack of familiarity with handlers;
- Genetic lines susceptible to stress.

MEAT PH CURVE

The final meat pH is established throughout different periods at post mortem, depending on the species, muscle type and level of stress that the animal was subjected to during pre-slaughter handling. The drop in meat pH is important to:

- Delay bad micro flora proliferation;
- Help determine flavor and odor;
- Promote meat tenderness, as some enzymes are dependant on acid pH to play a role in maturation.

Pigs and poultry have a more rapid drop in pH (affected by post mortem glycolysis rate) when compared to cattle and sheep (see Box).
Variations in pH drop in several muscle types and animal species

<table>
<thead>
<tr>
<th>Species</th>
<th>Muscle type</th>
<th>Meat classification</th>
<th>Time (hours) to reach pH 5.5 – 5.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigs</td>
<td><em>Longissimus dorsi</em></td>
<td>Normal</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PSE</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Adductor</td>
<td>Normal</td>
<td>8</td>
</tr>
<tr>
<td>Poultry</td>
<td><em>Pectoralis</em></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>Cattle</td>
<td><em>Longissimus dorsi</em></td>
<td></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Adductor</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td><em>Sternomandibular</em></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Sheep</td>
<td><em>Longissimus dorsi</em></td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

Source: Jensen et al. (2004)

The occurrence of meat defects such as PSE and DFD is directly related to the speed at which the pH drops in the muscle associated with temperature. In some species such as beef, DFD is more prevalent, while in other species such as pigs and poultry, PSE is more common.

The final pH in pork meat is normally in the range 5.5 – 5.8 (dropping from 7.0 – 7.2), which is reached within approximately **6 to 8 hours post mortem**. In situations of extreme stress, where pigs develop PSE, the muscle pH reaches between 5.2 and 5.4 within 1 to 2 hours after slaughter and up to 5.1 within 12-24 hours post mortem.

**MEAT DEFECTS**

**DFD**

Meat with the **DFD defect**, standing for **dark, firm, and dry**, is a consequence of inadequate **ante mortem** handling, which determines muscle glycogen utilization, contributing to an **elevated final pH** (reduced production of lactic acid due to low glycogen reserve).

This condition is observed in animals subjected to a long duration of stress (chronic stress), generally related to handling at the farm, mixing, fights, inadequate conditions during transport and in the holding area at the slaughterhouse.

For DFD, the elevated final meat pH (around 6.0) reduces growth of good microflora i.e. lactobacilli and favors proliferation of putrescent microorganisms responsible for depreciating the product, as well as changes to physical, biochemical and organoleptic properties of the meat, resulting in:

- High water-holding capacity (WHC) in the muscle fibers, promoting a dry appearance on the surface;
- Firm texture;
- Dark coloration;
• Short conservation period (shelf-life);
• Meat improper for elaboration of industrialized products (fermented product).

To reduce the incidence of DFD meat, it is necessary to **minimize stressful factors during pre-slaughter handling**. Thus, the following are recommended:

• Move animals in small groups, in a calm manner, from the farm, during transport and all the way to the holding pens at the slaughterhouse;
• Load and unload pigs calmly, do not use an electric prod;
• Keep a short interval between transport and lairage, with adequate pen space allowance;
• Avoid mixing unfamiliar animals during transport and at holding;
• Promote thermal comfort, avoiding heat and cold stress.

**PSE**

**PSE (pale, soft, exudative) meat** is normally associated with intense or acute stress that occurs close to slaughter time.

**This condition is observed in animals subjected to short-term and intense stress, just prior the stun and slaughter** resulting in an increase in blood concentration of stress hormones. These hormones can interfere with muscle metabolism, causing temperature increase, excessive use of muscle glycogen, and deposition of high concentrations of lactic acid in the muscle shortly **post mortem**.

At the same time, if lactic acid concentration increases (greater acidification), the pH at 45 minutes will be low (less than 6.0) and when associated with elevated temperature (above 30° C), produces more protein denaturation during the muscle-to-meat conversion process, promoting development of PSE. This condition is characterized by low water-holding capacity and excessive exudation leading to refusal of cuts by the processor and consumers.

**Image:** Pork loin sample (**Longissimus dorsi**) with PSE
Aspects of DFD and PSE pork loin cuts in relation to appearance of a normal loin

<table>
<thead>
<tr>
<th>DFD</th>
<th>![DFD Image]</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL</td>
<td>![NORMAL Image]</td>
</tr>
<tr>
<td>PSE</td>
<td>![PSE Image]</td>
</tr>
</tbody>
</table>

The incidence of PSE meat can be caused by exposure of pigs to a stressful environment, although PSE development is potentiated in pigs more susceptible to stress (for example, if they have the Porcine Stress Syndrome gene – the "halothane gene"). Despite the genetic influence, development of this abnormal effect (PSE) at post mortem is only triggered when pigs undergo stressful events near to slaughter time. The main muscles affected by the process are the Longissimus dorsi (loin) and Semimembranosus (round cut).

Image: Post mortem pH curve for normal, PSE and DFD pork meat.
Source: adapted from Gregory (1998)

Occurrence of PSE meat reduces productivity and industry profitability, particularly in the area of industrialized products (such as ham) produced by brine inoculation. Cooked ham produced with PSE meat has a high index of reprocessing due to release of water (brine) that accumulates in the bottom of the package after cooking.

Annual costs at Canadian slaughterhouses associated with PSE in pigs, as reported by Austin Murray in 2001, can reach up to 4.5 million dollars, with an average loss of 5 dollars per carcass.

Stress preceding slaughter must be minimized in order to reduce incidence of PSE meat, as this condition can increase body temperature and accelerate the post mortem pH drop. To prevent PSE, the following is recommended:
Select genetic lines free of halothane and acid meat genes;
Avoid exercising the pigs prior to slaughter or subjecting them to an environment which can induce heat stress;
Perform calm and gentle handling and avoid use of an electric prod;
Provide a silent resting environment that promotes pigs’ recovery (adequate holding time, space, access to water and thermal comfort);
Avoid mixing of unfamiliar groups;
Adjust line speed according to good handling practices and facilities, avoiding fast line speed;
Avoid post mortem factors that can aggravate development of PSE meat (electrical stimulation, elevated temperature at scalding, slow carcass cooling).

PHYSICAL-CHEMICAL ASSESSMENTS
Specific evaluations of pork are needed to determine with high precision the defects mentioned pH assessment

The pH is an important indicator of meat quality properties and can be used to detect both PSE and DFD. The pH measurements must be carried out in the carcass at different time points; 45 minutes (slaughter line) and 24 hours post mortem (cooling chamber) using a glass electrode connected to a portable pH meter, and the reference muscles are: Longissimus dorsi (loin) and Semimembranosus (round cut).

Initial pH – i.e. pH\(_{(45\text{min})}\) – values smaller than 5.7 – 5.8 are useful for detecting PSE, as some pork cuts become PSE within the first hour or so. Values for pH\(_{(24\text{h \ post\ mortem})}\) above 6.0, associated with DFD meat, indicate a high risk of microbiological contamination since this meat does not have an acid pH to inhibit proliferation of microorganisms.

COLOR ANALYSIS

Color is also an important factor that assists in identification of meat defects, in addition to being an important characteristic for consumers at buying. Myoglobin is the main protein pigment composing the meat; it varies according to species, age, sex and muscle type and can be influenced by stress to which the animals are exposed prior to slaughter.

The post mortem pH curve is important for determining defects such as PSE and DFD. Pale meat, characterizing PSE, is a consequence of protein denaturation while the muscle is still hot, leading to a high concentration of free water in the tissues and partial myoglobin protein denaturation.

Color assessment can be carried out in the Longissimus dorsi (LD) and Semimembranosus (SM) muscles, in the 24 hour post mortem period, using methods such as:

- Photos from the Pork Quality Standards;
- Japanese Color Standards – JCS;
- A Minolta Colorimeter.

The meat color methodology described by the Pork Quality Standards and Japanese Color Standards consists of a scale ranging from 1.0 to 6.0, where low values correspond to pale coloring while high values indicate dark coloring. Intermediate values are considered normal.
Color analysis using the Pork Quality Standards

<table>
<thead>
<tr>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
<th>6.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pale pinkish gray to white</td>
<td>Grayish pink</td>
<td>reddish pink</td>
<td>Dark reddish pink</td>
<td>Purplish red</td>
<td>Dark purplish red</td>
</tr>
</tbody>
</table>


Image: Color analysis using the Japanese Color Standards – JCS

1.0 2.0 3.0 4.0 5.0 6.0

Image: Color analysis with a Minolta colorimeter

Drip loss

Processed meat is affected by low water-holding capacity, limiting industrialization processing and yield. In addition, fresh meat with high exudation has low appeal to consumers, resulting in low market acceptance.
Assessment of water loss can be carried out by:

- **Absorption loss method** – assessed by placing a paper filter over a meat sample;
- **Drip loss method** – water loss by gravity, causing dripping, that usually uses samples placed in nets inside inflated plastic bags. To improve this method, the Danish Meat Research Institute developed the EZ-DripLoss, where samples are placed into specific reservoirs to measure gravity activity. Results from meat samples with 2 – 5% dripping are considered normal, less than 2% as DFD and greater than 5% as PSE.

Images: Method of exudation by gravity to measure pork meat drip loss.

Method of exudation by gravity to measure pork meat drip loss (EZ DripLoss)

The relationship among the three assessments (pH, coloration and drip loss) allows an accurate determination of the incidence of meat defects (PSE and DFD), as well as some intermediate variants of these defects (RSE and PFN) from meat considered normal.

**RSE meat** (reddish, soft, exudative) is a defect type intermediate between PSE and normal, in which **low water-holding capacity** (drip loss above 5%) is observed, although its **coloration remains normal**, as it does not reach extremes of protein denaturation.

The meat classified as **PFN** (pale, firm, non-exudative) as it says, **is pale, but has a firm texture and is non-exudative**. RFN meat (reddish, firm, non-exudative) is considered **normal** for having a normal meat pattern, as its color, texture and exudation criteria are met.

Another method for classifying pork meat quality is presented in the box below. The relation of average values for final **post mortem** pH, drip loss, subjective color according to the Japanese Color Standard (JCS) and objective color by the Minolta method are shown.
Classification of pork meat samples in relation to average values of post mortem pH, drip loss and coloration (JCS and Minolta):

<table>
<thead>
<tr>
<th>Classification*</th>
<th>pH Drip loss by exudation</th>
<th>Japanese Color Standards **</th>
<th>Coloring by Minolta</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSE</td>
<td>&lt; 5.5</td>
<td>&gt; 5%</td>
<td>1 – 1.5</td>
</tr>
<tr>
<td>PSE (moderate)</td>
<td>5.5-5.6</td>
<td>&gt; 5%</td>
<td>2-3</td>
</tr>
<tr>
<td>PFN</td>
<td>5.5 - 5.8</td>
<td>&lt; 5%</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>RSE</td>
<td>5.6 - 5.8</td>
<td>&gt; 5%</td>
<td>3</td>
</tr>
<tr>
<td>RFN</td>
<td>5.6 - 5.8</td>
<td>2 – 5%</td>
<td>3</td>
</tr>
<tr>
<td>DFD (moderate)</td>
<td>5.8- 6.1</td>
<td>&lt; 5%</td>
<td>3-4</td>
</tr>
<tr>
<td>DFD</td>
<td>&gt; 6.1</td>
<td>&lt; 2%</td>
<td>≥ 4</td>
</tr>
</tbody>
</table>

Tab: PSE (pale, soft and exudative); PFN (pale, firm and non-exudative); RSE (red, soft and exudative); RFN (red, soft and non-exudative) e DFD (dark, firm and dry).

Source: *Warner (1994); Correa et al. (2007); **Nakai et al. (1975)

METHODS OF CONTROLLING MEAT QUALITY

Implementation of procedures that accurately evaluate Control Points (CPs) and Critical Control Points for Animal Welfare (CCPs for AW) in each step of the process, especially the pre-slaughter handling, and in all stages that can interfere with the final product quality and animal welfare, is essential for controlling meat quality.

Control Points are considered the steps or procedures that are important for affecting the welfare of animals, but that are controlled with implementation of good production practices during handling and operational procedures within the animal welfare program. The Critical Control Point during pre-slaughter handling is understood as the stage, point or procedure where preventive actions must be executed to eliminate or maintain a risk factor under control, eliminating the risks for animal suffering.

When a carcass or a meat cut does not meet quality standards, it must be discarded, or otherwise partially or conditionally used for a product with less value. Economic losses to the slaughterhouse from this may be enormous, but are often undetected or unknown. Carrying out daily monitoring, establishing incidences and tolerable limits to control and minimizing these losses is essential for improving animal welfare and profit to the slaughterhouse.

A department, team or person must be adequately trained and designated to monitor all CPs and CCPs for AW during loading, transport and at the slaughterhouse in a way to include all processing stages (from farm to slaughterhouse).

The department in charge must be integrated with other production stages and implement the CPs and CCPs for AW, preventive and corrective actions, as well as notifying and engaging all personnel involved with animal care. A high level of collaboration and commitment among production, transport, slaughter, inspection and quality assurance teams and area supervisors is critical.
Success in controlling slaughter operations requires knowledge of methods available for assessing the CCPs for AW and the advantages of implementing them in the production routine. For this, the quality assurance department must have appropriate knowledge and implement a monitoring system that is capable of assessing quality failures with precision, and interpret these assessments and their outcomes.

There are many assessment methods that do not require financial investment, such as the ones for monitoring animal welfare, which comprise assessment of damaged crates or other holding and handling facilities, incorrect shackling, stunning and bleeding failures, fractures, hematomas and contusions. Others require equipment, for instance physical-chemical measurements (color, pH and water-holding capacity).
ANNEX A: ANIMAL WELFARE AUDIT - PIGS EXAMPLE
(BASED ON VARIOUS INDUSTRY STANDARDS RECOMMENDATIONS)

Animal welfare audits are procedures that can be used for monitoring operators’ performance and equipment efficiency, as well as assisting with facilities’ improvements, handling of animals and preparation of the slaughterhouse for market and product quality demands. Monitoring methods must be objective and easy to implement under commercial conditions.

The main Control Points and Critical Control Points for Animal Welfare, as well as tolerance limits described below are in accordance with those suggested by the researcher Dr. Temple Grandin, Voogd Consulting Inc. and American Meat Institute Foundation, with adaptations.

Procedure for determining the results (sampling) – At plants slaughtering over 1000 pigs/day: Observe 100 animals for each criterion below; when the number of animals is lower, then observe 10% of animals, preferably from different groups or pens. Poor performance during this audit indicates compromised animal welfare and can result in meat quality losses.

CP 1: Transport and unloading

All pigs must have sufficient space to lie down at the same time without lying on top of each other while in the transport vehicle compartments. A space allowance of 0.425m²/100 kg is recommended, equivalent to a density of 235 kg/m². The vehicle must be properly parked at the unloading dock with no space (gap) between the ramp and the first unloading compartments. The pigs must be unloaded as soon they arrive at the slaughterhouse. This procedure must be carried out calmly, with gates in each compartment opened as animals exit the trailer. When opening the first compartment, wait for pigs closest to the ramp to recognize the new environment and exit then follow with opening of the subsequent compartments. This practice must be continued until all pigs are unloaded. Mortality rate during transport must be recorded along with potential causes. Verify whether sharp or abrasive objects can injure the animals during transport and unloading by the ramp. Perform daily maintenance.

CP 2: Slipping and falling during unloading and handling to the restrainer

A slip is considered when the animal loses balance and slips with one of its legs or when only the limbs (knee) touch the floor. A fall is when any other part of the body touches the floor.

To differentiate a fall from a slip, observe the part of the pig’s body touching the floor. The area below the line corresponds to a slip and the portion above the line is considered a fall.

Sampling – observation of falling and slipping must be carried out during handling of pigs and throughout all areas where animals are moved, from unloading to entrance to the restrainer. Assess 50% of the animals at unloading and the other 50% during moving of pigs at the plant (removing pigs from the pens and entrance to the restrainer), totaling the recommended number of observations, according to the slaughter volume.

Acceptable limits – Incidence of 1% falls and/or 3% slips or more should be considered unacceptable.
CCP 1: Emergency slaughter

Immediate emergency slaughter must be considered when pigs have severe injuries, contusions or fractures and/or are non-ambulatory showing signs of suffering. These animals must be carefully segregated at unloading, using humane methods and tools. When removal of the pig from the vehicle is not possible, or this procedure causes further suffering to the animal, then the emergency slaughter must be carried out inside the trailer, as long as adequate methods of stunning and bleeding are used.

CP 3: Stocking density in the holding pens

All pigs must have sufficient space to perform their basic movements and have access to a drinker.

CP 4: Water availability

Clean water must be provided in sufficient amounts for all pigs during the entire lairage period in the holding pens.

CP 5: Lairage period and thermal comfort

A lairage period in the holding pens between 2 and 4 hours is recommended for pigs.

The time recommended from feed withdrawal until slaughter is not less than 8 hours and not more than 18 hours total (fasting time at the farm, transport and time at the slaughterhouse).

The holding area environment must provide thermal comfort to the pigs. Thus, the presence and effectiveness of shaded areas, ventilation and high-pressure fog must be assessed.

CP 6: Electric prod

The application of an electric prod to sensitive areas of the pig (eyes, snout, genitals, and anus) is not permitted. Occurrences of any of these actions, as well as electro-restraint (immobilizing conscious pigs using electricity) are considered major (severe) non-conformances. The use of an electric prod is only acceptable as the last resort, and only when the pig has space to advance, for a period of 1 second, on the rear limbs.

Excellent 0%
Good 1-10%
Acceptable 10-15%
Unacceptable 15-29%
Serious problems 30% or more

Assess the use of electric prod in the single file chute (alleyway and entrance to restrainer). The use of an electric prod is not allowed in any other area of the slaughterhouse.
**Sampling** – It is unacceptable for more than 15% pigs to be prodded. The percentage is of the animals on which the prod is used, not the number of times the prod is used on each pig (which should rarely be more than once).

**CP 7: Vocalization during handling and restrainer**

Refer to vocalizations (acute and/or long) that are produced by the animal in response to adverse stimulation (stressful) during handling, restraint and stunning.

**Sampling** – Assess 50% of animals at the exit of pens to the alleyway giving access to the restrainer and 50% at the entrance of the restrainer, totaling the recommended number of observations, according to the slaughter volume.

**Acceptable limits** – it is unacceptable if more than 25% of pigs vocalizing during handling and entrance to restrainer.

**CP 8: Vocalization when in contact with electrodes**

Refer to vocalizations given during application of electrodes to stun the pigs.

**Sampling** – Assess at the exit of restrainer the recommended number according to slaughter volume, at the moment the electrodes are applied.

**Acceptable limits** – no more than 1% of pigs should vocalize when in contact with the electrodes.

**CP 9: Electrode positioning**

Assess pigs at the exit of restrainer or in front of the bleeding table. Focus on the most correct positioning, according to the description in the chapter on head-only stunning - electronarcosis.

**Sampling** – Assess according to slaughter volume at the moment the electrodes are applied.

**Acceptable limits** – it is unacceptable for more than 1% of pigs to have electrodes positioned incorrectly. For those with incorrect positioning, corrective actions should be taken post assessment.

**CCP 2: Stunning efficiency**

The presence of a conscious pig at the bleeding table is considered a **severe non-conformance**. Only pigs not showing signs of consciousness must be bled. Conscious pigs must be re-stunned immediately. There no tolerance to begin any following procedures (bleeding, shackling, scalding) in any pig showing sensibility or return to consciousness.

**Sampling** – Assess pigs at the bleeding table, soon after stunning and bleeding, with the recommended number according to slaughter volume.

**Acceptable limits** – It is unacceptable for more than 1% of pigs to be conscious at the exit of the restrainer. Furthermore, **any conscious animal must be re-stunned prior to bleeding**. Conscious animals during bleeding are unacceptable.
A pig incorrectly stunned is identified when the following are detected:

- Rhythmic breathing (RB) and/or
- Righting reflex (RR) of head and attempt to recover posture and/or
- Vocalization (VO) or
- Any of these signs in combination with Corneal reflex (CR).

CCP 3: Bleeding efficiency

All pigs must be bled without showing any sign of consciousness and sensibility to pain. It is recommended that bleeding, with a good blood flow, must be carried out within a maximum of 15 seconds post stunning.

Sampling – Assess after bleeding the recommended number according to slaughter volume of the plant.

Some additional points that are considered non-conformances at the plant are shown below:

- Intentional negligence and/or any violent behavior toward the pigs;
- Dragging conscious animals;
- Conscious animals at bleeding;
- Driving a pig on top of another that is falling;
- Failure to provide water to all holding pens;
- Failure to provide sufficient space to the pigs (0.6m²/100 kg live weight);
- Using electric prod or objects on sensitive areas (eyes, snout, ears, genitals or anus);
- Using excessive force toward any animal;
- Severe lesions due to falls.

To avoid other non-conformances, be attentive to the following points normally observed in slaughterhouses:

- Mortality rate during transport;
- Conditions of the transport vehicles (density, adequate structure and repair);
- Unloading (truck unloaded upon arrival at the plant, absence of space between truck and unloading ramp, appropriate ramp slope);
- Non-slip floor to prevent falls and slips;
- Emergency procedures for non-ambulatory animals at arrival to the plant (proper use of stretcher and emergency cart and handling);
- Adequate restraint in the restrainer or stunning box – which should be adjusted to the group size, and belts should be running in synchrony;
- Electrical parameters according to recommendations;
- Availability of a portable backup stunner for any failures;
- Maintenance of electrodes.
EXAMPLE A OF AN ANIMAL WELFARE AUDIT AT THE SLAUGHTERHOUSE

Plant: _____________________________________________________________

Date: ____ / ____ / ________

Auditor: ________________________________ Number of animals slaughtered/ hour:
________________

Each space in the box below represents an assessed pig. Mark according to the legend.

CP 1 – TRANSPORT AND UNLOADING

Assess 10% of vehicles (V) unloaded on the audit day

- Is the vehicle stocking density adequate?
- Is the vehicle parked correctly with no space (gap) between the unloading ramp and the load compartment?
- Were pigs unloaded promptly upon their arrival at the slaughterhouse (1 h maximum)?
- Were pigs unloaded calmly from the vehicle? Were the openings of the compartment gates synchronized with exit of the pigs?
- Were pigs unloaded with help of handling tools (if any) that do not promote bruises or pain?
- Are there records for mortality during transport and attributed causes?
- Is there adequate maintenance of the vehicle compartments and unloading ramp, with no sharp edges or abrasive objects that can injure the pigs?

CCP 1 – EMERGENCY SLAUGHTER

Assess the unloading and holding facilities at the plant

- Were non-ambulatory pigs subjected to immediate emergency slaughter? Failure in carrying out this procedure is considered as a severe non-conformance.
- Was removal of non-ambulatory pigs performed with use of humane methods and no dragging of the animal?
- If no non-ambulatory pigs were observed, were appropriate equipment and provisions available to deal with them when they do occur?

CP 2: Slips and falls

(X) = No slipping and falling;

(B) = Falls;

(E) = Slips.

CP 3 – DENSITY IN THE HOLDING PEN

Assess in the holding pens at the plant

- Is there enough space in the pens to allow all pigs to lie down at the same time, walk around and access water?
CP 4 – WATER AVAILABILITY

Assess in the holding pens at the plant

- Is there clean water available to allow at least 15% of pigs access to drinkers simultaneously?

CP 5 – LAIRAGE AND THERMAL COMFORT

Assess in the holding pens at the plant

- Does the environment in the holding area promote thermal comfort for the pigs? Is there shade, ventilation and fog that are being used effectively?
- Are pigs kept in lairage for a period of 2 to 4 hours, as recommended?

CP 6: ELECTRIC PROD

(X) = Pig moved without use of electric prod;
(S) = Pig moved with use of electric prod without apparent reason;
(M) = Pig moved with use of electric prod in response to balking;
(F) = Pig moved with a tool that can cause suffering.

CP 7: VOCALIZATION

(X) = Pig does not vocalize;
(B) = Pig vocalizes in response to electric prod;
(Q) = Pig vocalizes due to falling or slipping;
(P) = Pig vocalizes due to excessive pressure in the restrainer or mounting from other animals.

CP 8: VOCALIZATION IN RESPONSE TO ELECTRODE

(X) = Pig does not vocalize;
(V) = Pig vocalizes.

CP 9: ELECTRODE POSITIONING

(X) = Electrode correctly applied;
(P) = Incorrect application of electrode.

CCP 2: STUNNING EFFICIENCY

(X) = Pig correctly stunned;
(MI) = Pig not well stunned.
A pig is considered not well stunned when showing:

- Rhythmic breathing and/or;
- Righting reflex and attempt to recover posture and/or;
- Vocalization or
- Any of these signs in combination with corneal reflex.

CCP 3: Bleeding efficiency

\( (X) = \) Good blood flow;

\( (S) = \) Poor blood flow.

ADDITIONAL AUDIT CRITERIA

Does the slaughterhouse has an animal welfare program that describes in detail all procedures, from transport to slaughter? Does the plant have an active plan with preventive and corrective actions for when non-conformances are detected?

Is there a routine of trainings on good handling practices and animal welfare? Are there records? Do the operators work in the areas on which they received training?

Stunning, bleeding and re-stunning procedures (failures).

Are the pens and alleys in good repair and free of any sharp obstacle that can cause lesions, hematomas and contusions? The floor must be clean, draining water properly to prevent holes and water puddles. Is there monitoring of facilities for the criteria above?

Maintenance of stunning equipment – Does the plant have a program describing in detail the preventive maintenance of the stunning equipment? What is the maintenance frequency of this equipment (include emergency)?

Is the electrical stunner adjusted for a minimum current of 1.3 amperes for finisher pigs and a minimum of 3.0 amperes for adult pigs (sows and boars)? Is there a monitoring screen that allows for verification of these values? Register the electrical parameters:
ANNEX B: VISUAL ASSESSMENT OF CARCASSES

CARCASS LESIONS

Quantifying the incidence of carcass lesions (scratches) is an indicator to assess pre-slaughter handling quality in pigs. As an appropriate method, use the carcass lesion standard from the Meat and Livestock Commission (MLC) with adaptations, for a 1 to 5 scoring system with intermediate values (1.5, 2.5 etc.), according to the description below:

1. Carcass with few “light” lesions;
2. Carcass with lesions;
3. Carcass with some severe lesions;
4. Carcass with many severe lesions.

Source: MLC (1985)

Lesions on the animal’s dorsal and posterior areas, with hoof scratches resulted from mounting, may have occurred in the single file chute or at the entrance of the restrainer, particularly if an electric prod was used.

The electric prod must be avoided if possible since its application is a painful procedure that leads to distress and agitation of the group, with the potential of causing a high incidence of bruises and meat defects (blood splashing/spotting).
Monitoring of carcass lesions can also be used to identify their origins and causes, which are differentiated in: lesions from fighting, handling and crowding. When lesions are caused by fights among the pigs, lesion incidence is higher in the anterior region of the animal (neck and shoulder), normally characterized as double teeth scratches. Remember that a prolonged fasting time can also contribute to an increase in fights, because the pigs become more aggressive when they are hungry.

Characteristic lesions of handling and crowding result mainly from aggression, facilities, inadequate handling and high density and are easily differentiated by location and shape from bruises due to fights (bites).

HEMATOMA, CONTUSION AND FRACTURES

The occurrence of hematomas, contusions and fractures is evidence of inadequate handling. In addition, these injuries represent significant economic losses, affecting prime meat areas and being difficult to remove without compromising the remaining area or cut (e.g. ham, loin). They can also devalue the cuts, as pigs suffering injuries prior to slaughter tend to produce meat with undesirable pH24 values.

- **Hematoma** – this usually occurs during pre-slaughter handling, when a trauma affecting the resistance of blood vessel walls results in blood leakage from the vascular system to tissues or organs. A hematoma can increase the volume it affects, as it can spread in all three dimensions.

- **Contusion** – this is caused by an acute trauma, with no exposed injuries or fractures, which can result from pain and edema. For instance, muscle and subcutaneous tissue (swollen) trauma can either produce contusion, or elevated levels of blood leakage (hematomas).
The coloration of a hematoma and/or contusion in the carcass can indicate whether it is an old or recent event. This change in color occurs due to hemoglobin (initially red) degradation in the blood retained in the tissue, which produces a greenish or yellowish coloration. Thus, a recent hematoma has a “live” red color progressing to purplish red (hematomas due to loading, transport and moving in the slaughterhouse) and as time goes by, it becomes greenish or yellowish (old hematomas that occurred at the farm).

In animal species with greater percentage of red fibers, coloration in relation to age of hematoma/contusion is affected by various factors, and there are differences among the main research results. Given this, histological evaluation of the affected area may be needed to determine the lesion age. The box below shows approximate coloration to estimate hematoma and/or contusion age.

<table>
<thead>
<tr>
<th>Hematoma coloration</th>
<th>Time of hematoma occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Up to 1 day</td>
</tr>
<tr>
<td>Blue or purple</td>
<td>2 to 5 days</td>
</tr>
<tr>
<td>Green</td>
<td>5 to 7 days</td>
</tr>
<tr>
<td>Yellow</td>
<td>7 to 10 days</td>
</tr>
<tr>
<td>Disappearance</td>
<td>15 to 28 days</td>
</tr>
</tbody>
</table>

Some traumatic events during pre-slaughter handling that can cause hematomas and/or contusions are:

- Abrupt stopping and inadequate density in the transport vehicle;
- Inadequate loading and unloading;
- Incorrect handling of gates in the truck and alleyways at the slaughterhouse;
- Inadequate facilities (ramps, slippery floor, obstacles, edges, perforating objects);
- Aggressive handling with use of inadequate tools (sticks, metal bar);
- Use of electric prod;
- Mixing of groups and fights.

Fracture – Bone fractures must be quantified daily and causes must be identified at the plant; violent traumas during pre-slaughter handling can result in rupturing of bones and ligaments causing severe pain, suffering, and debility and can lead to death of pigs due to blood loss (hemorrhage, hypovolemic shock).

Often pigs show locomotion problems even if a visible fracture is not observed as the skin is not torn. However, it is common to detect serious fractures (with laceration of the skin) and intense hemorrhagic areas during the post mortem inspection.
An extended area of blood surrounding the broken bone is observed in fractures occurring pre-slaughter. The amount of blood lost (hemorrhage) will depend on pressure, space around the affected area and irrigation.

**The occurrence of fractured bones is multipartite and can happen due to factors such as:**

- **Trauma** – accidents, violent trauma during handling at the farm, transport and slaughterhouse;
- **Genetics** – some genetic lines are more susceptible and present failures in the ossification process, particularly young pigs selected for rapid growth with irregular patterns of ossification;
- **Nutrition** – low concentration of minerals and vitamins in the ration can lead to deficiencies in the animal's bone composition and formation, contributing to formation of lesions;
- **Lack of exercise** – pigs raised outdoors can exercise more and have a stronger muscle tone, ligaments and bone structure, compared to pigs raised in intensive systems (confined) that have movement restriction and low locomotory activity; consequently, the bone structure of the latter may be weakened with a predisposition to fractures.

**BLOOD SPLASHING (SPOTTING)**

Increase in muscle activity and blood pressure occurs when pigs are stunned using electronarcosis, because the circulating electrical current stimulates muscle contraction. This rise in blood pressure can damage the capillary system supplying the musculature. For this reason, hemorrhagic spots may be observed in the muscle, called blood splashing or spotting.
Causes of blood splashing

Blood splashing can be caused by a number of factors, among them:

- Long periods of electrode application during pig stunning;
- Several electrode applications;
- Excess of electrical current during stunning;
- Long stun-to-bleed interval, due to elevated blood pressure sustained for a long period;
- Using low frequency (60 Hz) electrical current during stunning;
- Susceptibility of capillary blood system (due to nutritional deficiency, genetic factors);
- Using electric prod during pre-slaughter handling.

Blood splashing can be reduced by employing better handling practices from the farm until the moment of bleeding, such as:

- Adequate nutrition of pigs at the farm;
- Handle pigs calmly, without using an electric prod during the entire process;
- Maintenance of electrodes and adjustment of stunning equipment;
- Training of operators;
- Stunning by gas reduces incidence of blood splashing in the muscle due to low stimulation of musculature, when compared to electrical stunning methods;
- Short stun-to-bleed interval (maximum 15 seconds).
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